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BUSINESS LOGISTICS IN MODERN MANAGEMENT

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FACULTY OF ECONOMICS IN OSIJEK

JOSIP JURAJ STROSSMAYER UNIVERSITY IN OSIJEK

Osijek, Croatia 2019

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C O N T E N T

FOREWORD

For the last 19 years, the Faculty of Economics in Osijek, Josip Juraj Strossmayer University of Osijek in Croatia, has had both the tremendous honour and great responsibility to organize the longest-running scientific and international conference in the field of business logistics and supply chain management in the Republic of Croatia. Current 19th international scientific conference Business Logistics in Modern Management continues a tradition of bringing together researchers, academics and professionals from mainly Central and Eastern Europe countries to Eastern Croatia, and to city of Osijek. This year 75 authors from Belarus, Croatia, Czech Republic, Germany, Hungary, Poland, Serbia, Slovakia, and Slovenia present their work in Proceedings publication . Editorial board received and assessed 55 papers, and among them 37 were accepted for publication after successfully overcoming two double-blind international reviews. Intending to increase quality and internationality of the Conference, the review board was extended and it consists of 44 distinguished scientist from Croatia, Germany, Hungary, Poland, Serbia, Slovenia, Ukraine and United States of America.

Scientific papers in the Proceedings are divided into following seven chapters: Digitalization and innovations in supply chain, Risk and efficiency analysis in supply chains, Transportation, Distribution logistics, Urban, humanitarian and green logistics, Procurement, and Interdisciplinarity in logistics. Consistent with the sustained growth of the European economy, researcher's interests are again turning to central logistic and supply chain areas such as transport and various other aspects of supply chain efficiency. Additionally, many authors perceive innovations and information technology implementation as a source of impending progress in supply chain management and logistics. Along with particularly interesting topics, articles in this year's Proceedings use diverse research approaches – from generally applicative, certain supply chains (industry) connected, to country-specific – as well as different methodology choices: both quantitative and qualitative research methods appropriate for the field of supply chain and logistics.

There have been numerous challenges in logistical theory and practice during the past year, but papers published in the 19th Proceedings, as well as presentations and discussions during Conference, demonstrate that scientists from Central and Eastern Europe meticulously search for successful theoretical conclusions and practical solutions, suggest further improvements, and open new research questions.

In recent years, lectures by invited keynote speakers have become one of the most powerful elements/aspects of our conference and motivating, driving force for its participants. Therefore, this year we are particularly proud that two remarkable researchers and scientists have accepted our invitations and hold plenary lectures. Dr. Alexander Trautrims from Nottingham University Business School, Great Britain, was speaking about modern slavery in supply chains as immensely important, but still neglected topic in contemporary supply chain management. On the other hand, Prof. Arthur V. Hill from Carlson School of Management, University of Minnesota, USA, enriched the Conference by presenting his exciting research on forecasting the forecastability quotient for inventory management.

For the seventh consecutive year, international scientific conference Business Logistics in Modern Management and its Proceedings are recognized as a significant scientific achievement by the Ministry of Science and Education of Republic of Croatia, and therefore we are grateful for their support. Finally, our appreciation goes to all authors, reviewers, editorial board and committee members for their expertise, time and selfless effort devoted to the Conference and the publication it provides.

In Osijek, 10 October, 2019.

Davor Dujak,
Editor

I. DIGITALIZATION AND INNOVATIONS IN SUPPLY CHAINS

LOGISTICS INNOVATIONS DEVELOPMENT IN THE CEE REGION

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Abstract

Although innovation in general and logistics innovation in particular have been discussed in various contexts, there has been a limited amount of empirically based research on logistics innovation and its determinants. The purpose of this paper is to investigate determinants behind the probability of introducing innovations in logistics, delivery or distribution methods for inputs, goods and services among manufacturing firms in eight Central and East European (CEE) countries during the 2012-2014 period using the bivariate probit analysis. To this end, the paper uses data from Community Innovation Survey (CIS), a confidential dataset compiled by Eurostat on innovation activities of firms in the EU member states. Findings reveal differences in innovation process among three groups of firms as well as different mediating effects of selected variables on creation of logistics innovations and combined effects of public subsidies and procurement. The paper adds to the knowledge of determinants of incremental and radical logistics innovations in the CEE region.

Key words: innovation, logistics innovation, firm performance, bivariate probit analysis, CEE region

1. INTRODUCTION

In order to survive and prosper in today's dynamic and competitive business environment, firms increasingly depend on the ability to innovate. Consequently, the concept of innovation is valued in most organizations to create and sustain competitive advantage (Soosay & Hyland, 2004) and the same refers to logistics industry in general. Nowadays, many firms place emphasis on leveraging logistics capabilities as a source of competitive advantage (Esper et al., 2007). As argued by Chapman et al. (2002), the logistics industry is a service-based industry, transformed from the business concept of transportation to that of serving the entire logistical needs of customers. Although innovation is a key process for logistics service providers, Buse & Wallenburg (2011) highlight a high failure in logistics innovation in practice. According to Manners-Bell & Lyon (2019), logistics companies have often been accused by their customer of lacking innovation, while they in turn have levelled accusations that manufacturers and retailers have been more focused on cost cutting than creativity. Due to intense competitive and turbulent environment, logistics service providers have to continuously improve logistics service quality and firm performance (Panayides, 2007). In that context, Bellingkrodt & Wallenburg (2013) show that innovativeness is a strong driver of logistics service providers' firm performance. Furthermore, logistics service providers can evoke a higher level of customer satisfaction when being innovative (Bellingkrodt & Wallenburg, 2015).

In broad terms, logistics innovation itself can be defined as "any logistics related service from the basic to the complex that is seen as new and helpful to a particular focal audience" (Flint et al., 2005, p. 114). In that context, innovations can be internally or externally focused, depending on whether the focus is on operational efficiency or new or improved service to consumers. Therefore, logistics innovation can be considered service innovations triggered by technological innovations (Saatcioglu et al., 2014). As noted by Lin (2007), the innovation in logistics technologies can be significantly positively influenced by organizational encouragement, quality of human resources, environmental uncertainty, and governmental support for logistics service providers. In addition, technological innovation have to be complemented with non-technological innovation concerning services, people and organization in order to survive and prosper (De Martino et al., 2013). Although they can involve elements of technologic innovations, many of the innovations occurring within the supply chain and logistics industry are organizational. They mainly refer to relationships with customers and suppliers, operational processes or business models (Manners-Bell & Lyon, 2019). Additionally, Grawe (2009) stresses the importance of logistics innovations primarily due to their cost-cutting nature, which can be difficult for competitors to detect and imitate.

Although the issue of logistics innovations has attracted the interest of researchers and practitioners, the lack of knowledge base regarding empirically based research in logistics innovation has been frequently emphasized (Lin, 2007; Daugherty et al., 2011; Su et al., 2011; Björklund & Forslund, 2018). To fill this gap in the existing literature, the purpose of this paper is to investigate determinants behind the probability of introducing innovations in logistics, delivery or distribution methods for inputs, goods and services among manufacturing firms in eight Central and East European (CEE) countries during the 2012-2014 period using the bivariate probit methodology. The paper is divided into four main parts. After a brief introduction on logistics innovation, determinants of logistics innovation within the context of literature review are discussed. Following the literature review, the third section explains the empirical strategy whereas the fourth section brings out the research findings. Finally, in the last section some conclusions have been drawn upon.

2. LITERATURE REVIEW

In general, logistics innovations have been discussed from different perspectives and in various contexts. Some examples include the following: the effectiveness of shipping knowledge on organizational innovation and logistics value (Lee and Song, 2015), logistics-driven packaging innovation in retail supply chains (Hellström & Nilsson, 2011), the process of a logistics innovation in a healthcare supply chain context (Su et al., 2011), outbound logistics services in the automotive supply chain (Rajahonka & Bask, 2016), the innovative strategies in the context of eco-efficiency innovation (Rossi et al., 2013), the influence of logistics process innovations on ambidexterity performance (Ardito et al., 2018), etc. However, despite this interest, there have been limited previous studies addressing empirical research in the context of logistics innovations.

It is generally accepted that firm's knowledge base is conducive to innovation activity (Petrou & Daskalopoulou, 2013) and that knowledge resources play an important role in development of innovations (Chapman et al., 2003; Nieves et al., 2014). As firms pursue strategies to innovate, the major resource lies in the people within the organization (Soosay, 2005). Therefore, the importance of learning in today's hypercompetitive global supply chain environment has been underlined (Esper et al., 2007). As stressed by Yazdanparast et al. (2010), the process of co-creation of value in a logistics context has three phases: learning, innovation and execution, and outcomes. In addition, Autry & Griffis (2008) suggest a positive relationship between logistics innovation and supply chain knowledge development. According to Hakansson & Persson (2004), the learning associated with the combination of resources across supply chains leads to increased levels of innovation. In addition, Panayides and So (2005) affirm that relationship orientation has a positive influence on organisational learning and innovation. Similarly, Kuhne et al. (2013) argue that the characteristics of the chain relationship quality may be important factors for the improvement of the innovation capacity in chains.

When examining the German transportation industry, Wagner (2008) outlined the importance of innovation for the competitiveness of logistics service providers. However, his findings revealed that only 30% of the logistics service providers' were innovators with innovation activities mainly including technological advanced infrastructure and equipment investments. Further, Germain (1996) examined manufacturers and the adoption of logistics process innovation. Size and environmental uncertainty were found to directly predict radical, but not incremental innovation while specialization predicted both. Additionally, the results revealed that decentralization of manufacturing operations did not predict logistics process innovation.

Flint et al. (2008) posit that supply chain learning and innovation processes are driven by processes aimed at studying changes in customer value and contribute to perceptions of superior organizational performance. Innovativeness is an important determinant of logistics service quality and, consequently, customer value and firm performance. Panayides (2006) argues that relationship orientation in the logistics service providers-client relationship will lead to higher levels of innovativeness, improvement in the quality of logistics service and improved performance for the logistics service providers. Similarly, Grawe et al. (2015) highlighted a relationship between logistics innovation and performance of service providers and of customers. Additionally, Ralston et al. (2013) emphasize logistics salience as an important resource for firms looking to provide differentiated services and innovative logistics operations to their customers.

Empirical studies of logistics innovations have focused on the innovation process. In that context, Grawe et al. (2011) showed that innovative logistics processes could lead to greater operational flexibility, which could further lead to higher levels of logistics performance. Furthermore, Fugate et al. (2010) highlight that logistics performance positively affects organizational performance. Daugherty et al. (2011) confirm a positive relationship between logistics service innovation capability and market performance. However, the study by Hazen & Byrd (2012) suggests that adoption of a logistics innovation by itself may not necessarily produce a sustained competitive advantage. Instead, when combined with complimentary firm resources, the innovation may yield a sustained competitive advantage for the adopting firm. Additionally, Kwak et al. (2018) provide evidence for the importance of supply chain innovation and risk management capability in supporting competitive advantage. Golgeci & Ponomarov (2013) suggest that both firm innovativeness and innovation magnitude are positively associated with supply chain resilience.

The environment surrounding firms can affect the firm's ability to innovate. In order to turn environmental problems into business opportunities, many companies are beginning to consider the integration of environmental or green aspects into their service offerings (Isaksson & Huge-Brodin, 2013). In that context, Dai et al. (2015) suggest that green supply chain integration has a positive impact on developing incremental environmental innovation, while only customer integration has a significant positive impact on developing radical environmental innovation. Further, Björklund & Forslund (2018) explored the sustainable logistics innovation process emphasizing the process behind its successful implementation, critical factors as well as challenges whereas Andersson & Forslund (2018) addressed sustainable logistics innovation and performance measurement. In addition, the role of innovation in reverse logistics performance was analysed. Innovation in reverse logistics programs was found to be related to operational service quality at both small and large firms (Richey et al., 2005). Moreover, reverse logistics innovation was positively associated with environmental and economic performance (Huang & Yang, 2014).

3. EMPIRICAL STRATEGY

Our analysis aims to investigate determinants behind the probability of introducing innovations in logistics, delivery or distribution methods for inputs, goods and services among manufacturing firms in eight Central and East European countries that have become largest European production hub over the past decades. Ability to handle business logistics in efficient and competitive manner requires from them continuous search for channels for improvement of this part of business activities either through indigenous pushing of knowledge and technology frontiers or through absorption and implementation of knowledge implementation of knowledge developed by others. Investigation of such kind then could help all those businessmen and policy makers interested in improvements over competitiveness of manufacturing industry in the region.

The problem with investigations of this type is that they are often faced with barrier in form of lack of relevant data. One exception from this rule is Community Innovation Survey (CIS), largest European firm level database on innovation behaviour of firms. The survey is compiled from data collected through biannual survey. It covers information on firm innovation behaviour in period of two years prior to survey and latest version of dataset is commonly released within two and half to three years after the completion. At the time of writing of this article, the latest available version of survey was the 2014 one. One characteristic of CIS is that it is highly confidential database accessible by researchers through either Eurostat's Safe Center in Luxembourg or through Eurostat's secure servers. Access to database is granted on the basis of research proposal by National Statistical Offices of each EU member state and information on some firms can be removed from the sample.

For the purpose of this analysis we were given access to data on eight Central and East European countries (Bulgaria, Estonia, Croatia, Hungary, Latvia, Lithuania, Romania and the Slovak Republic) covering a total of 17.999 firms. Table 1 presents distribution of enterprises across countries as well as information on firms that have been involved in logistics innovations. As it can be seen from there, the number of firms is largest in Bulgaria, Croatia and Romania but lowest in Latvia.

Table 1. Number of firms in the database

Country	Number of firms	Logistics innovators	Radical innovators	Incremental innovators
Bulgaria	7378	194	72	122
Estonia	928	48	15	33
Croatia	1303	146	36	110
Hungary	1121	62	15	47
Lithuania	1026	72	26	46
Latvia	562	40	17	23
Romania	4475	86	16	70
Slovak Republic	1206	66	17	49
Total	17999	714	214	500

Source: Eurostat Community Innovation Survey

The proportion of firms involved in logistics innovation is very small with only 4% of firms in sample being involved in such type of innovation. The majority of these innovations are of incremental type meaning that these logistics practices have been known elsewhere in the world but they have been first time applied in surveyed companies. This should not come as a surprise since the majority of enterprises, in general, are involved in incremental type of innovation. It can be expected that such practice becomes even more pronounced in countries as CEE ones where domestic knowledge and technology capabilities are weak and foreign investment has been found only to raise indigenous production capabilities rather than innovation ones.

The above shows that our intention is to explore determinants of incremental and radical logistics innovations in the CEE region. For this reason, a model is constructed that takes into account number of innovation determinants recognised in the literature as important for decision of firms to innovate. Hence, we include two categorical variables for small and medium sized firms since small firms are known to lack human capital, technology and financial resources for undertaking of innovation on the one hand but also have been found to anticipate changes faster than large firms and thus may be also more inclined towards innovations. One categorical variable controls for membership of firms in enterprise groups. In less advanced countries like CEE such groups have been found as an important channel of knowledge and technology spillovers relevant for creation of innovations. Moreover, being member of a group in such countries often implies vertical backward and forward linkages with other group members at home and abroad that may increase pressure for creation of logistics innovations.

We also include two categorical variables for previously abandoned and ongoing innovations since previous innovation experience increases efficiency of existing innovation processes. One categorical variable controls for market orientation of firms and takes value of one if firm is an exporter. Participation in international markets has been often cited as a source of learning by exporting channel that provides firms with insights into novel business practices, enables realization of demonstration effects but also helps them integrate in production networks of foreign partners or integrate them into own production networks all of which should increase the need for creation of logistics innovations. One categorical variable controls for firms with 10% or more employees with tertiary degree. Quality of human capital is a common proxy for absorptive capacity of firms and their knowledge capabilities. It is expected that absorptive capacity helps firms implement incremental innovations present elsewhere but also more easily develop skills and competences required for development of radical innovations.

We also control for public support to creation of innovations. Ability of firms to innovate can be increased through public incentives from either supply (push) or demand (pull) side. Such incentives provide financial means, signal future market trends, help firms release their innovations in market in early stages of their development and generally provide shield from competition in early stages of innovation development. We include two categorical variables, one that takes value of one if firm received financial support in form of subsidies and another that controls for firms that received public support through public procurement of innovations, a novel incentive channel whose relevance in the European Union is on the rise. Overall, one would expect positive effects of public support but it is also known that in advancing economies such as those in our sample public policies place stronger emphasis on production than innovation capabilities and even when innovation policies exist, they often are constructed in a way that does not yield desired outcome. For this reason, there are no a priori expectations on these variables.

Need for logistics innovations may also be increased among firms that recently introduced some new form of product innovation. To control for this we also include share of revenues coming from incrementally or radically new products. Our model also includes three variables controlling for different types of enterprise restructuring. First variable controls for introduction of marketing innovations such as changes in design and packaging, new techniques for product promotion, new methods of product placement and sales channels, and new pricing methods. Such changes may open new business opportunities that could lead to need for logistics innovations. Second controlling variable is the one on internal restructuring that takes value of one if firm introduced organizational innovations such as new practices of supply chain and quality management, new methods for organization of work responsibilities and decision making or new methods for organization of external relations since such practices may improve organizational efficiency, release funds that could be used in development of different types of innovations including logistics ones or they may create needs for changes in a way logistics affairs are handled.

Third restructuring variable takes value of one if firm experienced some type of external restructuring. Specifically, we control for two types of restructuring, mergers and takeovers of other enterprises and sales and outsourcing of some of own functions. Such practices may provide firms with new knowledge and resources required for pursuit of innovations. Finally, one variable controls for collaboration in development of logistics innovations. Specifically, we control for those firms that developed logistics innovations in collaboration with others or those innovations development has been assigned to external sources. Such practices help firms supplement the lack of own innovation capabilities and for this reason, a positive effect can be expected. Model also controls for country specific effects through inclusion of country time dummy variables. Detailed description of variables can be found in Table A1 in Appendix.

Although two types of innovation analysed in our research are distinctive, they also share many common points. For example, many knowledge and technology capabilities required for one type of innovations are also required for others, changes in institutional framework or business environment may affect decisions of firms to pursue both types of innovations etc. As not all such factors can be controlled for, it is likely that two processes will be codetermined with set of unobservable factors. The method capable of handling such estimations is bivariate probit methodology. This methodology allows for correlation in error terms between two equations but assumes that error terms are not correlated with any of explanatory variables. To control for heteroscedasticity we also employ robust standard errors.

4. RESULTS OF INVESTIGATION

4.1. Baseline specification

As a first step of our analysis, we run model with all previously mentioned explanatory variables in their original form and without consideration of their potential interactions. Table 2 presents marginal effects for those firms that only introduce incremental innovations, those that introduce radical innovations only and firms that introduce both types of innovation. For categorical variables these effects refer to effect on probability of introduction of given type of innovation as a result of change from base level of variable in question while in case of continuous variables they refer to effect on probability of innovation from unit change in continuous variable.

Results from Table 2 reveal differences in innovation process among three groups of firms. Those firms that introduce only incremental innovations that can also be called imitation have lower chances of innovating if they are part of the group. This can be attributed to the fact that such activities are undertaken by other group members. Experience with innovation pro cess seems beneficial for the emergence of incremental innovations suggesting that core innovation capabilities are being developed this way. Strongest effects, however, are found from marketing and organizational innovations, collaboration and turnover from product innovations. Hence, under pressure of changes in product innovation and as a result of successful commercialization of such innovations firms look for ways to improve their business logistics through imitation of practices of other, more competitive rivals.

Table 2. Results of baseline specification

Variable	Incremental innovation only	Radical innovation only	Both types of innovation
Small	0.003	-0.003	-0.003
Medium	0.002	0.001	0.0001
Group	-0.01**	-0.001	-0.0001**
Abandoned	0.001	0.01***	0.0002**
Ongoing	0.01**	0.004**	0.0002**
Exporter	0.004	0.003	0.0001**
Hcapital	0.001	0.003**	0.0001**
Subsidies	0.003	0.004***	0.0002**
Procurement	0.003	0.006***	0.0002***
Marketinginno	0.02***	0.005***	0.0004***
Orginno	0.02***	0.01***	0.001***
Restructuring	0.003	0.002	0.0001
Collaboration	0.04***	0.01***	0.001***
Innovation turnover	0.03***	0.01***	0.001***
Number of observations	17.999		
Wald test rho=0	69.45***		

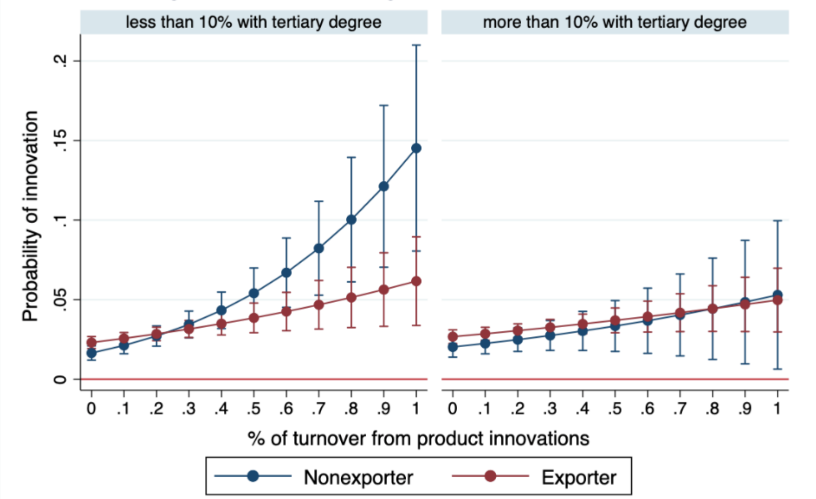
Note: ***,** and * denote statistical significance at 1%, 5% and 10% levels of significance. Country dummies and constant term included
Source: Authors' calculations

A far more interesting issue is the one of radical innovations. Here too we find highly significant and positive influence of previous innovation experience further strengthening our belief that this channel improves indigenous innovation capabilities within business logistics. As expected, we find positive and significant coefficient on human capital. This signals that own absorptive capacity embodied in skilled and knowledgeable workers increases probability for creation of innovations that are not imitation of others but those that are truly novel at world level. In case of radical innovations, we also find positive effects from both channels of public incentives suggesting that all previously mentioned effects of public support here matter. Finally, internal restructuring, collaboration and production innovation commercialization turn out to be the strongest determinants of radical innovations as well. Findings among firms that practice both types of innovation are similar to those for radical innovations. The only exception is that for this group of firms exporting experience also matters.

4.2. Mediating effect of indigenous human capital and market orientation on commercialization of product innovations

We next turn to mediating effects that some of covariates might have on creation of logistics innovations. Learning by exporting may provide firms with superior knowledge that could result in success in creation of logistics innovations but this effect does not necessarily flow directly. Rather, learning by exporting may help firms in commercialization of their product innovations and in that way influence creation of logistics innovations. Both channels, however, depend on absorptive capacity of firms embodied in their human capital. To explore existence of such channels we enrich our model with three way interactions between exporting experience, human capital and share of turnover coming from incremental and radical innovations. As before, we present results for incremental innovators, radical ones and firms engaged in both types of logistics innovations.

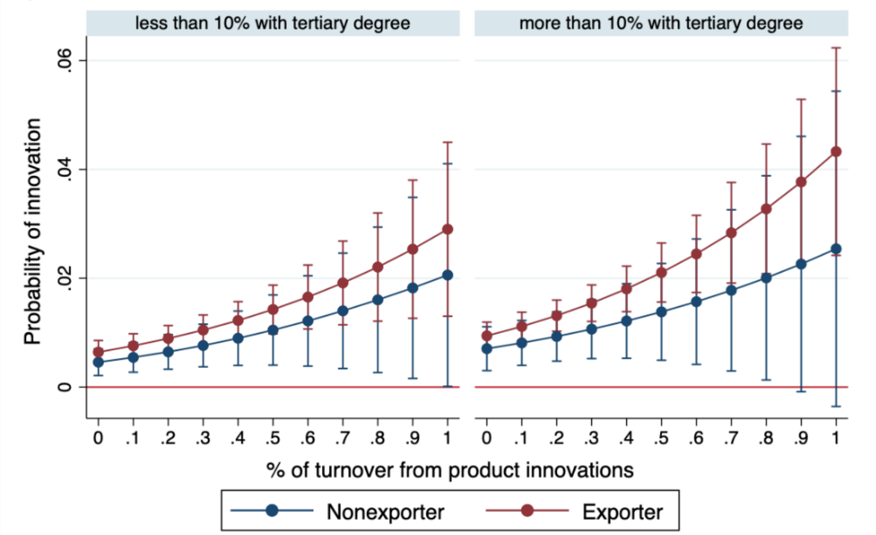
Figure 1. Predictive margins for incremental innovators



Source: Authors own calculation

Figure 1 presents predictive margins for incremental innovators from interaction between human capital, exporting experience and revenues from commercialization of innovations. For firms with both high and low levels of skilled human capital we find statistically significant and positive effects. The probability for introduction of logistics innovation increases as product innovation intensity of firms becomes higher and this is particularly strong among firms with lower levels of human capital but we do not detect significant differences among exporters and non-exporting firms in any group at all levels of product innovation revenue.

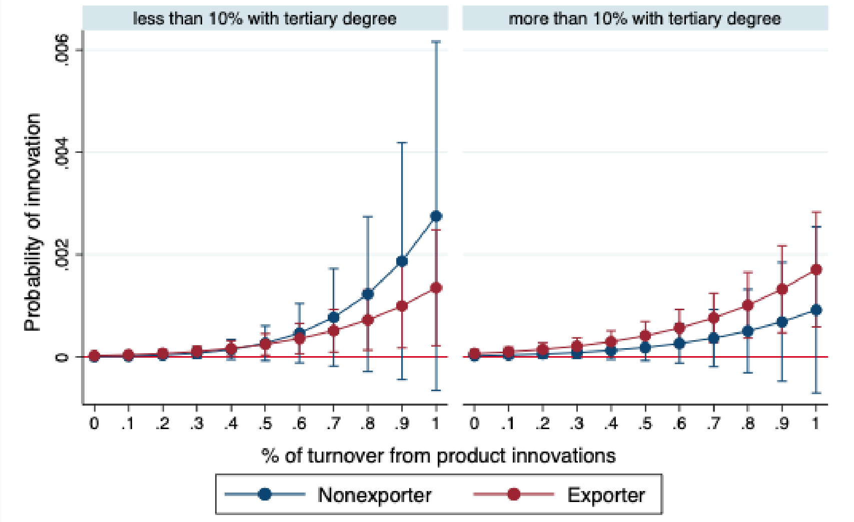
Figure 2. Predictive margins for radical innovators



Source: Authors own calculation

Effects among radical innovations are somewhat different (Figure 2). We can see that at lower levels of product innovation intensity in both groups of human capital we observe statistically significant and positive effects on introduction of radical innovations. However, for group of non-exporters this effect seems to vanish at very high levels of innovation intensity. At these levels, we observe that interaction between innovation intensity, human capital and exporting matters for introduction of radical logistics innovations.

Figure 3. Predictive margins for firms with radical and incremental logistics innovations



Source: Authors own calculation

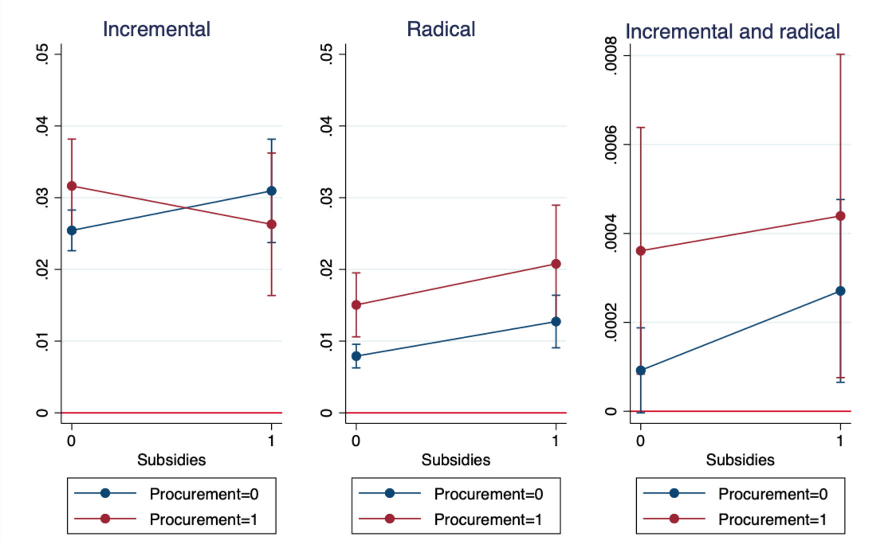
Finally, findings for firms that are involved in both types of innovation do not find any effect for non-exporting firms but we do reveal positive effect of exporting at higher levels of product innovation intensity (Figure 3). Together, all these findings suggest that it is only among those firms most fiercely competing in product-innovation intensive market segment that absorptive capacity and learning by exporting play a decisive role in creation of business logistics innovations.

4.3. Effect of public push and pull channels

One channel that may bear particular relevance for creation of logistics innovations is public support. To explore its relevance we add to our model interaction terms between public push (subsidies) and pull (procurement) incentives for innovations. The reason for inclusion of such interaction lies in the fact that in theory these two measures should provide stronger effects when combined. However, the lack of coordination between policy makers, inappropriate construction of measures or information asymmetries may be reasons why they may produce inferior results than when treated alone.

Figure 4 presents combined effects of public subsidies and procurement for our three groups of firms. Starting with incremental innovators it is evident that the effect of public incentives is statistically significant and positive. It seems that even those that do and do not receive procurement have higher chances of introducing incremental innovations than those firms that do not receive subsidies. This finding questions the validity of subsidy schemes. Among those that receive subsidies for innovation, effect is again stronger for firms that complement it with public procurement but also for those that do not receive such support although we do not detect differences between two groups.

Figure 4. Combined effects of public subsidies and procurement



Source: Authors own calculation

Similar findings can be observed among radical innovators. Here, however, we find that among non-recipients of subsidies firms that received support through procurement have higher chances of introducing radical innovation than firms without any form of public support. Finally, once again we find that recipients and non-recipients of procurement incentives have higher chances of introducing innovation if they also received push incentives. The last segment of investigation is related to the group of firms that introduces both radical and incremental innovations. We find complementarity effects from procurement suggesting complementarity of public measures for this group of firms.

5. CONCLUSION

Whereas the literature on innovation in general is well advanced, logistics innovations in particular have not been dealt with in depth. Although it can be argued that logistics innovations have attracted considerable interest, there is still a need for more empirically based research to broaden current knowledge of the field. Therefore, this presented the primary motivation for our research to fill the mentioned gap. Our research addressed the lack of empirical research in logistics innovations, placing emphasis on determinants of incremental and radical logistics innovations in the Central and Eastern Europe countries. Consequently, it expands the existing knowledge about logistics innovation and contributes to providing an empirical understanding and valuable insights into the dynamic process of logistics innovations in the CEE region.

As regards the innovation process, our findings reveal differences among firms that introduce only incremental or radical innovations and the ones that introduce both types of innovation. Further, different mediating effects of indigenous human capital and market orientation on commercialization of product innovations were also found among the three groups of firms. Taken together, the results suggest that absorptive capacity and learning by exporting play a crucial role in creation of business logistics innovations among firms intensely competing in product-innovation intensive market segment. Finally, combined effects of public subsidies and procurement for our three groups of firms were also observed.

Overall, the findings provide grounds for managerial decisions on investments in logistics innovations and their improvement and development. Examining logistics innovation processes in general and such research in particular may be helpful to executives and policy makers interested in improvements over competitiveness of manufacturing industry in the region. However, there are some limitations that our research could not resolve. Primarily this refers to the inability to explore effects on particular types of logistics innovations such as inventory management systems, e-procurement, digital supply chain management, reverse logistics or new delivery models. Future research should also address the relevance of individual motives for introduction of logistics innovations such as costs, market opportunities or regulatory requirements as well as barriers to introduction of this type of innovations.

6. REFERENCES

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APPENDIX

Table A1. Description of variables

Variable	Description
Radical	Categorical – 1 if firm introduced radical (new to the world) logistics, delivery or distribution method for their inputs, goods or services
Incremental	Categorical – 1 if firm introduced incremental (new to the firm) logistics, delivery or distribution method for their inputs, goods or services
Small	Categorical – 1 if firm is categorized as small firm
Medium	Categorical – 1 if firm is categorized as medium sized firm
Group	Categorical – 1 if firm is part of an enterprise group
Abandoned	Categorical – 1 if firm has previously abandoned innovations (innovation experience)
Ongoing	Categorical – 1 if firm has ongoing innovations (innovation experience)
Exporter	Categorical – 1 if firm sells all or part of its products in international market
Hcapital	Categorical – 1 if firm employs 10% or more staff with tertiary degree of education
Subsidies	Categorical – 1 if firm received public financial support for development of innovations in three years prior to survey
Procurement	Categorical – 1 if firm received public procurement for innovation contract in three years prior to survey
Marketinginno	Categorical – 1 if firm introduced marketing innovations
Orginno	Categorical – 1 if firm introduced internal organizational innovation
Restructuring	Categorical – 1 if firm experienced merger, take over, sale or contracting out of some of its activities
Collaboration	Categorical – 1 if firm developed logistics innovation in collaboration
Innovation turnover	Continuous - % of revenues from incremental and radical product innovations
Country1-8	Categorical – eight categorical variables for each of countries in the sample (Bulgaria as reference category)

OMNICHANNEL IN CRM SYSTEMS FROM THE PERSPECTIVE OF THE SOFTWARE SERVICE PROVIDER

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Abstract

Scientific literature combining omnichannel and CRM systems is not extensive (single papers available). The authors' motivation is to expand the state of knowledge in this field. The goal of the paper is to perform a comparative analysis of the functionality of CRM systems used to support several different fields of activity within one company - a perspective of the software service provider.

The featured research tool is a survey questionnaire used with a sample of 243 company employees in November 2018. The subject of the analysis is a company that operates in a range of different branches on the Polish market. The company has a large collection of various CRM and auxiliary systems used to serve diverse groups of its customers.

The research results are analysed crosswise: first in detail - horizontally (the prism of functionality) and vertically (the prism of the channel type - the type of CRM system), then in general - holistic. The effect of the research is the determination of the company employees' satisfaction with specific functionalities of a given CRM system (channel) along with an assessment of the legitimacy of their use.

Only scientific articles from Scopus databases were considered for literature research. The results of the practical part are adequate for companies that have many CRM systems (not one). In the future, the authors plan to repeat the study on a sample of customers of the company – a look from the second perspective.

After the era of classic customer relationship management systems (CRM), the era of omnichannel customer relationship management systems (OCRM) is coming. This is what the modern market (customers) expects and what is also urgently needed by companies.

Key words: omnichannel, omni-channel, CRM, customer relationship management, CRM system, software service provider, functionality analysis

1. INTRODUCTION

Organizations operating on the market are aware of the fact that in order for them to function and make a profit, it is necessary to attract customers who will buy their services. In a popular trade-specific opinion, acquiring a new customer costs the company six times more than maintaining the current one. Therefore, the company's role is to get to know customer habits and motivate them to make repeat purchases of their services.

In view of the above, increased knowledge about the customer is needed. Hence, companies are investing in newer and more advanced technologies in order to manage customer relations in a better way. The development of such technologies has allowed to create tools that make managing companies easier and more effective. Initially, companies introduced simple applications that facilitated work with customers. Their role was to build a database, exchange information about customers and prepare reports on contacts with them. As time went by, new tools were developed that had new, more extensive functionalities and technologically advanced connections with other IT solutions. The creation of various modules facilitating customer service contributed to the emergence of a tool called a CRM system.

In today's business, the customer is not seen as being important only when the transaction occurs, but also during other forms of contact with the company. CRM systems allow the customer to feel that he/she is not just one of several million customers, but rather one of the few.

The research problem of the article is focused on the functioning of CRM systems in the conditions of implementing a new multi-channel sales strategy – omnichannel: selection of the most important functionalities in the CRM system modules along with their assessment. The goal of the paper is to perform a comparative analysis of the functionality of CRM systems used to support several different fields of activity within one company from the perspective of the software service provider. The article is important for the design and adaptation of CRM systems, adequate to the needs and requirements of the modern logistics software market.

The paper is organized as follows: section 1 – introduction (research problem, goal, main contribution of the paper), section 2 – relationships between omnichannel and CRM systems (state of art); section 3 – subject of research (company with a large collection of various CRM and auxiliary systems used to serve diverse groups of its customers that operates in a range of different branches on the Polish market); section 4 – evaluation of the functionality of selected CRM systems (research methodology, profile of the respondents, functional evaluation of individual CRM system modules, holistic synthesis of the test results); section 5 – general conclusion (summary).

2. OMNICHANNELING IN CUSTOMER RELATIONSHIP MANAGEMENT

The literature on customer relationship management is definitely more extensive than the literature devoted to omnichannel (Table 1). A literature search was carried out on 30 April 2019 in the Scopus abstract and citation database. The Web of Science database was deliberately omitted by the authors because, as their previous experience shows (Domański et al., 2018), scientific articles from Web of Science are included in Scopus.

Table 1. Number of articles about omnichannel and customer relationship management in the Scopus database - separation

search	omnichannel	customer relationship management
1	109	1 239
2	112	10 168
3	97	4 359
1 or 2	158	10 447
1 or 3	151	4 788
2 or 3	142	11 684
1 or 2 or 3	185	11 839
1 and 2	63	960
1 and 3	55	820
2 and 3	67	2 843
1 and 2 and 3	52	696

Legend: 1 - title, 2 - abstract, 3 - keywords.
Source: own study

The number of articles (Table 1) should not come as a surprise because customer relationship management is a historically earlier concept which has existed since the early 1990s. Omnichannel, on the other hand, is a relatively young notion which has been in existence for only a few years.

A more detailed literature search showed the existence of only 3 articles which in their content simultaneously take up the subject of omnichannel and customer relationship management (Table 2).

Table 2. Number of articles about omnichannel and customer relationship management in the Scopus database - conjunction AND

omnichannel \ customer relationship management	1	2	3
1	0	0	0
2	0	1	0
3	0	1	1

Legend: 1 - title, 2 - abstract, 3 - keywords.
Source: own study

These are respectively (Table 2):
2-2 – design by companies omnichannel customer experiences aimed at achieving long-term customer loyalty, provide guidance for mobile service providers on customer experience management strategies and specifically on touchpoint prioritization, adaptation, monitoring and design (Ieva & Ziliani, 2018);
3-2 – the challenges for CRM, how digital transformation changes the flow of information from customer to company and vice versa, the influence on corporate

strategy, broader definition of CRM regarding both aspects, the perspective of the company and the perspective (and perception) of the customer (Krämer et al., 2016);
3-3 – customers were actively engaging with brands on a number of levels – from complaints to complements and beyond, different sectors had different challenges, social dancing often requires brands to do a coordinated conga through multiple channels and complex internal processes (Millard, 2015).

The authors also carried out a literature study taking into account the method of writing down the concept: omni-channel instead of omnichannel, CRM instead of customer relationship management. The effect of this approach is the extension of the whole set by two more articles:
- in context of the contact center, the omnichannel approach comes across as an idea of creating seamless and integrated environment for modern customer experience through integrated channels, which allows agents to work on a better interface and to use a richer set of customer and service data (Picek et al., 2018);
- customers expect seamless interaction with companies throughout all available communication channels; however, many companies rely on different software solutions to handle each channel, which leads to heterogeneous IT infrastructures and isolated data sources; omni-channel CRM is a holistic approach towards a unified view on the customer across all channels (Carnein et al., 2017).

Lack of a correlation between both concepts - omnichannel and customer relationship management - in the global scientific literature testifies to a clear gap in the state of knowledge on the subject. A much wider range of knowledge is offered by not searching for a correlation between these concepts (Table 3).

Table 3. Number of articles about omnichannel and customer relationship in the Scopus database - alternative OR

omnichannel\customer relationship management	1	2	3
1	1 348	10 277	4 668
2	1 351	10 279	4 471
3	1 336	10 264	4 455

Legend: 1 - title, 2 - abstract, 3 - keywords.
Source: own study

Without doubt, the research material (Table 3) seems interesting. It might form the basis for a separate scientific project that the authors could carry out in the future. However, for the purpose of this article, due to a large body of sources to analyse, this thread will not be further developed.

Instead, the authors carried out a literature search in the form: title-abstract-keywords (omni-channel) AND title-abstract-keywords (CRM) - 9 articles and title-abstract-keywords (omni-channel) AND title-abstract-keywords (customer relationship management) - 16 articles. It is a development of Table 2 - its results are presented in Table 4.

Table 4. List of articles about omni-channel and CRM/customer relationship management in the Scopus database – conjunction AND: title-abstract-keywords

Author	Year	Scope of interest	Cited
Církovský & Maryška	2018	concept of customer relationship management systems usage for complex campaigns in health care area	0
Critchley	2018	administration of Dynamics 365 Customer Engagement application	0
Elton &Lopez	2018	how ELLE, the global fashion and lifestyle magazine, engages its audience across all platforms to inform marketing, advertising and brand management	0
Heuchert et al.	2018	entity-relationship-model and a linkage model that takes an IS perspective and thereby enables communication between marketing and IT	1
Miell et al.	2018	need for improvements to 3D visualisation, user experience and online customer relationship management of existing websites, aligned with omni-channel retailing practice	1
Wang et al.	2018	building brand equity through establishing key resource advantages in different brand usage situations	0
Won	2018	case study of Lotte Shopping which is trying to reinforce the omni-channel strategy, which can create synergy among various distribution channels based on its core competencies	0
Carnein et al.	2017	three case studies which demonstrate challenges of omni-channel CRM and the value it can provide	0
Manser Payne et al.	2017	proposed an omni-channel integrated marketing communications framework for advancing the field	16
Niimi & Hoshino	2017	defined “the variety of user access patterns” collected from their web browsing history	0
Park &Lee	2017	consumer channel choice behaviour in the perspectives of consumer sociodemographic information, consumer behaviour and corporate communication strategies	9
Pascoe et al.	2017	adopted a best-worst scaling approach to better understand consumer choices in an online/offline branding environment	2
Aradhana	2016	identified the level of utilization of various retail technologies by retailers and the	3

		upcoming technologies which will drive business in the future in the Indian context	
Kotarba	2016	strategic actions that need to be undertaken in order to prepare the financial services industry for managing customer relationships in an increasingly technosocial environment	7
Picot-Coupey et al.	2016	one of the first studies to empirically investigate the challenges of an e-tailer when moving towards an omni-channel strategy	23
Cavender & Kincade	2015	developed a luxury brand management (LBM) framework that accounts for the changing luxury environment	3
Hutchinson et al.	2015	value of a structured, formal CRM system which helps SME retailers compete in a complex, competitive and omni-channel marketplace	11
Kijpokin	2015	roles of corporate marketing strategies and brand management in the global retail industry	5

Source: own study

The scope of detailed thematic threads to be discussed (Table 4) is diverse. In the context of the literature search conducted by the authors, none of the articles explicitly takes into account (as the main subject) the analysis of the functionality of the CRM system in terms of the implementation of the omnichannel strategy from the perspective of the supplier (operator) of this class of application. The authors of the article had already presented their first view on shaping the logistics system of customer service in the conditions of implementing the omnichannel strategy (general treatment) (Domański & Hadaś, 2017).

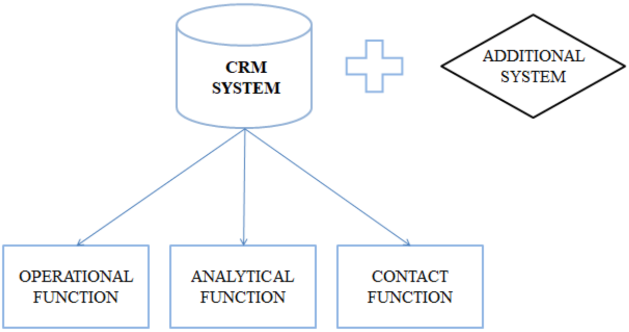
3. SUBJECT OF THE RESEARCH, ARCHITECTURE OF THE COMPANY CRM SYSTEM, CHANNELS OF COMMUNICATION (SALES)

The subject for analysis in the article is an international provider of services for individual and business customers. The company operates on the market in many areas, including: landline telephony, mobile telephony, retail and wholesale internet services provision, data transmission, satellite transmission, infrastructure leasing, electricity sales, gas sales, banking and insurance.

The company has extensive infrastructure in Poland which is necessary to provide the aforementioned services. The company features over 600 fixed points of sale throughout the country, a developed network of partner retailers and mobile salespersons. In Poland, the company employs over 16 000 people.

Due to its large and varied scope of activity, the analysed company had to implement a wide variety of IT systems that are necessary for the proper functioning of services provided to customers. The operation of each segment of services is possible thanks to the use of appropriate IT systems and tools. In most cases, the main system, called the CRM system, is integrated with smaller subsystems and auxiliary systems. They are designed to fulfill additional, most often complementary, functions that are not offered by the CRM system and the need for them is business justified. The most important requirements that must be met by the company CRM system or the company CRM system with support tools are the performance of the following functions: operational function, analytical function, contact (also called interactive) function - Figure 1.

Figure 1. Architecture of the company CRM system



Source: own study

There are often doubts in the company about the validity of keeping so many CRM systems instead of one that would replace the others. By analyzing the structure of the system, it is easy to come to the conclusion that one system will not be able to function for different profiles and areas of the company's operations. Each of them is individually personalized for the specific profile of needs.

A very important aspect in the company's functioning is to shape the relationship with customers through communication channels (sales of services). Currently, in addition to traditional communication channels, which include e-mail and infoline, it is also possible to contact the company through self-service on a website, mobile applications, chat, Facebook. The most popular form of contact with the company - infoline - is increasingly being replaced by other communication channels. Customers currently prefer self-service channels, including an individual account on the company's website. Thanks to such a tool, they have full access to information about services they are using. Such a solution is being increasingly chosen by customers because it is them who can decide when is the right time and place for this kind of interaction. The next evolutionary step is the introduction of a customer account in the form of a mobile application, the operation of which is even simpler and faster (all that is required is an Internet-enabled phone). An additional convenience for the customer who is interested in simple and fast communication with customer service staff is a chat (a type of communicator). Thanks to this solution, customers are able to get in direct contact with a customer service staff member who will solve their problems. An equally innovative contact channel, which is increasingly being chosen by customers, is contact via social media, including Facebook. Currently, the presence of social media in each person's life is growing, so it is important for companies to use this opportunity as one of many forms of communication with the customer. Regardless of a communication channel used for the sales of services, it is important that communication takes place in both ways and does not rely on uploading posts by only one side.

4. EVALUATION OF THE FUNCTIONALITY OF SELECTED CRM SYSTEMS

4.1. Research methodology

Obtaining information on individual systems and their functionalities was possible thanks to using a survey questionnaire. The questionnaire was made available to the employees of the analysed company in electronic form through an internal questionnaire system. The study was conducted among all employees who perform operations on four key CRM systems: landline services, mobile services, sales of electricity and sales of gas. The survey was anonymous.

The questionnaire contained four single-choice questions and one descriptive question. The first question concerned the respondent’s work area (a module in the CRM system), the second one related to the length of time the respondent has served for the company. In the third question, the respondent marked the most important functionality in the CRM system module in which he/she works (in accordance with the answer to the first question) in order to answer, on this basis, the fourth question, i.e. to evaluate the selected functionality with respect to four CRM systems (scale from 1 to 5, 1 - the lowest rating, 5 - the highest rating). When selecting the lowest ratings (1 or 2), the respondents had the opportunity to justify their choice in the fifth question. The survey was conducted between 12 and 30 November 2018. 243 questionnaires were filled in.

The aim of the authors' research was, on the one hand, to diagnose the prevalence of omnichannel sales in modern CRM systems (tool used - systematic literature search), and on the other hand, to forecast the possibility for omnichannel sales in the CRM system based on the case study analysis (tool used - pilot survey of its functionality). From the operator's perspective, the omnichannel strategy is related to work in a given CRM system, and within it the operation of given modules of this system - the authors of the article are aware of having adopted the simplification of the type of sales channels.

The subsequent analysis of the results was carried out in a cross-section of individual CRM system modules - it has a simultaneous double-track character: horizontal - a given functionality versus a given CRM system, vertical - a given CRM system versus a given functionality. As part of the analysis of the results, attention was focused on both searching for similarities and differences in assessments (upward or downward deviations of the assessments). The holistic synthesis of research results is included in the summary of the research part. The survey allowed to analyse four selected CRM systems - drawing conclusions about their operation (functional assessment).

4.2. Profile of the respondents

Table 5 shows modules in which the survey participants work. The majority of the respondents are people performing their daily duties in the customer module (24%) and the service module (22%) - 58 and 54 people respectively.

Table 5. Structure of respondents according to the area of work in the company

Module in which the respondent works	No. of people (quantity)	No. of people (percentage)
sales module	46	19 %
customer module	58	24%
operational module	54	22%
invoicing module	47	19 %
analytical module	38	16%
TOTAL	243	100%

Source: own study

The next place is taken by the invoicing module and the sales module, which are used by 19% of the total number of employees, i.e. 47 and 46 people respectively. The smallest number of respondents work in the analytical module - 16% of the total, i.e. 38 people. The number of operators in individual modules is correlated with the number and labour intensity of the tasks being performed.

Table 6 presents the structure of respondents due to the length of work in a selected area of the company. The largest part of the surveyed people, i.e. 47%, are employees whose experience in the declared area of the company is more than 6 years (115 people). Another large part of respondents (35%) are employees whose length of work in the company is between 5-6 years (85 people).

Table 6. Structure of respondents according to the length of work in a given area of the company

How long you have worked in a given area in the selected company	No. of people (quantity)	No. of people (percentage)
1-2 years	21	9%
3-4 years	22	9%
5-6 years	85	35%
more than 6 years	115	47%
TOTAL	243	100%

Source: own study

The lowest percentage (9%) is made up by a group of people working in a given area in the range from 3 to 4 and from 1 to 2 years - 22 and 21 people respectively. Shorter work experience in a given module, apart from natural staff fluctuations, is also a manifestation of changes in organizational structures that result from implemented changes in company CRM systems (tendencies to automate processes). The fact that the majority of people (82%) have long, corporate work experience, raises the validity of the research results.

4.3. Functional evaluation of individual CRM system modules

Sales module

For the survey participants, the most important functionality in the sales module was the introduction of annexes/modifications of contracts. 27 people responded in this way, i.e. 59% of the surveyed employees of this module (Table 7). Another important activity that they perform in the sales module was entering orders. 32% of the respondents, i.e. 15 people, provided such an answer. Monitoring orders was important for only 9% of the respondents working in a given area, i.e. 9 people. Generation of sales documents and integration with the logistics department were irrelevant to the respondents.

Table 7. Ranking of functionality in the sales module

Sales module	No. of people (quantity)	No. of people (percentage)
entering orders	15	32%
monitoring orders	4	9 %
generating sales documents	0	0 %
integration with the logistics department	0	0 %
introduction of annexes/modifications of contracts	27	59%
TOTAL	46	100%

Source: own study

Additional information obtained from people working in this area allowed to draw conclusions that, due to the implementation of an automated process, generating documents is not important for the respondents because these activities are carried out automatically without the need for humans to interfere in it. The same applies to integration with the logistics department. Previously, it was necessary to prepare a file in a suitable format that was forwarded to the logistics department. Today, it is done automatically by the robot.

In the case of entering orders, according to the respondents working in the sales module, this functionality was rated the highest in the CRM system of electricity sales - the rating on a scale from 1 to 5 is 4.8. CRM for landline services received a rating of 2.4, which is the lowest result. In the case of monitoring orders, the highest result of 4.8 was received by CRM for mobile services. The lowest rating for this functionality, i.e. 2.1, was obtained by CRM for gas sales. Generation of sales documents and integration with the logistics department were not assessed (appreciated by respondents) for any of CRM systems. The functionality of introducing annexes/modifications of contracts was assessed the highest in the case of a mobile services system - 4.7. The lowest rating of 3.2 was received by a gas sales system. Details of the horizontal assessment are presented in Table 8.

Table 8. Functional assessment in the sales module

System / Functionality	CRM for landline services	CRM for mobile services	CRM for electricity sales	CRM for gas sales
entering orders	2.4	4.1	4.8	3.7
monitoring orders	4.5	4.8	3.4	2.1
generating sales documents	-	-	-	-
integration with logistics department	-	-	-	-
entering annexes/modifications of contracts	3.6	4.7	4.5	3.2
AVERAGE	3.5	4.5	4.2	3.0

Source: own study

Continuing the analysis of assessments vertically (Table 8) and taking into account the entire system of landline services, the respondents indicated monitoring orders as the highest-rated functionality - 4.5 points. The lowest result was obtained by entering orders - 2.4. Monitoring orders was the highest-rated functionality in the CRM system for mobile services, while the lowest was entering orders. The respondents awarded them 4.8 and 4.1 points respectively. The reverse occurs in the case of the CRM system for electricity sales. Here, the highest-rated functionality turned out to be entering orders with a rating of 4.8, while the lowest was monitoring orders - 3.4. The same situation occurs in the case of CRM for gas sales. However, the highest-rated functionality, i.e. entering orders, scored 3.7, while the lowest – monitoring orders - 2.1. Taking into account the average rating of all functionalities for specific CRM systems, the highest rating was received by the system for operating mobile services - average 4.5. The lowest rating, however, was given to the gas sales system - average 3.0. For both systems, the sales module functions as a separate system. The respondents expressing a low rating of the system in the gas category quoted a non-intuitive interface as the main reason.

Customer module

In the case of the client module, the most important functionality for the respondents was data modification. 26 people answered in this way, i.e. 45% of the total number of those responding to this question (Table 9). The creation of a customer account was indicated by 20 people, i.e. 34%, while the inputting data by only 12, which is 21% of all responses, and is synonymous with the fact that the respondents considered it the least important activity.

Table 9. Ranking of functionality in the client module

Customer module	No. of people (quantity)	No. of people (percentage)
creating a customer account	20	34%
inputting customer data	12	21%
modification of customer data	26	45%
TOTAL	58	100%

Source: own study

In the opinion of respondents working in the client module whose assessments were presented in Table 7, the functionality of account creation was the highest-rated in the CRM system for gas sales. It obtained the highest mark on a five-point scale. The lowest result of 4.4 was obtained by the landline services system. Another functionality, i.e. inputting customer data, obtained the highest rating, i.e. 4.8 points, simultaneously in three systems: landline services, electricity sales and gas sales. The lowest rating, not much smaller though, of 4.7 was received by CRM for mobile services. The functionality of customer data modification had the highest rating in the case of two systems: electricity sales and gas sales - 4.4 points. The lowest rating of 4.1 was received by a system for landline services. Details of the horizontal assessment are presented in Table 10.

Table 10. Functional assessment in the client module

System / Functionality	CRM for landline services	CRM for mobile services	CRM for electricity sales	CRM for gas sales
creating a customer account	4.4	4.6	4.8	5.0
inputting customer data	4.8	4.7	4.8	4.8
modification of customer data	4.1	4.3	4.4	4.4
AVERAGE	4.4	4.5	4.7	4.7

Source: own study

Continuing the analysis of ratings vertically (Table 10) and taking into account all functionalities in CRM for landline services, the highest-rated was inputting customer data (4.8), the lowest was data modification (4.1). The same functionality obtained the lowest rating in the mobile services system (4.3), while the highest was inputting data (4.7). In the case of CRM for electricity sales, two functionalities were assessed the highest: creating a customer account and inputting data. They obtained 4.8 points each. The lowest rating (4.4) was given to the modification of customer data. The respondents assessing all functionalities in the CRM system for gas sales awarded the highest and at the same time the maximum rating to the creation of a customer account. The lowest result of 4.4, as in the other systems, was obtained by the modification of customer data. Taking into account the average rating of all functionalities in given systems, the highest rating (4.7) was simultaneously obtained by two of them: gas and electricity sales. The lowest rating of 4.4 was obtained by CRM for landline services. This may be due to the fact that gas and electricity sales is a relatively new segment of services for the selected company and the systems for operating them are created with current needs being taken into account.

Operational module

The most important functionality for the surveyed service module staff were complaints and notifications. 35 people responded in this way, which is 65% of the total number of respondents answering this question (Table 11). Another important functionality is history, which was indicated by 16 people, i.e. 30% of all the respondents. Only 3 respondents chose interaction with customers as the most important in their assessment. This is only 5% of the total number of respondents working in the service module.

Table 11. Ranking of functionality in the service module

Operational module	No. of people (quantity)	No. of people (percentage)
interaction with customers	3	5 %
history	16	30%
complaints and notifications	35	65%
TOTAL	54	100%

Source: own study

In the case of customer interactions, it was rated the highest in the CRM system for gas sales, as it received 4.7 points, and the lowest in electricity sales - 2.1. The respondents were in agreement when assessing the other two functionalities, i.e. history, complaints and notifications. They were rated the highest in the gas sales system where they obtained 4.4 and 4.6 points respectively, while the lowest in the CRM system for mobile services: 2.5 and 2.7. Details of the horizontal assessment are presented in Table 12.

Table 12. Functional assessment in the service module

System / Functionality	CRM for landline services	CRM for mobile services	CRM for electricity sales	CRM for gas sales
interaction with customers	3.7	4.1	2.1	4.7
history	4.2	2.5	3.4	4.4
complaints and notifications	4.1	2.7	3.2	4.6
AVERAGE	4.0	3.1	2.9	4.6

Source: own study

Continuing the analysis of assessments vertically (Table 12), history in the landline system was the highest-rated - 4.2. The lowest result was obtained by interaction with customers - 3.7. In the case of CRM for mobile services, the situation was the opposite to that in the aforementioned system, i.e. the highest rating of 4.1 was obtained by the functionality of interaction with customers, while the lowest by history - 2.5. In the electricity sales system, the surveyed service module employees rated history as the highest at 3.4 points and interaction with customers as the lowest at 2.1. The highest-assessed functionality in the CRM system for gas sales was, according to the respondents, interaction with customers, which obtained 4.7 points. History received 4.4 points, which classifies it in the last position. Comparing the average rating of all functionalities, the CRM system for gas sales looks best, as it has an average of 4.6, the lowest is the electricity sales system - 2.9. The users of the electricity sales system indicated as the reason for low rating the need to fill unnecessary fields of the complaint form and the need to set up many filters to read the history.

Invoicing module

For the survey participants, the most important functionality in the invoicing module was an invoice preview. 24 people answered in this way, which is 51% of the surveyed employees of this module (Table 13). Another important activity for many of them was generating invoices, which was indicated by 14 people and making corrections, which was important in the assessment of 9 respondents. This is 30% and 19% respectively of the total number of respondents of the invoicing module. Creating the invoice shipping process was irrelevant to the survey participants as it did not gain any points.

Table 13. Ranking of functionality in the invoicing module

Invoicing module	No. of people (quantity)	No. of people (percentage)
generating invoices	14	30%
making corrections	9	19 %
invoice preview	24	51%
creating the invoice shipping process	0	0 %
TOTAL	47	100%

Source: own study

The invoice generating functionality gained the highest number of points, as many as 4.8, in the electricity sales system, while the lowest number, 3.2, in the gas sales system. Making corrections and invoice previews were the highest rated for one system - CRM for mobile services, 4.7 and 4.9 respectively. As regards the lowest rated functionality, the respondents were no longer so unanimous. Making corrections was assessed the lowest in the context of gas sales CRM, where it received a rating of 2.4, while the preview of corrections was the lowest-rated functionality in the electricity sales system - 3.4. The creation of the invoice shipping process was not assessed by the survey participants at all. Details of the horizontal assessment are presented in Table 14.

Table 14. Functional evaluation in the invoicing module

System / Functionality	CRM for landline services	CRM for mobile services	CRM for electricity sales	CRM for gas sales
generating invoices	4.3	4.5	4.8	3.2
making corrections	3.1	4.7	4.4	2.4
invoice preview	3.7	4.9	3.4	4.6
creating the invoice shipping process	-	-	-	-
AVERAGE	3.7	4.7	4.2	3.4

Source: own study

Continuing the vertical analysis of the ratings (Table 14), in the CRM system for landline services, generating invoices was rated the highest and obtained 4.3 points. The lowest number of points, 3.1, was obtained by invoicing. In the case of the mobile services system, the highest rated functionality was the invoice preview, which gained 4.9 points. Generating invoices was rated at 4.5 points, which classifies it as the lowest-rated functionality. Employees of the invoice module indicated generating invoices, which received 4.8 points, as the highest-assessed functionality in the CRM system for electricity sales. The lowest result of 3.4 was obtained by the invoice preview. In the case of CRM for gas sales, the invoice preview of 4.6 was rated the highest and the lowest was making corrections - 2.4. The overall average of all functionalities indicated CRM for mobile services as the system with the highest average of 4.7. The lowest was CRM for gas sales - 3.4. High assessment of the functionality of the CRM system for mobile services may result from the major update of the invoicing module which was carried out in July 2018.

Analytical module

Employees of the analytical module answering the third question of the survey indicated creating summaries as the most important functionality out of all available there. Such an answer was provided by 71% of the respondents, i.e. 27 people (Table 15). 11 respondents, i.e. 29%, indicated drawing up reports as a significant functionality in their assessment. Data collection was irrelevant to them because it did not receive any points.

Table 15. Ranking of functionality in the analytical module

Analytical module	No. of people (quantity)	No. of people (percentage)
data collection	0	0 %
creating summaries	27	71%
drawing up reports	11	29 %
TOTAL	38	100%

Source: own study

The functionality of collecting data in the analytical module was not assessed at all by the surveyed employees. Creating summaries obtained the highest number of points in the case of CRM for electricity sales - 4.6. The lowest rating was in the context of landline services, as it gained 3.5 points. A similar situation was when assessing the functionality of drawing up reports. The highest rating was in the case of electricity sales - 4.1, and the lowest in CRM for mobile services - 3.7. Details of the horizontal assessment are presented in Table 16.

Table 16. Functional assessment in the invoicing module

System / Functionality	CRM for landline services	CRM for mobile services	CRM for electricity sales	CRM for gas sales
data collection	-	-	-	-
creating summaries	3.5	4.2	4.6	4.4
drawing up reports	3.7	3.9	4.1	4.0
AVERAGE	3.6	4.1	4.4	4.2

Source: own study

Continuing the vertical analysis (Table 16), in the CRM system for landline services, the highest-assessed functionality was drawing up reports - 3.7, the lowest was creating summaries - 3.5. In the case of other systems, namely CRM for mobile services, electricity and gas sales, the respondents unanimously indicated creating summaries as the highest-rated functionality in each of these systems. It was 4.2, 4.6 and 4.4 respectively. The lowest was drawing up reports, which obtained 3.9, 4.1 and 4.0 respectively in individual systems. Taking into account the average rating of all functionalities for a given system, the highest rating was obtained by CRM for electricity sales - 4.4, and the lowest by CRM for landline services - 3.6. It can be assumed that the lowest result is related to several years of functioning of the CRM system for landline services, which despite new emerging needs has not been updated.

4.4. Holistic synthesis of the test results

Table 17 presents a summary of the ratings of individual functionalities in individual modules of four company CRM systems.

Table 17. Summary of the ratings of individual functionalities in individual modules of four company CRM systems

Sales module	**CRM for landline services**	**CRM for mobile services**	**CRM for electricity sales**	**CRM for gas sales**	**Functionality average**
entering orders	2.4	4.1	4.8	3.7	**3.8**
monitoring orders	4.5	4.8	3.4	2.1	**3.7**

introduction of annexes/modifications of contracts	3.6	4.7	4.5	3.2	**4.0**
AVERAGE	**3.5**	**4.5**	**4.2**	**3.0**	
Customer module	**CRM for landline services**	**CRM for mobile services**	**CRM for electricity sales**	**CRM for gas sales**	**Functionality average**
creating a customer account	4.4	4.6	4.8	5.0	**4.7**
inputting customer data	4.8	4.7	4.8	4.8	**4.8**
modification of customer data	4.1	4.3	4.4	4.4	**4.3**
AVERAGE	**4.4**	**4.5**	**4.7**	**4.7**	
Operational module	**CRM for landline services**	**CRM for mobile services**	**CRM for electricity sales**	**CRM for gas sales**	**Functionality average**
interaction with customers	3.7	4.1	2.1	4.7	**3.7**
history	4.2	2.5	3.4	4.4	**3.6**
complaints and notifications	4.1	2.7	3.2	4.6	**3.7**
AVERAGE	**4.0**	**3.1**	**2.9**	**4.6**	
Invoicing module	**CRM for landline services**	**CRM for mobile services**	**CRM for electricity sales**	**CRM for gas sales**	**Functionality average**
generating invoices	4.3	4.5	4.8	3.2	**4.2**
making corrections	3.1	4.7	4.4	2.4	**3.7**
invoice preview	3.7	4.9	3.4	4.6	**4.2**
AVERAGE	**3.7**	**4.7**	**4.2**	**3.4**	
Analytical module	**CRM for landline services**	**CRM for mobile services**	**CRM for electricity sales**	**CRM for gas sales**	**Functionality average**
creating summaries	3.5	4.2	4.6	4.4	**4.2**
drawing up reports	3.7	3.9	4.1	4.0	**3.9**
AVERAGE	**3.6**	**4.1**	**4.4**	**4.2**	
SYSTEM AVERAGE	**3.8**	**4.2**	**4.1**	**4.0**	

Source: own study

Analyzing the ratings in terms of the average of the CRM system (Table 17), the total results are similar and they are in the range of 3.8-4.2. The difference between the lowest overall rating of the CRM system and the highest is 0.4 points. Such a result indicates that the tested CRM systems are similar to each other. This is, however, a tentative conclusion, because after an in-depth analysis of individual functionalities it can be concluded that the described CRM systems differ from each other. Therefore, the average should not be taken as a reliable result.

In Table 17, the extreme values of functionalities in individual modules are marked with colours: green - the highest, red - the lowest. Thanks to such an operation, it can be observed that functionalities in the CRM systems for electricity and gas sales were more often rated the highest in relation to other systems. In the case of the lowest-rated functionalities, the CRM system for landline services is in the first place.

In each of the tested CRM systems, there is a module that is assessed higher and one whose assessment is lower. It can therefore be stated that each system has its strengths and weaknesses. None of the tested systems fully meets the expectations of its users (operators).

5. CONCLUSION

The question of customer service has been and will continue to be a topical issue in the area of logistics. In the era of the 4th industrial revolution - ubiquitous digitization - providing the level of service expected by customers puts new challenges ahead of logistics systems. Today, the customer operates in many vendor sales channels at the same time. For the customer, such possibilities mean the luxury of choice, and for the suppliers' logistics systems they are the necessity for significant modifications to their business strategies.

The outcomes of the goal achieved in the article are assessment of the scale of omnichanneling in CRM systems (results of secondary research), current state of the scientific literature on the subject and assessment of CRM system functionality in the context of omnichanneling requirements from the perspective of the use (operator) of such a system serving its clients (primary research results) and a pilot case study survey.

The authors consider the following to be valuable elements of the article: an interesting research subject - a gap in the state of scientific knowledge on the subject, an interesting research object - one organization operating in many different business lines and offering many different CRM systems, many different functionalities within each CRM system and the size of the sample - 243 respondents. The research subject undertaken by the authors, in the light of the state of the world scientific knowledge (Scopus database), has the hallmarks of originality and innovation.

Only scientific articles from Scopus database were considered for literature research (research limitations), because in Scopus it is the same and even more than in Web of Science database. The results of the practical part are adequate for companies that have many CRM systems (not one) – useful for people designing and operating CRM systems (managerial implications). The authors plan to continue the current course of research – operators of CRM system modules serving clients, and also to start research similar to the current study but from the customer's perspective – a person served in the CRM system – a look from the second perspective (future). How time-consuming, technologically and organizationally complicated and expensive is transformation of the current customer relationship management systems (CRM) to the omnichannel customer relationship management systems (OCRM)? – Difficult to say. One thing is certain – this is a forward-looking direction of change.

To summarize, the subject of service level and customer relationship management is the essence of logistics. It is a timeless dilemma which is still very important for management and quality sciences.

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RETURNS IN E-COMMERCE AS A VALUE FOR CUSTOMERS FROM DIFFERENT PERSPECTIVES

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Abstract

E-commerce is one of the most dynamic and important sectors of the economy as well as one of the main factors leading to greater competitiveness. The dynamic development of e-commerce is driven by rapidly expanding Internet access, but also by growing mobility and popularity of portable devices, via which customers order goods and services at a convenient time and place more and more frequently. They do not only order things, but, more and more often, everyday products to which they want to have very fast access. If products do not meet their expectations, they want to return them. Returns in e-commerce should be seamless and leave a good experience. Thanks to that, they could add some new value for customers. If online sellers take returns seriously, they can gain a competitive advantage in the form of greater customer satisfaction and loyalty. The subject of value for customers in e-commerce is a relatively new research area (Francis et al., 2014). Most of the studies conducted so far have focused on customer-seller relations, excluding the role and participation of other entities involved in the process of value creation for the customer (Bakker et al., 2008). The first aim of the article is to present the results of research on value for customers in e-commerce returns from the different perspectives of: customers, online sellers, suppliers and complementors. The second objective is to determine the impact of returns on customer satisfaction and loyalty and, consequently, on consumer spending and business performance. The research evaluated the significance of factors evoked by different entities that create value for the customer, using empirical research, on a sample of 800 respondents.

Key words: e-commerce, returns, value for customer, satisfaction, loyalty

1. INTRODUCTION

Supply chains, i.e. the flow of goods from a supplier to a customer, are given a lot of attention. They most often concern one-way flows, e.g. from a manufacturer to the final customer, through various intermediaries. In the case of return logistics, the opposite direction of product movement occurs. The problem is that such products do not return through the exact same entities that they have already passed through. In other words, redistribution channels rarely coincide with distribution channels. It is also problematic to plan and forecast such returns in the supply chain (Mollenkopf et al., 2007; Srivastava & Srivastava, 2006).

Return logistics in traditional trade is an area which, contrary to appearances, is quite broad. It does not only include sustainable waste management, but also management of returns of goods resulting from damage, wear and tear, defects or surpluses. Some of these returned goods are disposed of and some are repaired or reused. Each of these processes is complex and requires a lot of experience.

In e-commerce, there is another type of return that is not always found in traditional trade. This is the so-called consumer return (XiaoYan et al., 2012). In the case of online purchases, the customer has the right to withdraw from the contract without giving any reason, and return the product ordered. This type of return in e-commerce is the most common one, and has been the focus of this study.

There are two goals of this paper. The first one is to present the perception of returns from the perspective of the customer, seller, product supplier and service provider supporting e-commerce (complementors). Another objective is to determine the impact of returns on customer satisfaction and loyalty and, consequently, on consumer spending and business performance.

For the purpose of this article, research was conducted using the methods of direct observation and secondary source analysis. Additionally, results of empirical research carried out separately in the group of customers, sellers, suppliers of goods and service providers supporting e-commerce in Poland were applied.

2. RETURNS IN E-COMMERCE

The right to return in e-commerce in Poland results from the Act on Consumer Rights. A person who has concluded a distance or off-premises contract may withdraw from it within 14 days without giving any reason. It is noteworthy that not all customers are entitled to return goods without giving reasons. Only consumers have such a right. In the case of a purchase of goods by a company, the online retailer does not have to accept such a return. Some companies, however, meet such needs and offer the possibility of returns to companies. Thanks to this, they stand out on the market and build their competitive advantage.

Increasingly, especially in the clothing and footwear industry, retailers are extending this statutory return period to 30 or even 100 days. An example of the former is the Eobuwie shop and the latter may be represented by the Zalando shop. At the same time, they offer free returns. Research shows that the longer return terms make customers feel safer and freer. However, this does not mean that customers take advantage of this privilege. 84% of shoppers do not use the extended return period (Klich, 2017).

Internet shopping, as opposed to shopping in stationary stores, is connected with convenience, but also with the impossibility to check goods before buying them. Customers cannot check them organoleptically, so returns at online shops are more frequent than in stationary shops. A study by the Chamber of Electronic Commerce (2016) shows that 40% of the returns are due to a different size of the product than the customer expected. It is therefore important to have a precise description of the sizes including the length, width and height of individual items, or exact parameters of equipment, e.g. electronics. It is also advisable to present accurate photos without unnecessary retouch, and three-dimensional visualizations. Thanks to this, the customer gets more information and can check if the product fits him, and the seller can thus reduce the number of returns (Powers & Jack, 2015).

Returns are not pleasant for customers. They take extra time, and customers often have to pay for them. Besides, the situation can be stressful for some people - especially for those who do it for the first time. They do not always know where or how to report a return, how to prepare and pack the shipment, how to order a courier or where to bring the shipment. They are not sure if the return will be free, if and when they will receive the money. So the return should be made easier for the customer. Most often, the customer will make a return because of the goods, not because of the salesperson himself/herself. If the customer has decided to return the goods, she/he will do so regardless of the conditions. If the process is cumbersome, it can cause additional frustration. A very simple return procedure can leave the customer with a positive experience that will make them want to return to the same seller. Therefore, it is important to have an interactive return form and easy email or phone contact with customers. Unfortunately, a large number of sellers still have very unfriendly return forms in the PDF format, which are very cumbersome to fill in.

In return logistics of e-commerce, delivery is the biggest problem and the most expensive process at the same time. In the case of low-value products, some customers do not exercise their right to withdraw, especially when they have to pay for the shipment. If shops always covered all costs, customers would probably order more goods eagerly. Returns are often only seen as additional costs by shops. This is understandable because apart from the costs of delivery to the customer, additional activities have to be taken into account – detailed quality control of the goods, reimbursement, preparation of sales documents and other processes similar to those that are carried out during the receipt of goods from a supplier (Bernon et al., 2016).

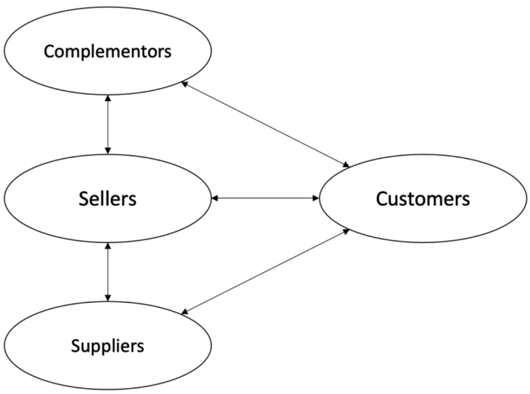
3. E-COMMERCE ENTITIES INVOLVED IN RETURNS

Sellers are directly responsible for returns in e-commerce, because customers buy goods from them. Almost any person who has access to the Internet and financial resources can be a customer. On the other hand, sellers are mostly companies that have their own online stores or cooperate with other intermediaries such as: marketplaces, auction or group sales platforms. However, there are other types of entities that have a direct or indirect impact on how a return proceeds. These are both suppliers of goods sold through the Internet and providers of services supporting (complementary to) e-commerce. The former have a significant impact on returns, because in addition to supplying the goods themselves, they prepare detailed product descriptions, photos and instructional videos. They also design the packaging that must be durable during transport and handling. Providers of services supporting e-commerce (complementors) are a special group. These are companies that provide value (usually by means of additional services) to the customer, which sellers or suppliers of goods are not able to create. The key ones include: logistics service providers and courier companies (Bask, Lipponen & Tinnilä 2012), marketplaces, financial service providers (e.g. of electronic payments), marketing service providers (e.g. website positioning and search engine optimisation companies).

The following considerations cover all these types of entities. This is a completely new approach. Until now, in empirical studies of e-commerce (including returns), only one type of entities has been analysed - most often sellers or customers. Usually, authors do not take these two stakeholder groups into account at the same time. Entities that are not always directly involved in the sale of products, i.e. the aforementioned suppliers of goods and supporting services, are not taken into account, either. In such an approach, the issue of returns cannot be captured from several perspectives.

This study was designed to change this approach and include a survey of e-commerce returns – simultaneously from the perspective of the customer, the seller, the supplier of goods and the complementors (supplier of the supporting services) (Nalebuff & Brandenburger 1996). The research assumed that the respondent was to look at returns through the final customer's "eyes", regardless of their role in e-commerce. The questions addressed to each of these groups were therefore about how customers perceived the issue of returns (see Figure 1). The main reason of this was that the central point of the e-commerce system is the customer who ultimately evaluates the value and converts it into a monetary equivalent for the other network members (Kawa & Światowiec-Szczepańska, 2018).

Figure 1. E-commerce entities involved in returns



Source: own elaboration

4. RESEARCH METHODOLOGY

CATI (computer-assisted telephone interview) was selected as a technique of information collection, which had been preceded by FGIs (focus group interviews). The research with the use of qualitative methods was aimed at a preliminary analysis of the problems of returns and providing information necessary for the proper organization of the research by the quantitative method, including, most importantly, the design of a measuring instrument (Kawa & Światowiec-Szczepańska, 2019).

A structured questionnaire was used for the survey. In addition to questions about the availability of products, delivery time and form, information about the status of the order, questions were asked about returns, which are one of the key elements of the logistics value in e-commerce. In particular, they covered the following aspects possibly offered by the online retailers: free return of goods, a simple return procedure, returnable packaging, the possibility to return used goods and to return goods after the statutory 14-day limit.

Apart from the issues related to returns, the respondents were asked about customer satisfaction with the purchases made and their loyalty to the online sellers. Additionally, all the companies had to compare their performance (financial and non-financial) with that of their direct competitors. These replies can be used to investigate the impact of returns on customer satisfaction and loyalty and the performance of the sellers, product suppliers and complementors. The customers, in turn, were asked about their spending on purchases via the Internet.

The database of companies operating in e-commerce, suppliers and customers in Poland was used as the sample. It included, inter alia, data from the Regon database kept by the Central Statistical Office in Poland and Polish commercial databases, such as DBMS, Bisnode. Approximately 10 thousand respondents took part. In all four general populations, non-random purposeful sampling was applied. The sample was selected from those entities that had relevant experience in selling (e-tailers) or purchasing (customers) products via the Internet, cooperating with online sellers (suppliers and complementors).

The research was conducted between November 2017 and May 2018 by an external entity – a research and expert agency with extensive experience in empirical research. In total, 800 correctly completed questionnaires were received (200 records in each group – customers, sellers, suppliers, and complementors) (Kawa & Światowiec-Szczepańska, 2019).

5. PERCEPTION OF RETURNS IN E-COMMERCE FROM DIFFERENT PERSPECTIVES

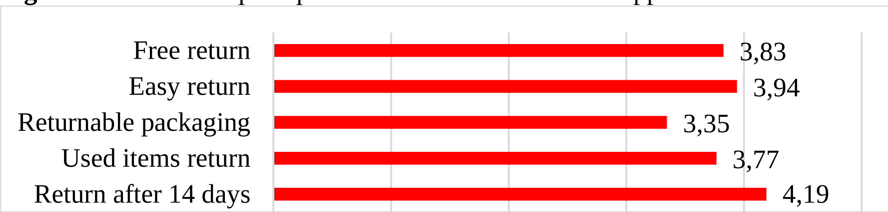
The subsequent parts of this section present the results of the surveys for the individual groups of the respondents, i.e. customers, online sellers, suppliers and complementors. These different perspectives are presented to show the common elements and differences in the perception of returns, in particular in the customer's expectations and the seller's, product supplier's and complementor's opinion about them.

5.1. Customer's perspective

The customers' perspective is most important, because they buy the goods and then they return part of them. The respondents were asked to evaluate each of the listed factors (facilities) associated with returns, offered by sellers, i.e. free return, easy return, returnable packaging, return of used items and return after 14 days. For the statements related to these factors, they were supposed to use a five-point Likert scale from 1 to 5, where 1 meant "I strongly disagree" and 5 meant "I strongly agree”. Figure 2 shows the averaged research results in terms of value. Figure 3, in turn, shows the same results, but in percentage terms. Thanks to the second figure, it can be found out what the distribution of the individual answers was. A similar approach was adopted for the other groups of the respondents, i.e. Internet sellers, suppliers of goods and complementors.

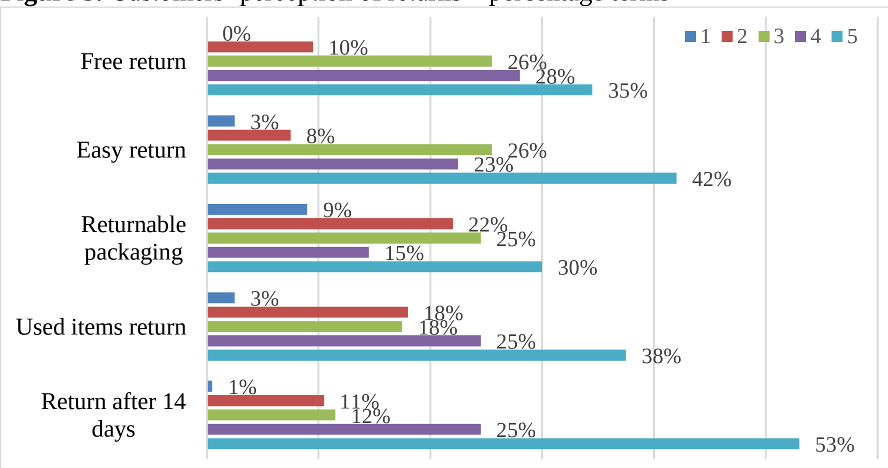
The most important result of the survey in the group of the customers is that, contrary to appearances, free return is not most important for them (average score of 3.83 out of 5.00). The highest rating was given to the possibility of returning goods after the statutory 14 days (4.19). 78% of the customers agreed with the statement that they buy from such sellers who allow to return goods after 14 days. Although the customers return the goods earlier than that, the extended period is essential for them. This may be due to a need to create a 'safety valve' for themselves, which they may use if needed. Other factors such as easy return (3.94) and return of used items (3.77) were identified as quite important by the customers. Returnable packaging was least significant (3.35). For 31% of the customers, it was not important whether online retailers offered returnable packaging or not (Figure 2 and 3).

Figure 2. Customers’ perception of returns – value-based approach



1 = strongly disagree to 5 = strongly agree
Source: own elaboration

Figure 3. Customers’ perception of returns – percentage terms

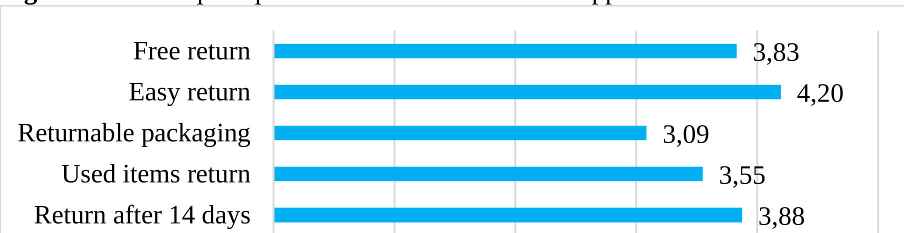


1 = strongly disagree to 5 = strongly agree
Source: own elaboration

5.2. Seller's perspective

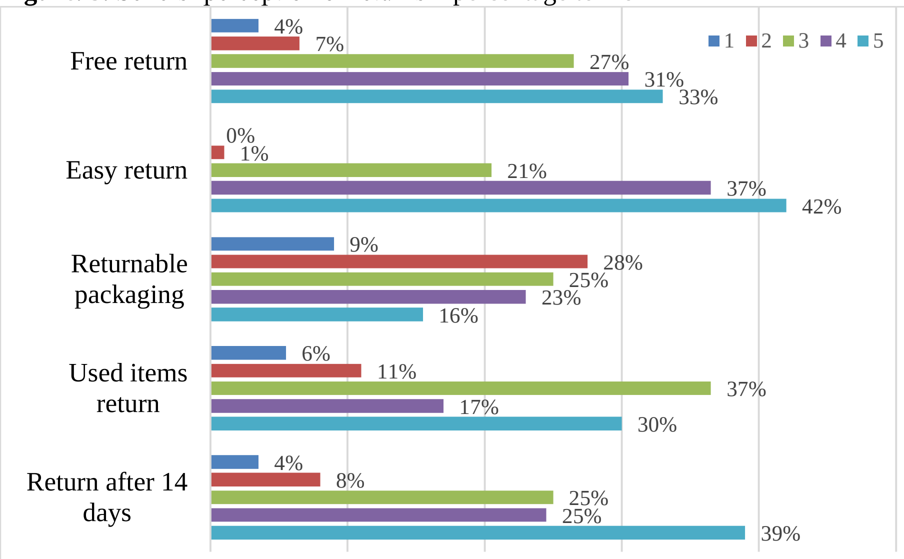
The sellers were asked to assess whether the customers bought from online shops that offered facilities for returning goods. The results of the research show that the sellers think differently from their customers. Most retailers agreed with the statement that online customers buy from such sellers whose return procedure is simple (79%). This factor was rated at 4.20 (Figure 4). Next came the possibility to return goods after the statutory 14 days (3.88) and free return (3.83). The latter was evaluated by the customers in the same way in terms of value. The return of used items (3.55) was indicated as quite important for customers in the sellers' opinion. As in the case of the customers, the retailers considered return packaging to be the least important for customers (3.35). 37% of the sellers denied that their customers bought from sellers who offered returnable packaging (Figure 5).

Figure 4. Sellers' perception of returns – value-based approach



1 = strongly disagree to 5 = strongly agree
Source: own elaboration

Figure. 5. Sellers' perception of returns – percentage terms

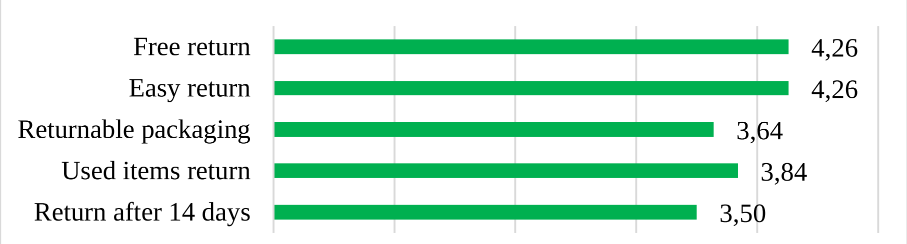


1 = strongly disagree to 5 = strongly agree
Source: own elaboration

5.3. Perspective of goods suppliers

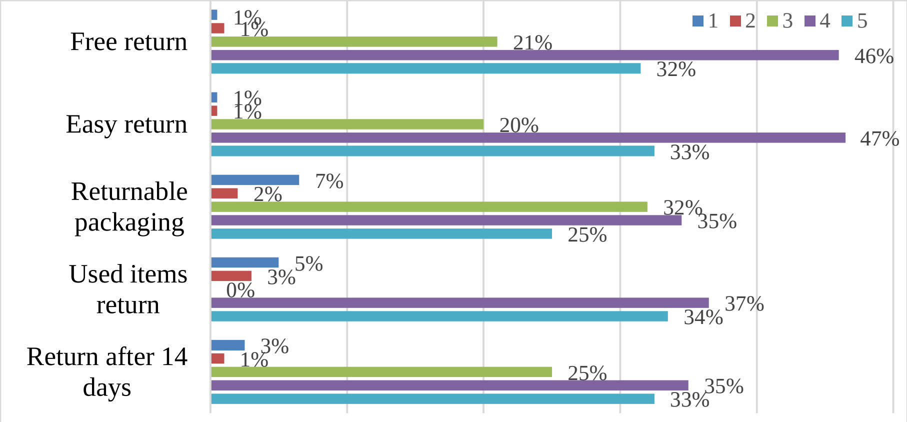
Similar to the sellers, the suppliers of goods assessed whether customers bought from online shops that offered facilities for returning goods. The perspective of the suppliers is a little different from that of the online shoppers. This may be due to the fact that the suppliers of goods are not in direct relations with final customers. However, the results of these surveys are very important for the suppliers, because they allow them to get to know customers' expectations and verify them against their own beliefs. All factors were rated quite high, at least at 3.5. Free return (4.26) and easy return (4.26) were rated very high by the suppliers of goods (Figure 6). 78% of the goods suppliers agreed with the statement that customers bought from online sellers who offered free return of products, and 80% said that a simple return procedure was important for customers (Figure 7). Return of used goods (3.84) and returnable packaging (3.64) were indicated as quite important for customers in the opinion of the suppliers of goods. The possibility to return after more than 14 days was the least important factor (3.56). This is a completely different perception than in the case of the customers for whom it is the most important aspect of returns.

Figure 6. Suppliers' perception of returns – value-based approach



1 = strongly disagree to 5 = strongly agree
Source: own elaboration

Figure 7. Suppliers' perception of returns - percentage terms

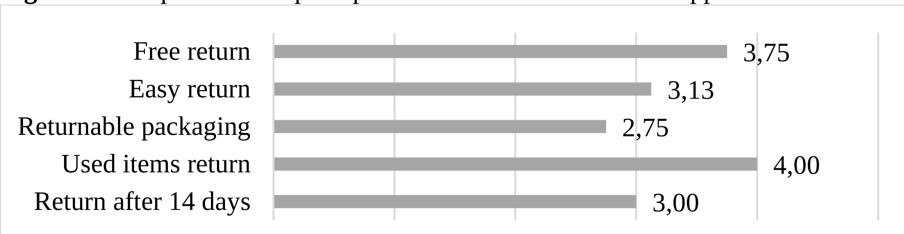


1 = strongly disagree to 5 = strongly agree
Source: own elaboration

5.4. Complementor's perspective

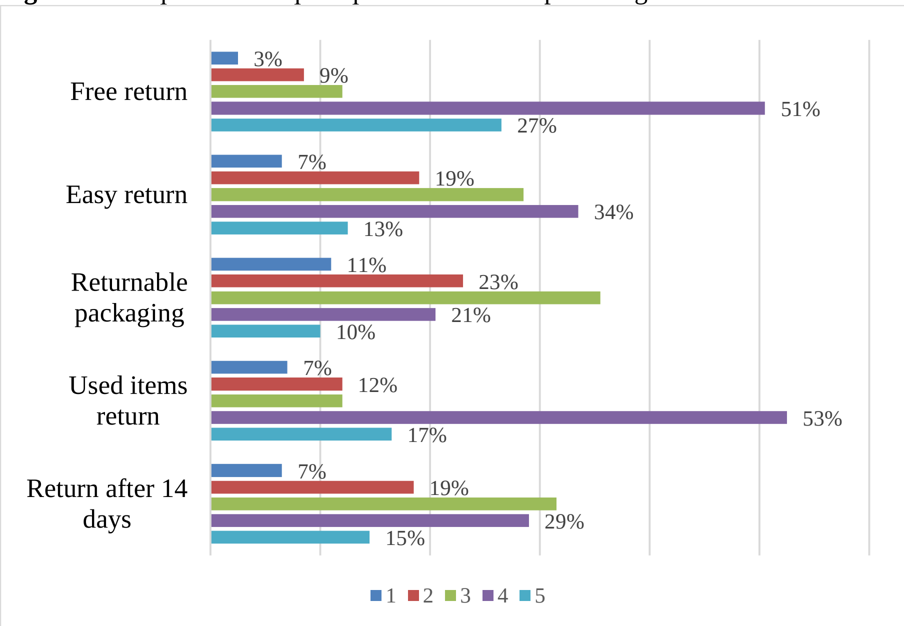
In the case of the complementors, the results of the research are completely different than in the case of the customers of online sellers. Apart from returning used items, all the other factors related to returns were rated below 4.00 (Figure 8). According to the complementors, customers buy from such online retailers who offer return of used products (4.00). 70% of the service providers agreed with the statement that customers bought from online retailers who offered return of used products. Less important are free returns (3.75), easy returns (3.13) and returns after 14 days. According to the service providers, returnable packaging is the least important factor (2.75) (Figure 9).

Figure 8. Complementors' perception of returns – value-based approach



1 = strongly disagree to 5 = strongly agree
Source: own elaboration

Figure 9. Complementors' perception of returns – percentage terms



1 = strongly disagree to 5 = strongly agree
Source: own elaboration

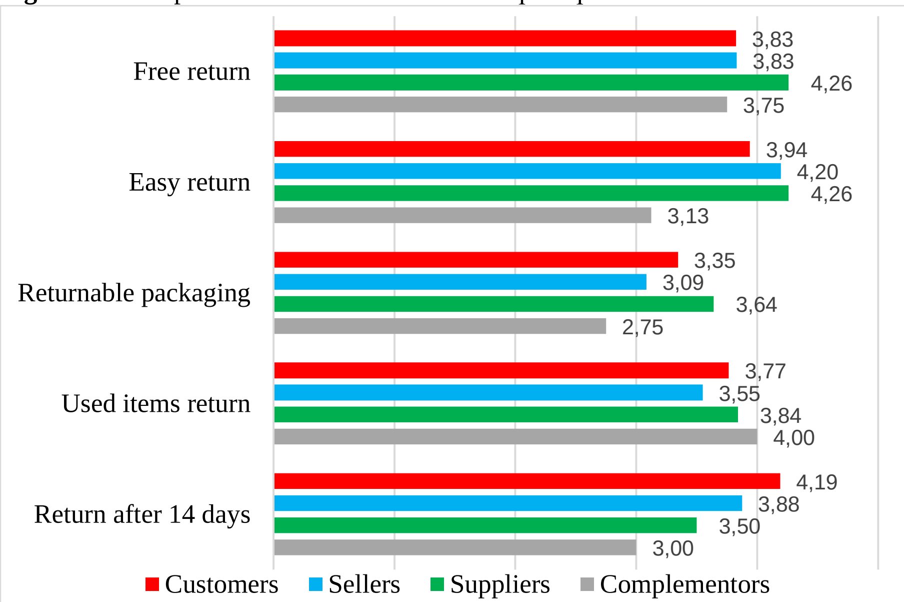
5.5. Comparison of perceptions of returns by individual e-commerce entities

The research has shown some differences in the perception of e-commerce returns by the different groups of actors. The most important thing for the customers was the extended period of return of the purchased goods. It was perceived differently by the sellers, suppliers of goods and complementors. The further away the entity was from the final customer, the lower the rating was. The suppliers considered this to be the least relevant factor for the customers. There were also quite significant differences in the case of returnable packaging. This factor was rated highest by the suppliers of goods and lowest by the complementors. Returnable packaging was generally rated lowest. This may be due to the fact that there are not many solutions of this kind on the market yet, and none of the operators saw such a need for the e-commerce customers (Figure 10).

Free returns were rated very high (at least at 3.75). All entities (except for the suppliers of goods) rated them in a similar way. The same applied to the simple return procedure. Apart from the complementors, it was rated very highly by the remaining respondents.

Relatively smaller differences were observed in the case of returning used items. Interestingly, this service is not yet widely used in Poland. Web sites that provide such services are developing slowly. However, it is very likely that in the future such services will be commonly provided by sellers. If some of their customers now return goods that they have already used, and the vendors return all the costs in order to build their good image in the market, why not make it a paid service? The same concerns cars, bikes and scooters rented for minutes.

Figure 10. Comparison of e-commerce entities' perceptions of returns

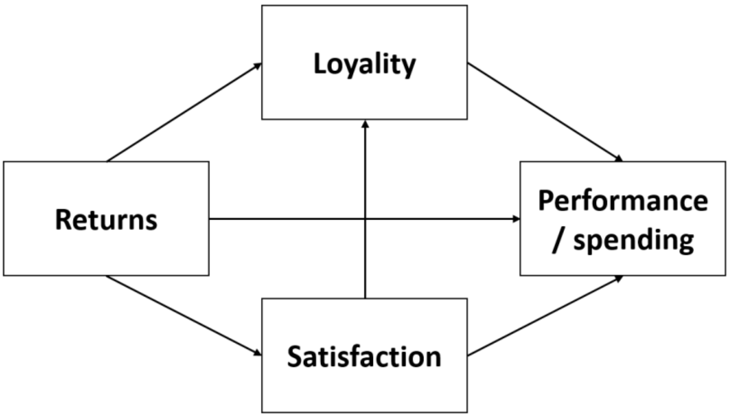


Source: own elaboration

6. RETURNS AND SATISFACTION, LOYALTY AND SPENDING OR PERFORMANCE

E-commerce research often emphasises that delivering the right value to the customer increases his/her satisfaction, which in turn translates into customer loyalty and, further, into repurchasing (Chiou & Pan, 2009; Chiu et al., 2009). However, the impact of this loyalty on the performance of companies and on customer spending, in particular in the context of returns, is rarely mentioned. Using one of the statistical measures, i.e. correlation, the relationships between the variables connected with returns and those related with customer satisfaction and loyalty, customer spending and performance of firms were examined. In other words, it was a question of checking whether greater attention to returns in e-commerce resulted in greater customer satisfaction and loyalty, and, in turn, in influence on customer spending and company performance. In addition, it was examined what direct impact returns have on spending and performance (Figure 12).

Figure 12. Model for testing relationship between returns and satisfaction, loyalty and spending or performance



Source: own elaboration

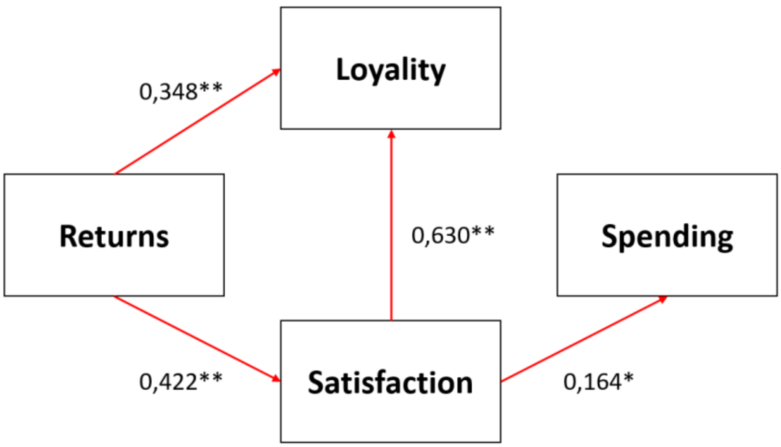
Satisfaction was measured by the customer's happiness with their purchases, their feeling that the seller understood their needs and that they would recommend purchasing from the same seller to their family or friends. Loyalty, in turn, referred to buying again from the same seller in the near future, even if the conditions changed, i.e. the products, their delivery and payments offered by other vendors would be more competitive (Cyr, 2008). In the case of performance, the respondents were asked to compare their parameters with those of their direct competitors in the last financial year, in terms of revenue, profit, ROI and market share. On the other hand, expenditure related to average customer spending on e-commerce within a month. The quality of the results was verified using validity and reliability measures (all Cronbach's alpha coefficients of the constructs were higher than 0.75).

The Pearson correlation coefficient was used to study the relationship between the variables. In addition to the strength of the relationship, it was very important to determine whether the correlation was statistically significant. In this way, it was possible to confirm that the correlations were not accidental and allowed to generalise the results of the conducted tests with a sufficiently high degree of probability. In Figures 13-16, the statistically significant correlations are represented by red arrows and the strength of the relationships is represented by the values.

6.1. Customer's perspective

In the group of the customers, there is a strong link between returns and shopping satisfaction. The latter, in turn, affects spending and, to quite a large extent, loyalty. Confirmation of these correlations means that the more attention a customer pays to returns, the more satisfaction they get from shopping and the more loyal they are, and thus the more they spend on shopping (Figure 13). This means that all e-commerce stakeholders should pay special attention to the issue of returns, because creating value from them for the customer will bring them benefits.

Figure 13. Customer perspective: confirmed correlations

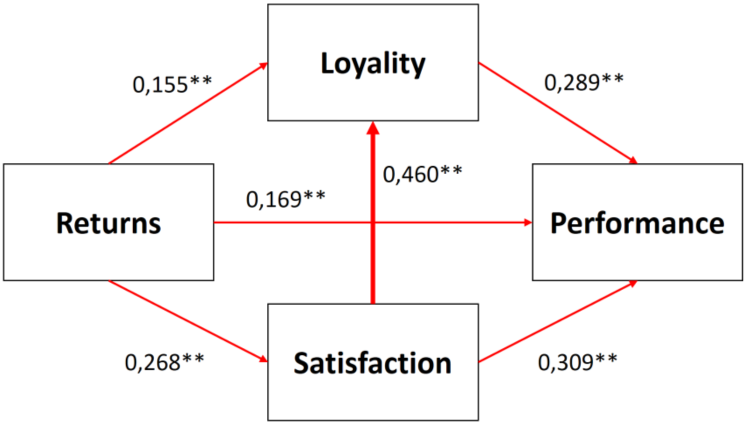


Source: own elaboration
*p<.05, **p < .01

6.2. Seller's perspective

In the case of the sellers, all correlations were confirmed. There is a medium relationship between returns and shopping satisfaction, as well as between satisfaction and loyalty. Interestingly, all the variables (returns, satisfaction and loyalty) have a positive impact on performance. This means that, according to the sellers, customers for whom returns are important are more satisfied and, as a result, more loyal. The sellers who believe that customers attach more importance to returns may expect better results than their competitors (Figure 14).

Figure 14. Sellers' perspective: confirmed correlations

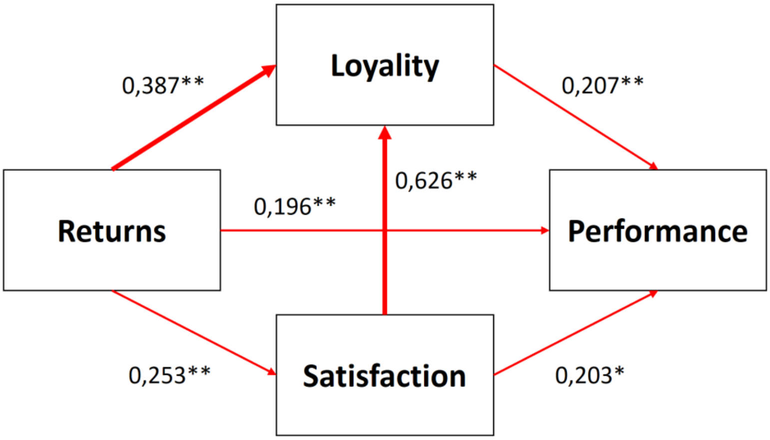


Source: own elaboration
*p<.05, **p < .01

6.3. Perspective of suppliers of goods

With regard to the suppliers' perspective, all relationships between the variables were confirmed. Unlike in the case of the customers and sellers, there was a strong link between returns and loyalty. Also, all variables (returns, satisfaction and loyalty) had a positive impact on performance. This meant that, according to the suppliers of goods, customers who paid more attention to returns were more loyal. The suppliers of goods who take returns seriously can expect better performance than their competitors (Figure 15).

Figure 15. Perspective of goods suppliers: confirmed correlations

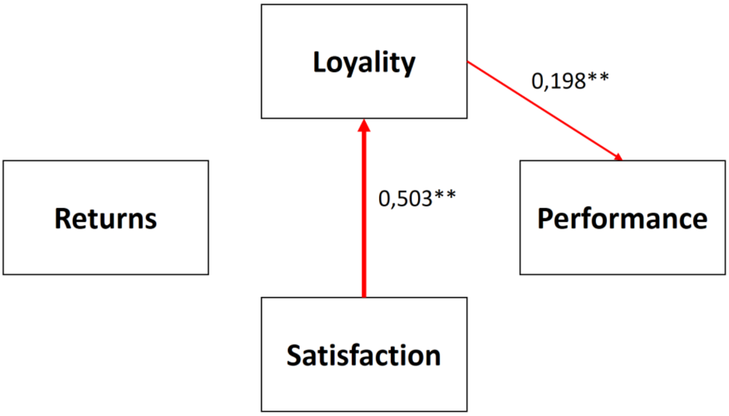


Source: own elaboration
*p<.05, **p < .01

6.4. Complementors' perspective

In the case of the complementors, in turn, there was no confirmed relationship between returns and satisfaction and loyalty. This means that, according to the complementors, customers who pay more attention to returns are neither more or less satisfied with their purchases nor loyal. There was only, as in the case of the other entities, a correlation between satisfaction and loyalty, and the latter influenced performance (Figure 16).

Figure 16. Complementors' perspective: confirmed correlations



Source: own elaboration
**p < .01

7. CONCLUSIONS

E-commerce returns are a very important component of value for the customer. The research has shown that the customers pay a lot of attention to extended return time and a simple return procedure. Free return is not the most important thing for them. The perspective of the sellers, suppliers of products and complementors is a little different from that of the customers. The further away the entity is from the end customer, the more differentiated the assessment associated with e-commerce returns is. This is probably due to the fact that the suppliers are not in a direct relationship with final customers and do not know what their expectations are.

A positive relationship between returns and satisfaction and loyalty has been confirmed for most of the e-commerce entities (except for the complementors). The more attention the customer pays to returns, the greater the customer's loyalty and satisfaction with their purchases is, and thus their expenses grow. For the sellers and suppliers of goods, this means better performance than the competition's. Returns therefore have an impact on satisfaction, which in turn affects loyalty (repeated purchases). Greater loyalty, in turn, influences higher customer spending and better company performance.

The online sellers, the product suppliers as well as the complementors should pay more attention to returns because their customers would then spend more money, which translates into their performance. It is therefore important to ensure, to the greatest extent possible, that products are returned within more than 14 days, that there is a simple return procedure and that goods are returned free of charge. Other factors (return of used products, returnable packaging) are also important, but not crucial. However, it is likely that with the emergence of new services, both the possibility to return used items and the provision of returnable packaging will become increasingly important.

It should be stressed that the studies presented focused on only one independent variable, which was linked to returns. In e-commerce there are many more variables (e.g. delivery to the customer, packaging, communication with the customer) that can affect satisfaction, loyalty and the customers' spending / the firms' performance. They may be subject to further research.

8. ACKNOWLEDGEMENTS

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APPROACH FOR THE SYSTEMATIC TRANSITION OF THE COMPANY INTO INDUSTRY 4.0

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Abstract

Industry transforms its production and business models according to Industry 4.0 concept, a current trend of automation and data exchange in manufacturing technologies that includes cyber-physical systems, the Internet of things/services, cloud and cognitive computing. Digital maturity is the ultimate precondition for transition. Intralogistics, an ubiquitous activity inside every company, consequently follows this trend and expands the concept of industry 4.0 in the field of logistics. In doing so, traditional companies have to lead their development along the evolutionary path, on which they are faced with a lack of examples of good practice that might be followed. They can use maturity models, but the use of these often requires the involvement of consulting firms. Maturity models are supportive tools to assess the AS-IS state, derive and prioritize improvement measures and control the progress. With the awareness of the inadequacy of merely the use of maturity models for the transition in industry 4.0, we began to evolve complementary tools.

The paper examines the applicability of the maturity model, more specifically The Digital Maturity Model 4.0, in combination with Business Process Modelling and the AS-IS state analysis in the light of the technological upgrading according to Industry 4.0 guidelines on specific case study in Tooling manufacturer. The paper concludes that the maturity model is useful for general diagnostics, but for more detailed planning of further development steps analytics at the process level is needed.

Key words: industry 4.0, maturity model, business process modelling, Digital Maturity Model 4.0

1. INTRODUCTION

In line with rapidly changing customer demands, ever-intensified market competition, growing product complexity and demanding legal requirements, there is a high demand on improved production efficiency, product quality, energy consumption and cost containment for manufacturing companies (Vrečko et al, 2019). In response to this, Industry 4.0 is ubiquitous. According to the German Industry 4.0 Working Group, Industry 4.0 revolves around “networks of manufacturing resources that are autonomous, capable of controlling themselves in response to different situations, self-configuring, knowledge-based, sensor-equipped and spatially dispersed” (Kagermann et al., 2013). The need to speed up digitization and digital transformation is more than obvious (Sommer, 2015). Like in other areas, also in production Industry 4.0 is transforming the way companies think about how their operations can and should be run. The above definition and indicated trends can be helpful for companies on their path to Industry 4.0, but it can also cause a sense of helplessness, lack of knowledge and irrational investment (Sternad, 2018). The rapid development of information technology and technology in general makes it even more difficult to find optimal routes and solutions. Advancements in robotics, virtual and augmented reality (Vujica Herzog et al., 2018), sensor technology, along with the significant growth of the Industrial Internet of Things allow many industries to connect machinery and human workers in ways never seen before. Improved efficiency brings vast cost savings and reduces the unpredictability of events due to human involvement and lack of data in real time. Once again, planning a path to these positive effects is in the hands of individual companies that do not have the opportunity to copy good practices. One of recurring questions is how to achieve digital and Industry 4.0 maturity or what needs to be done. Solution providers are heralding digitalisation and Industry 4.0 as the great answers to all problems, but few are providing honest and achievable strategies for introducing them into industrial environments. The digitalisation and Industry 4.0 projects usually come with significant investment (Jereb, 2017) and overhaul of current operations, which for most companies is an insurmountable challenge.

Paper contributes to answering the question how can companies get started with digitalisation and Industry 4.0 projects. From previous research (Sternad et al., 2018) we learned about the usefulness of maturity models, and at the same time also about their failure to give companies the exact directions of what to develop. In the case study, we compare the results of using the maturity model and business process modelling. Business process modelling is the activity of representing company’s processes, so that the current process may be analysed, improved, and automated (Aguilar-Saven, 2004).

In paper, we answer the following research questions:

RQ1: Are there any similarities/differences in results from digital maturity assessment and results from analysis of business process model?

RQ2: Can analysis of business process model complement maturity model’s general guidelines with more details?

The actuality of the problem demonstrates also the contribution of Prinz et al. (2016), who have written about LPS-learning modules for Industry 4.0. They propose the development of so-called ‘audit/maturation module’. The idea is to support companies systematically with the transformation to an Industry 4.0. Every company has to develop its own schedule of how to create the design fields of technology, organization and staff. Their module will also include some kind of maturity model.

2. METHODOLOGY

Literature review was used to learn about the methodology of assessment using the Digital Maturity Model 4.0 and the characteristics of the workplace according to the guidelines of the Industry 4.0. The theoretical background about maturity models was set from scientific papers found in Google scholars, Web of Science and Elsevier.

The selected maturity model (The Digital Maturity Model 4.0) was used on the example of a Tooling manufacturer. In the company, we surveyed the project manager, head of production and the IT manager. A self-assessment tool in a form of questionnaire consists of 28 statements, 7 in each dimension (Figure 1). Respondents marked on a 4-point scale how much do they agree with each of the statements (0 - completely disagree, 1 - somewhat disagree, 2 - somewhat agree, 3 - completely agree). The sum of points places assessed company in one of four classes: a skeptic, adopter, collaborator, or differentiator.

Figure 1. Questionnaire

"How much do you agree with each of the following statements?"

0 = Completely disagree 2 = Somewhat agree
1 = Somewhat disagree 3 = Completely agree

Culture

	We believe that our competitive strategy depends on digital
	Our board and our C-level executives back our digital strategy
	We have the right leaders to execute on our digital strategy day-to-day
	We invest in targeted digital education and training at all levels of our organization
	We clearly communicate our digital vision both internally and externally
	We take measured risks in order to enable innovation
	We prioritize overall customer experience over the performance of any individual channel

Organization

	Our organization structure prioritizes customer journeys over functional silos
	We dedicate appropriate resources to digital strategy, governance, and execution
	The staff supporting our critical digital functions are best in class
	We have digital skills embedded throughout our organization
	Our organization model encourages cross-functional collaboration
	We have defined and repeatable processes for managing digital programs
	Our vendor partners deliver value that enhances our digital competencies

Technology

	Our technology budget is fluid to allow for shifting priorities
	Our marketing and technology resources work together to co-create our digital technology road map
	We have a flexible, iterative, and collaborative approach to technology development
	We leverage modern architectures (APIs, cloud, etc.) to promote speed and flexibility
	We measure our technology teams by business outcomes not just system up-time
	We use customer experience assets, like personas and journey maps, to steer our technology design
	We use digital tools to promote employee innovation, collaboration, and mobility

Insights

	We have clear and quantifiable goals for measuring the success of our digital strategy
	Every employee understands how her performances ties to corporate digital goals
	We use customer-centric metrics like Net Promoter Score or lifetime value to measure success
	We measure how channels work together to accomplish a desired outcome
	Customer insight actively steers our digital strategy
	Customer insights inform digital design and development
	We feed lessons learned from digital programs back into our strategy

Source: Gill & VanBoskirk, 2016

In parallel, with the help of Business Process Modeling, we recorded the AS-IS process state and critically evaluated it. With the help of employees, we defined the main phases of the business process, which add value for the client. A guided tour along reference workplaces on the value chain from the tool order to the verification of the tool at the customer's plant was organized. Process data were gathered with partially structured interviews with employees on reference workplaces, and presented with synoptics (Figure 2).

Figure 2. Example of synoptic

ACTIVITY/TASK	Input		EXECUTION	
Flow Chart for workplace: **TOOLMAKER**	Data: • paper/oral communication/e-mail/signal... • electronic/paper... • send to a worker/has to be pick it on remote place...	Material: • type • delivery method	Executor: • worker/matchine/vehicle/tool... • location • visible/need for searching	Time: • Cycle time • in % according to the entire process • disturbances
The tool is assigned to the toolmaker **P1.TO**	**Toolmaker receives a plan:** • paper document (also available electronically on a shared computer in the assembly - small display diagonal, 5 tool-makers per 1 computer) • an explosion drawing with an illustrated sequence of installation of elements with unique markings of each individual assembly	No	Toolmaker	- 0.5 h - 5% - computer is busy - need for walking to the computer - not all the data is in paper documentation

Source: author

In the critical evaluation of the AS-IS state (Figure 3), we analysed each individual activity within the process. We were interested in whether the activity is routine / repetitive, ergonomically unacceptable, unnecessary, without added value, it represents a loss in terms of lean paradigm, technologically upgradable from manual to machine, using paper documents. Each positive answer was followed by proposal for improvement.

Figure 3. Example of synoptic

Task ID in the synoptic	Task name	AS-IS	Potential for Industry 4.0	
P1.T1	Getting acquainted with a work order	Use of the bill of material (paper document), 2D construction drawing (paper document), 3D electronic model	Augmented reality	**All information from a single source.** The use of virtual reality: posibility of rotation, an exploding view, a view of the whole or an individual part, the coloring of groups of components (eg. purchased parts) 
			AGV	
			Collaborative robot	
P1.T2				

Source: author

Further on, for each workplace similar tasks were grouped within a single row of proposal to improve the AS-IS state of specific workplace towards digital and Industry 4.0. Doing so, a transparent and concise proposal is made. One row of such proposal for Toolmaker's workplace is presented in Figure 4.

Figure 4. A part of the result from a critical analysis for a workplace “Toolmaker”

Activity with potential to Industry 4.0	ID Task	Task name	The effect of the TO-BE state	Description of the solution
Internal transportation	P1.T3	Moving castings / components from machining to assembly	The toolmaker is relieved of walking and carrying/transporting pieces between workplaces. Manual transportation is automated.	 Collaborative robot/AGV/mobile collaborative robot: • detects the completion of the previous phase, loads the piece and transports it to the next destination • operates on a call, allows worker to enter a command) to be fullfilled (eg. M10x20 or job destination).
	P1.T8	Carry in hands / transport of castings / pieces from the assembly into the heat treatment room		
	P1.T10	Moving parts from BPT to assembly		
	P1.T12	Moving parts from assembly to BKC/EŽ		
	P1.T14	Carry in hands/transport of pieces in the assembly		
	P1.T16	Carry in hands/transport of standard screws in the assembly DM		
	P1.T18	Carry in hands/transport of purchased goods from warehouse to assembly workplace		

Source: author

Based on the results from maturity assessment and critical analysis of AS-IS state, we answered research questions.

3. THEORETICAL BACKGROUND

3.1. The Digital Maturity Model 4.0

Software Engineering Institute has launched the Capability Maturity Model (CMM) more than twenty years ago (Paulk et al., 1993). This model became the basis for most maturity models that we know today. Based on the assumption of predictable patterns of evolution and change, maturity models usually include a sequence of levels that together form an anticipated, desired, or logical path from an initial state to maturity (Pöppelbuß & Röglinger, 2011). A maturity model serves:

- a descriptive purpose of use if it is applied for AS-IS assessments where the current capabilities of the entity under investigation are assessed with respect to given criteria (Becker et al., 2009)
- a prescriptive purpose of use if it indicates how to identify desirable maturity levels and provides guidelines on improvement measures (Becker et al., 2009).

Forrester’s Digital Maturity Model 4.0 is one of several maturity models that help companies assess their overall digital readiness (Gill & VanBoskirk, 2016). It evaluates digital sophistication across four dimensions:

- culture (a company’s approach to digitally driven innovation, and how it empowers employees with digital technology);
- technology (a company’s use and adoption of emerging technology);
- organisation (how aligned a company is to support digital strategy, governance, and execution);
- insights (How well a company uses customer and business data to measure success and inform strategy).

The evaluation is carried out by completing the pre-prepared standard form. Respondents mark on a 4-point scale how much do they agree with each of the 27 statements. The sum of points places the company in one of four classes: a skeptic, adopter, collaborator, or differentiator. The result should help determine a starting point for company's digital strategy (see Figure 5).

Figure 5. Companies distribute into four maturity segments

Level of maturity	Maturity segment	Characteristic behavior	Strategy	Score range
High	Differentiators	Leveraging data to drive customer obsession.	Blend the digital and physical worlds.	72-84
	Collaborators	Breaking down traditional silos.	Use digital to create competitive advantage.	53-71
	Adopters	Investing in skills and infrastructure.	Prioritize customer relationships over production.	34-52
Low	Skeptics	Just beginning the digital journey.	Prompt a willing attitude.	0-33

Source: Gill & VanBoskirk, 2016

Explanation of classes (Gill & VanBoskirk, 2016):

- Skeptics are technology-sluggish firms — skewed toward extremely large financial services, telecom, and public sector firms — that have limited experience innovating or applying an outside-in approach to strategic planning.
- Adopters have more digital practice than Skeptics do. In response to initial return from digital marketing and sales channels, they are willing to invest in the base architecture they need to scale their digital ambition — like a CRM system or e-commerce platform. Even so, most adopters are manufacturers, utilities, or healthcare companies that prioritize production over customer relationships.
- The greatest identifier of Collaborators is that firms in this segment are significantly more apt to collaborate internally and externally to enable practice and innovation with digital. 95 % of Collaborators emphasize the overall customer experience of their brand over the performance of any individual channel.
- Differentiators report strong revenue growth and tend toward pure-play or heavily online-focused retailers who are consistently more skilled than average at all the marketing and eBusiness functions we considered in this study, including project management, customer insights, and direct marketing.

3.2. Properties of Workplace 4.0

Howaldt et al. (2017) start their discussion: "Behind labels like "smart manufacturing" and "advanced manufacturing", hides the attempt to accelerate the digitalisation of production. In Germany, the future of manufacturing is intimately bound up with the vision of Industry 4.0. Wide scale implementation of this technology-centred vision appeared to be necessary and crucial for competitiveness."

Many companies are currently facing the challenge that plenty of technologies like the information and communication technology are indeed available but the companies, i.e. the individual employees, are not prepared for a successful use of Industry 4.0 (Prinz, 2016). Industry 4.0 differs from the approach of computer-integrated manufacturing (CIM) of the 1980s concerning the human role in the production environment. Whereas CIM considered the workerless production, the human role in Industry 4.0 is still very important and essential (Hirsch-Kreinsen, 2014). The success of human collaborative behaviour is based on individual's competences in interdependent functions (Topolšek, Čižman & Lipičnik, 2010). As a result of the interlinking of cyber-physical systems in Industry 4.0, the real-time depiction of all processes in a factory is now possible (Spath et al., 2013). For this reason, employees on the production planning and control level will be confronted with a high amount of information and data, generated by the entire infrastructure of cyber-physical systems. Besides, it can be assumed that formerly separated tasks and competences will merge (Spath et al., 2013). The increasing complexity of work will also concern the shop floor level. As simple tasks will be more and more automated, the remaining tasks will mostly consist of problem solving. For the human operator, mastering this complexity requires larger amounts of knowledge and competences than ever before (Ullrich et al., 2015). Digitized processes allow human independent control and automated communications between technical systems, which are becoming more responsive and reliable. Flexibility is being improved with adding interconnected multifunctional machines, robots and autonomous vehicles in production environment to implement the strategy of covering market niches and to satisfy customers' individual demands. Non-digitized data is becoming an obstacle to reach the maximal effects of transformation of traditional industrial environment into industry 4.0.

Industry 4.0 is a transformation that is powered by nine foundational technology advances: augmented reality, big data and analytics, autonomous robots, simulation, horizontal and vertical system integration, the industrial internet of things, cybersecurity, the cloud, additive manufacturing (Gerbert et al., 2015). Demand for employees in the mechanical-engineering sector may rise by as much as 10 percent. Employment growth since 2001 has been entirely based on jobs that have no repetitive tasks. The growing use of software, connectivity, and analytics is increasing the demand for employees with competencies in software development and IT technologies, such as mechatronics experts with software skills.

4. RESULTS

4.1. Assessment results with the Digital Maturity Model 4.0

The purpose of presenting the assessment results is not their precise explanation. The interpretation is very subjective and depends on the skills of the analyst. The main purpose is to show the generality of the collected data when using one of maturity models on practical case. From theory, we know that since their provenance, maturity models have been subject to criticism (Pöppelbuß & Röglinger, 2011). Characterized as "step-by-step recipes" they oversimplify reality and lack empirical foundation. We indicate the need for use of complementary techniques for the proper determination of maturity.

The assessment results are presented separately for each of four dimensions.

4.1.1. Culture

Results from assessment on dimension Culture are presented in Table 1. The respondents (project manager, IT manager, a head of production) from researched Tooling comapany agree that the employees' priority is the excellent experience of their clients with the whole process, and not only with a certain phase. This statement is assessed with three points on a scale from 0 to 3. Excellent customer experience with the entire process is an important area in Tooling company, where constant improvements are expected to improve products (tools for presses) and cycle time.

The respondents are also united that their company adopts moderate risks in the company in order to promote innovation. This is due to the nature of their products and their efford to preserve competitive advantage. Tooling companies are known for their innovation at producing tools. But digital maturity require inovativnes of digital transformation, which is new for this type of industry.

The employees have the most unequal opinion about planned investment in education and training on digitisation/e-commerce. The result points to a different intensity of training by individual departments.

Table 1. Maturity assessment on dimension Culture

Culture	Project manager	IT manager	Head of production	Average score
We believe that our competitive strategy depends on digital	3	2	2	2.33
Our board and our C-level executives back our digital strategy	3	2	2	2.33
We have the right leaders to execute on our digital strategy day-to-day	2	1	2	1.67
We invest in targeted digital education and training at all levels of our organization	3	1	3	2.33
We clearly communicate our digital vision both internally and externally	3	2	2	2.33
We take measured risks in order to enable innovation	2	2	2	2.00
We prioritize overall customer experience over the performance of any individual channel	3	3	3	3.00
Total	19	13	16	16.00

Source: Questionary from Gill & VanBoskirk (2016), results from survey by Author

The high level of agreement and mutual consistency was demonstrated by the following statements:

- we believe that our competitive strategy depends on digital;

• our board and our C-level executives back our digital strategy;
• we clearly communicate our digital vision both internally and externally.

The respondents partially agree (1.67 on a scale from 0 to 3) that they have the right leaders to execute on their digital strategy day-to-day. At the forefront of the company's efforts is a product, an excellent tool, and less a digital transformation.

4.1.2. Organisation

Results from assessment on dimension Organisation are presented in Table 2. The respondents do not share the same opinion on offered statements. The lowest score was assigned to "We have defined and repeatable processes for managing digital programs". The most defined and repeatable process is tool production from customer's order to assemly at the customer's hall. A minority od digital projects are guided by the same principle as other development projects. The result points to the weakness or even the absence of a digital strategy.

The respondents do not have the same opinion on the claim "The staff supporting our critical digital functions are best in class". The result indicates respondents' uncertainty. Each of respondents is faced with a dilemma: Am I familiar with what is happening in the company? Only well informed staff would know that company does not have digital functions; has no electronic store for its products, e-commerce with partners is limited, it does not have a department for processing digital data. A large amount of data is not in a digital form. Consequently, the need for excellent staff with digital competencies is also limited.

Table 2. Maturity assessment on dimension Organisation

Organisation	Project manager	IT manager	Head of production	Average score
Our organization structure prioritizes customer journeys over functional silos	3	2	3	2.67
We dedicate appropriate resources to digital strategy, governance, and execution	3	2	2	2.33
The staff supporting our critical digital functions are best in class	3	1	2	2.00
We have digital skills embedded throughout our organization	3	1	1	1.67
Our organization model encourages cross-functional collaboration	3	2	2	2.33
We have defined and repeatable processes for managing digital programs	2	1	0	1.00
Our vendor partners deliver value that enhances our digital competencies	2	2	1	1.67
Total	19	11	11	13.67

Source: Questionary from Gill & VanBoskirk (2016), results from survey by Author

The respondents share quite the same oppinion on four statements in Table 2. Business partners are a driving force that enhance digital competencies, especialy on vendor side. For example, some customers require the use of their electronic templates for shared documents. Partly, business partners can help to increase the digital competences of specific company, but that is not an assurance for electronic commerce between partners.

Results partly support statement that organizational model in researched company promotes inter-departmental collaboration. All departments tend to produce an excellent tool and satisfy customer. The tool often travels through the business process backwards due to the need for changes. That also contribute to improved collaboration.

Supporting services, such as informatics, feel a little less contribution to the customer experience. The contribution of IT to the excellent customer experience will probably be enhanced by the digital transformation of the company.

4.1.3. Technology

Results from assessment on dimension Technology are presented in Table 3. The respondents have the same opinion (partly agree 2.0 on scale from 0 to 3) about the statement „We measure our technology teams by business outcomes not just system up-time" (Table 3). Sales revenues are a key measure of success. Employees collectively contribute to maximizing the impact of their work. In doing so, they do not rely on digital technologies. In reearched company, the potential of introducing digital technologies is not explored.

Table 3. Maturity assessment on dimension Technology

Technology	Project manager	IT manager	Head of production	Average score
Our technology budget is fluid to allow for shifting priorities	3	2	2	2.33
Our marketing and technology resources work together to co-create our digital technology road map	3	2	2	2.33
We have a flexible, iterative, and collaborative approach to technology development	3	2	2	2.33
We leverage modern architectures (APIs, cloud, etc.) to promote speed and flexibility	2	2	1	1.67
We measure our technology teams by business outcomes not just system up-time	2	2	2	2.00
We use customer experience assets, like personas and journey maps, to steer our technology design	3	2	2	2.33
We use digital tools to promote employee innovation, collaboration, and mobility	3	2	2	2.33
Total	19	14	13	15.33

Source: Questionary from Gill & VanBoskirk (2016), results from survey by Author

Respondents have less unified opinion about all other statements in Table 3. The average values of the individual statements above 1.5 report partial agreements and higher level of digital maturity.

4.1.4. Insights

Results from assessment on dimension Insights are presented in Table 4. The respondents have the same opinion (completely agree 3.0 on scale from 0 to 3) only about the statement „Customer insights inform digital design and development". Employees agree that knowing the customer is crucial to business success. Result reports a mature state. Consequently, the modest use of customer-centric metrics to measure success in their company is surprising and rises a question about the method of data collection.

The applicability of claims given to statement „Every employee understands how his/her performances ties to corporate digital goals" is rather questionable because it contains values from 1 - somewhat disagree to 3 - completely agree. Probably employees who work on development projects are more familiar with corporate digital goals than others are.

A great deal of disagreement was found also about the statement „We measure how channels work together to accomplish a desired outcom", from 1 - somewhat disagree to 3 - completely agree. Dialogue with business partners takes place through meetings, phone, email and electronic partners' environments. The customer always determines communication. The diversity of answers probably indicates a lack of customer-centric metrics in use.

The respondents have a fairly uniform opiniona regarding all other statements on dimension Insights.

Table 4. Maturity assessment on dimension Insights

Insights	Project manager	IT manager	Head of production	Average score
We have clear and quantifiable goals for measuring the success of our digital strategy	2	1	1	1.33
Every employee understands how her performances ties to corporate digital goals	3	1	1	1.67
We use customer-centric metrics like Net Promoter Score or lifetime value to measure success	2	1	1	1.33
We measure how channels work together to accomplish a desired outcome	3	1	2	2.00
Customer insight actively steers our digital strategy	2	3	2	2.33
Customer insights inform digital design and development	3	3	3	3.00
We feed lessons learned from digital programs back into our strategy	3	3	2	2.67
Total	18	13	12	14.33

Source: Questionary from Gill & VanBoskirk (2016), results from survey by Author

4.1.4. Company's digital maturity

According to assessment results with the Digital Maturity Model 4.0 (Table 5), the expected degree of maturity in researched company is somewhere between "adopter" and "differentiator" (Figure 1). The average score (59) places the company on level "collaborator", which is one level more than notes the author of the maturity model for comparable companies (Gill & VanBoskirk, 2016). According to theory, the project manager was too optimistic, while the other two respondents were realistic.

Table 5: Positioning the company on a maturity scale

	100 % digital maturity [max score]	Project manager	IT manager	Head of production	Average score
Culture	21	19	13	16	16
Organisation	21	19	11	11	13
Technology	21	19	14	13	15
Insights	21	18	13	12	14
Total	84	75	51	52	59
Maturity level	Diferenciator	Diferenciator	Adopter	Adopter	Collaborator

Legend: Highest Score; Lowest score

Source: author

The result of the survey did not prove to be trustworthy or adequate to be used for decision making or defineing company's digital strategy.

4.2. Analysis of AS-IS state

A Business Process Modeling was used to record the AS-IS process state and critically evaluated it. Some of the main findings are presented below.

Observation of activities along the value chain, from customer's order to the final assebly in customer's production plant, shows the dominant presence of oral communication and paper documents (drawings, bill of material). 1/3 of machines is stil clasical, without NC or CNC controle, which means a communication barrier during technological preparation (CAD) and manufacturing (CAM).

A toolmaker, as a worker with a crucial assignment of assembly, is spending at least 1/5 of his time on work for walking arround the shop flour in order to verify the status of manufacture process, transfer pieces between machines, supply with material. Alphanumeric designations are still wtritten manually on tool's components (marker, scratching, stamping of individual characters) although there is a possibility of laser marking. Screwing is also manual. Several assebly workpalces on cca 200 m^2 have one computer, pneumatic screwdriver, storage rack for screws, which is reflected in the increased need for walking. Locations of tool's components within the production plant are not known, which results in occasional search activities.

Collaboration or collaborative behaviour presents an important aspect of company success (Topolšek, 2011). Communication between departments in researched company is mostly oral, with the exception of the flow of data about the tool's model, its structure and technological process. As a result, employees have a stronger sense of cooperation at the expense of lower productivity. It seems that oral communication between employees gives rise to innovation.

Digitalization and digital transformation of business processes between partner is in starting phase. A digital communication between partners develops due to the requests of external partners to use their electronic templates and safe repositories for common documents. Partly, this contributes to increasing the digital competence of researched company, but we can not yet talk about e-commerce or digital communication between partners.

Company's web page is static rarely updated, electronic communication in social networks almost does not exist. In the recruitment of newcomers, emphasis is placed on occupational specific competences, digital are not even mentioned in job descriptions. Formal digital strategy is not existing.

The analysis of AS-IS state gave us very detailed informations about company's organisation, processes, resources, shop floor and other. Its weakness is, that it is not directing to collecting specific data needed for assessment of company's digital maturity.

5. DISCUSSION

Based on the case study, we mainly notice differences in methods and results between maturity assessment based on maturity model and analysis of AS-IS state designed by business process modelling. Maturity assessment uses questionnaire while analysis of AS-IS state uses partially structured interview and the predesigned form for process visualisation. Results from maturity assessment are presented numerically with score, while results from analysis of AS-IS state are presented with flow charts and text. The only similarity lies in the fact that both methods describe the current state for some targeted purposes in the future, such as improving key business indicators, preparing a strategy, searching for alternatives, etc.

Getting data with digital maturity assessment is highly targeted on digital, while the other approach tries to obtain as many different data as possible at the lowest level of process structuring, that is, at the level of the task. The weakness of the first approach lies in the fact that something important can be overlooked, while the other method collects to many data. When using a maturity assessment it is necessary to select very knowledgeable respondents who fully understand each technical term in a questionnaire. The results are during the evaluation process already prepared in a form for immediate use, which does not require a presence of expert with long-term practice or specific training. When practicing analysis of AS-IS state designed by business process modelling the situation is different. Observed employees have excellent understanding of their work, they do not need to knowledgeable. The observer examines different documents, conducts a time study, retrieves data from the ERP or other expert data systems, conducts interviews with a large number of employees, and does not ask them the same questions, but only issues that directly regard to their work areas. The observer must be a resourceful person, often with many years of practical experience, who masters work with data and business analytics, has the talent to oversee opportunities and is a great connoisseur of latest business models and global trends.

The case study confirms complementarity of digital maturity assessment and analysis of AS-IS state designed by business process modelling. Results from analysis of business process model complement maturity model's general guidelines with more details. In this way, we can validate the estimated level of digital maturity and effectively approach to the improvement of the current state.

6. CONCLUSIONS

The maturity model, more specifically The Digital Maturity Model 4.0, business process modelling and the AS-IS state analysis can be used as complementary methods in cases when digital maturity has to be defined. Their co-use increases the reliability of the result and gives a better starting point for further development. The digital maturity model is useful for general diagnostics, but for more detailed planning of further development steps analytics at the process level is needed.

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DIGITAL SUPPLY CHAIN: LEADING TECHNOLOGIES AND THEIR IMPACT ON INDUSTRY 4.0

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Abstract

In the era of rising technological innovations all parts of economy are affected by a tremendous amount of new, helpful and after all absolutely necessary business solutions. Supply chain management is one of the leading pioneers in the field of technological implementation among other industries. The need for new solutions is inevitably rising and demand for modified and better business models is an every- day struggle. New technological solutions have direct implications on servicing a variety of members in supply chain. Adoption time has been in positive correlation with the quantified amount of improvement. Improvement in manufacturing cost effectiveness, communication, procurement process, lead delivering time, final customer experience etc. are just some of positive final results in terms of gaining greater profit by using new technologies in business. For example, some research study showed that few companies even managed to reduce their document manipulation error to quote of zero by using blockchain based database. The aim of this research is to extract the leading innovative technologies, overview their possibilities of implementation and show the final effects on the members of supply chain. Further research can be focused on the deeper analysis of effects of each of the listed technology solutions and their practical implementation. Managing of interconnected entities and processes within supply chain in industry 4.0 is more than a challenge.

Key words: technology innovations, industry 4.0, supply chain, implementation effects

1. INTRODUCTION

Nowadays, a competitive business environment is additionally overwhelmed by a variety of digital technological business solutions which can or cannot be used in proper manner. There is a significant amount of innovative products which are promoted as high level business problem solvers but only few of them are actually embraced by companies. The role of key members in any supply chain is to filter out the best solutions available on market and implement them in their businesses; otherwise, the strong competition on saturated market will force them to develop their own innovations. In both cases, it is in the best interest of companies to be proactive and to take steps in improving business processes, communications and finally, business results. The improvement in conventional Supply chain management (SCM) is recognized through rapid implementation of new technologies. Switching from computers to smart devices is any area of business is considered to be a pick milestone in Industry 4.0. The same thing can be transferred onto SCM (Tjahjono et al., 2017).

Industry 4.0 and Digital Supply Chain (DSC) are results based on desire to improve quality of life and doing business by implementing technological solutions (Dossou, 2018). Traditional supply chain faces many challenges, unnecessary costs, vulnerable problems and its need to be smarter (Abdel – Basset et al., 2018). In that manner, a company needs to understand that digitalization of its business processes in modern era is a necessity in order to reduce costs and improve productivity. Mechanization, automation, flexible manipulation, real time communication, improved trust, agile service, shortened expected delivery time are main focuses in DSC.

Digital disruptions and rising of internet business forced supply chain decision makers to empower relationships between supply chain members by using new technologies (Vendrell – Herrero et al., 2016). Downstream, from supplier and manufacturer to final customer, everybody in the mentioned supply chain needed to make changes and to accept the new way of business. There are new types of technologies in Industry 4.0 which affect SC, for example: 1. Communications (real time communication between entities), 2. Merchandize manipulation (solutions based on robotics and sensor technology), 3. Origin track (blockchain technology), 4. Distribution of goods (self-driving vehicles), 5. Data managing (Big data usage), etc. It is crucial for every member to understand the value of adopting new technologies in order to make synergetic effect throughout the SC.

Beside many advantages in Industry 4.0, certain risks can arise (Huo et al., 2015). Poorly executed implementation, misunderstanding with technology purpose, security breaches, high level of technology reliability, potential loss of personal relations with supply chain members are just some of the problems which can be identified at DSC.

There is a lot of potential to achieve positive effect from Industry 4.0 on SCM. For example, main practical advantages have been seen at certain logistics functions, such as: Internal SC logistics, Internal purchasing, Provider packaging, Provider port logistics etc. Expected potentials in these functions are shown throughout a variety of advantages: flexibility, decreasing documentation efforts, usability of data, cost savings, traceability, decreasing of incorrect delivery, etc. (Muller, et al., 2018).

This paper addresses an overview of fundamental impacts of new technologies onto SCM. In the first part, the subject will be on definitions, vision and main concept of DSC. The second part will be focused on the most important technologies that have been implemented in DSC. The third part will show what the impacts and final results of digitalization of SC are. In the conclusion the paper will discuss the best recommendations for further technology implementation in SC.

2. DIGITAL SUPPLY CHAIN – DEFINITIONS, VISION AND CONCEPT

2.1. Digital supply chain - definitions

Traditional SCM is slowly but steadily shifting toward digitalization. The era of the usage of modern technologies in business models is on the way and a large number of companies have already taken steps in the redesign of its business processes. Making correct guidelines for companies will impact faster adoption time within SC members.

High quality of stated definitions and concept is something that must not be called into question. Providing the best advice for incoming Industry 4.0 is an obligation for every researcher. Before continuing elaboration on the impact of new technologies on SC the paper will focus on definitions, vision and concept of DSC. Büyüközkan, in his paper called Digital supply chain: literature review and a proposed framework for future research, claims that supply chains and logistics are in a rapid change and that today's digital model can replace physical model of warehouse management, trucks etc.

There is not a large number of authors who tried to define DSC, but few of them which did, made a great contribution to understanding the structure of DSC in one or two sentences.

Capgemini Consulting states that traditional supply chain relies on a mixture of electronic processes and paper-based documentations. The organizational structures are often illustrated by functional and geographical silos which are reluctant to share information openly, leading to a sub-optimal performance. DSC, on the other hand, has the capability of making widespread information available, superior collaboration and communications across digital platforms, resulting in enhanced reliability, agility and effectiveness.

Bhargava et al. state that DSC is composed of those systems (e.g. software, hardware, communication networks) that support interactions between globally distributed organizations and orchestrates the activities of the partners in supply chains. These activities include buying, making, storing, moving and selling a product.

Accenture Consulting proposes that digitalization has the potential to transform supply chains by making services more valuable, accessible and affordable. Accordingly, a different perspective is needed for digital technologies to create new supply chain opportunities. Organizations should reimagine their supply chains as a digital supply network that not only unites physical flows of products and services, but also talents, information and finance. In an abstract sense, people and data, as well as materials, products and supplies, must travel together across the extended enterprise.

According to **Kinnet,** DSC is an intelligent, value driven network that leverages new approaches with technology and analytics to create new forms of revenue and business value.

The analysis of the report prepared by **A.T. Kearney and WHU- Otto Beisheim School of Management** defines DSC as the best-fit technologies that support and synchronize supply chain processes – including warehouse and transportation systems, Radio Frequency Identification (RFID), advanced picking technologies, and innovative planning and scheduling systems to quickly alleviate areas of "pain", such as waste in the supply chain, in a world where demand is volatile and risks are high.

The Digital Supply Chain Initiative describes the DSC as a customer-centric platform that captures and maximizes the utilization of real-time information emerging from a variety of sources. They suggest that DSC enables demand stimulation, sensing, matching and management in order to have an optimized performance and minimized risk.

According to **Rouse**, DSC is a supply chain whose foundation is built on Web-enabled capabilities. Many supply chains use a mix of paper-based and IT-enabled processes. A true DSC goes far beyond this hybrid model to fully capitalize on connectivity, system integration and the information-producing capabilities of "smart" components.

Cecere defines DSC as a process that uses new technologies to define processes to sense, respond and orchestrate directionally from market to market (from the channel to supplier networks). The processes move at the cadence of the market.

2.2. Digital supply chain - vision

The best way to describe DSC vision is to show challenges which are facing current SCM and to give proper recommendation for further research. According to research on SC challenges conducted by SAP there are several topics regarding solving problems in modern SCM. Those challenges are: supply chain visibility; demand volatility and new demand channels; supply chain complexity management; globalization and sales growth; new business models and innovations; flexible response management; collaboration; process standardization and automation; fixing the supply chain basics; supply volatility management; segmentation of products and customers. Listed challenges are core basic of future development of SCM (Figure 1).

Figure 1. Summary of challenges and their priority in terms of creating new DSC vision

Source: https://www.sap.com/documents/2017/04/88e5d12e-b57c-0010-82c7-eda71af511fa.html, [access April 18, 2019]

Listed data in Figure 1 represents challenges which should be modified and improved. Given level of necessity in the changing of current state is represented in percentage so it can be fully understood. There is an obvious need for improving SC visibility for all members of chain. Full scale transparency is something which would almost every SC manager want to see in DSC. Demand, complexity management and sales growth are at a high level in necessity for change as well. New business models, flexible response management, collaboration and process standardization are something that approximately every other SC manager would like to see. In the end, fixing the basics of SCM, volatility management and segmentation of products is a basis for a change.

In conclusion, the vision of DSCM can be defined as an improved business model of doing business in SC based on innovative intelligent technological solutions in order to achieve top performance throughout SC network. The vision of DSC is most certainly one of the most important parts in terms of the implementation of a new concept in SCM. Foremost, it should be a true guideline to companies to embrace new aspects of doing business. Adopting new vision is a real challenge for companies' culture and there is a need to provide the guidelines and persuade SC members to change their business behavior.

2.3. Digital supply chain - concept

The conducted research on DSC carried out in 2018 indicated that the concept of DSC is still in its early years of research and development among academics, while it is widely recognized and discussed among practitioners. As far as it is known, there are no academic studies that explicitly focus on the DSC concept. However, there are supply chain focused articles which discuss DSC technologies in terms of their applications. The following analysis supports this statement (Büyüközkan et al. 2018).

According to the concept designed at **PWC** in 2016, the concept of DSC is best described as a model of an integrated supply chain ecosystem. The concept relies on digital tower as a centered and most important function in DSC (Figure 2). Concept recognizes Digital control as the crucial part of DSC functioning.

Figure 2. Traditional SC model

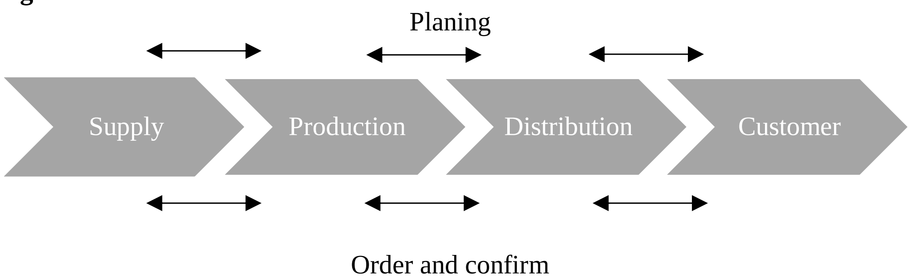
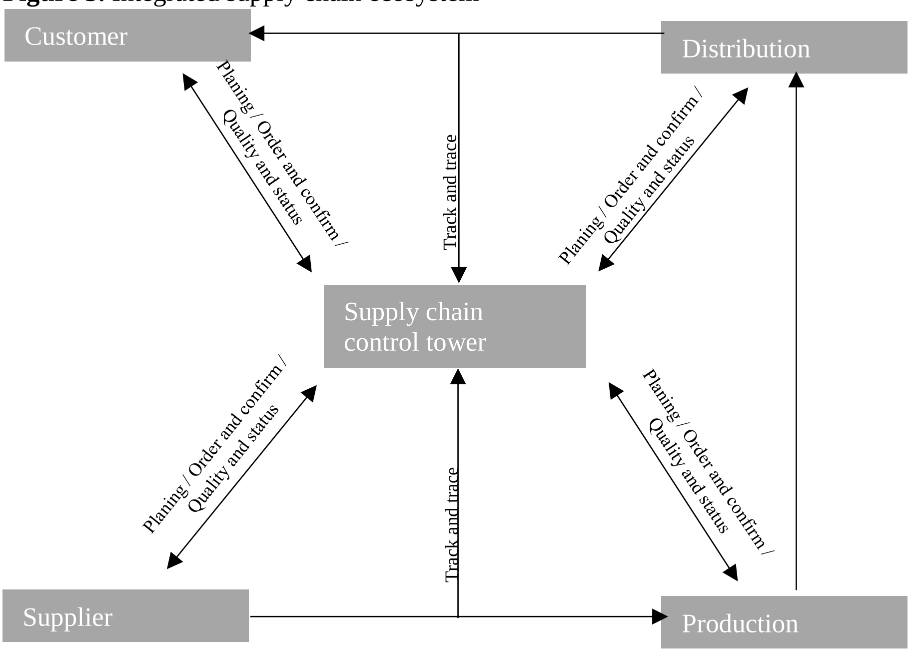


Figure 3. Integrated supply chain ecosystem



Source: https://www.strategyand.pwc.com/media/file/Industry4.0.pdf [access April 19, 2019]

The data in Figure 2 and Figure 3 show comparison between two concepts of SCM. Traditional-based concept depends on planning between two entities in SC. The result of planning is transferred to the next member in line etc. Ordering process is still much oriented on notifying the previous member about predicted demand. Process organization in traditional SCM can result in miscommunication, poorly executed strategy, late deliveries and finally, loss of customers. DSCM detected flaws with previous concept and delivered a new way of understanding SCM thanks to new technological solutions. Integrated supply chain ecosystem is now based on Digital control tower, a new function within SC, based on innovative technology. The control tower is set into the center of all business functions interconnected with all members in SC.

For example, if there is a rise of demand for a certain product, centralized system will recognize and immediately alert all stakeholders. System will also alert suppliers and manufacturers if it is out of stock. Simultaneously, system will send a notification to distributer and consumer about delivery time and place. If there is a blockchain system integrated, the producer can, for instance, track origin of ordered materials for production of its product. All these processes can be executed in real time. This brings another advantage to consumer who can now easily check the status of its delivery.

In conclusion, a new presented concept is the result of improvement in the understanding of optimization of processes inside SC and business oriented technology solutions.

3. LEADING TECHNOLOGIES IN DSC

Supply chain innovations are a combination of information and related technology developments and new marketing and logistic procedures to enhance service effectiveness, improve operational efficiency, increase revenue, and maximize joint profits (Bello et al., 2004).

Industry 4.0 brought an expanded focus on importance of resources, facility management, quality and/or speed of communication and delivery and finally increases in customer servicing efficiency. Logistics service providers are now equipped with more tools for satisfying customer needs than ever before. But in order to fully understand impacts of new technologies onto business models there is a need to list and explain main innovations that can be implemented in SC.

There are several main technological innovations which brought a turnover in business models at some or all members in SC (Tjahjono et al., 2017):

- blockchain technology
- AI (artificial intelligence)
- AR (augmented reality)
- big data advanced analytics
- drones (UAV)
- self-driving vehicles
- internet of things (IoT).

Blockchain technology - Blockchain technology (also known as distributed ledger technology) is essentially a peer-to-peer distributed asset database that can be shared across a network of multiple sites, geographies or institutions (Brown, 2016). This technology brings several essential values to DSC, such as: 1. Transparency, authenticity, trust and security and 2. Efficiency and cost/waste reduction (Wang et al., 2019). The benefits of using blockchain technology in supply chain are listed in Table 1. Blockchain technology is one of leading technologies in terms of changing business models in DSC.

Table 1. Perceived benefits of using blockchain technology in supply chains

Benefits of blockchain to SC	Explanation
Improves supply chain visibility	Reduces the need for double-checking and guesswork
	Allows the automation of data analysis activities (e.g. demand forecasting, asset monitoring, optimization and lean improvements)
	Allows the development of services such as track-and-trace
	Crucial for implementation in cold chains and luxury-item supply chains to provide provenance and proof-checking
	Information visibility improves internal business processes while adding value to the service/product for customers
Ensures secure information sharing and builds trust	One single data pool and system available to all stakeholders
	Highly secure system behind blockchains, as demonstrated in Bitcoin
	Standards can be set, thus increasing the overall quality of data in the entire chain
	Built-in trust helps brands gain customer confidence
Allows for operational improvements	Increased volume/accuracy of data helps organizations better monitor and evaluate their performance
	Opportunities to spot issues before they occur
	Speeds end-to-end supply chain execution

Source: Wang Y. (2019) Making sense of blockchain technology: How will it transform supply chains?, *International Journal of Production Economics,* p. 221-236

Artificial intelligence (AI) - to understand AI and how it works, AI can be viewed as a system which operates as a part of a larger framework comprising big data, machine learning, and AI. Computer algorithms and programs are created for these models. A class of models, called machine learning models, is particularly useful for learning from the data and making predictive decisions. At the heart of AI are data science models. Most AI models can be classified as predictive and prescriptive models. Predictive models predominantly offer forecasts of focal outcomes. These models typically offer an insight to retailers and supply chain members for key decisions. Prescriptive models focus on providing normative decision recommendations. These models can be thought of as offering foresight (Shankar 2018). According to Shankar, concrete benefits from AI system can be seen at: 1. Understanding and anticipating omnichannel and customer behavior, 2. Personalization and recommendation system, 3. Sales/customer relationship management, 4. In-store customer experience management, 5. Media optimization, 6. Inventory optimization, 7. Logistics, transportation and manipulation improvements, 8. Store cleaning and layout management etc.

Augmented reality (AR) - Augmented Reality refers to the layering of computer simulation models over the physical layout of current surroundings. In a sense, this is the hallmark of virtual reality, but AR refers to using this information to improve the efficiency of today's processes as they relate to the supply chain. Most common forms of Augmented Reality involve some sort of glass, visual display for a wearer to use in the process of increasing productivity and performance. For example, smart glasses in the warehouse are considered a form of Augmented Reality Supply Chain, explains Supply Chain Digest. Concrete benefits from AR can be seen at: 1. Picking optimization, 2. Facility planning, 3. Freight/container loading and 4. Dynamic traffic support (Merlino & Sproge, 2016).

Big data advanced analytics - Big data analytics is defined as a huge or complex set of data, which has a range of Exabyte and more. It exceeds the space of the technical ability of storage system, processing, managing, interpreting and visualizing of a traditional system (Kaisleret al., 2013).The term big data analytics can be defined as the application of advanced analytic techniques including data mining, statistical analysis, predictive analytics, etc. on big datasets as new business intelligence practice (Russom, 2011). Concrete benefits from Big data analytics can be seen in form of: 1. Descriptive analytics (analytics deal with the question of what has happened what is happening and why), 2. Predictive analytics deal with the question of what will be happening or likely to happen, by exploring data pattern using statistics, simulation, and programming, 3. Prescriptive analytics deal with the question of what should be happening and how to influence it, by driving alternative decision-based on descriptive and predictive analytics, using mathematical optimization, simulation or multi-criteria decision-making techniques.

Drones (UAV) - An unmanned aerial vehicle (UAV), commonly known as a drone, offers the advantage of speed, flexibility and ease in delivering goods to customers. They are particularly useful for tasks that are hazardous, dirty or simply to ease the process. Although the use of drone delivery is beneficial to the environment, cost saving is still a topic under debate. Ideally, drones yield lower energy consumption and reduce greenhouse gas emissions, thus reducing the carbon foot print and enhancing environmental sustainability (Chyuan Chiang et al., 2019). Concrete benefits from drone implementation are: 1. Reduce in time/cost of last mile delivery, 2. Diversification of transport services, 3. Customization of customer relationship, 4. Environment protection, 5. Better monitoring of traffic and optimization of transport routes, etc.

Self-driving vehicles –Self-driving vehicles (SDV) are automotive based solutions which are designed to transport people and goods from point A to point B completely autonomously (without human interference). This technology possesses a great potential in terms of cost savings, decrease in delivery time, safety, flexibility, monitoring etc. Special technique of SDV is so called `platooning`. Vehicle platooning is a coordinated movement strategy that has been proposed to address a range of current transport challenges, such as traffic congestion, road safety, energy consumption and pollution (Maiti et al., 2017).

Internet of things (IoT) - it as a grid of software, hardware, databases, virtual and physical objects, and sensors connecting and working together for serving humanity. The internet of things [IOT] enables anytime, anywhere, anything and any media communications. The IOT can be applied in any aspect of our lives. The smart devices of IOT enables supply chain companies to reduce cost which results from the acquisition process of knowledge. Applying IOT in supply chain management will make it smarter and have the following characteristics: 1. Instrumented: information in supply chain being machine generated, 2. Interconnected via using smart objects and IT systems, 3. Intelligent: optimize performance via making a large-scale of optimal decisions, 4. Automated: all processes must be automated to substitute low efficiency resources, 5. Integrated: collaboration between supply chain stages, 6.Innovative: the evolution (Abdel-Basset et al., 2018).

The presented technologies are main accelerators in current Industry 4.0 in terms of changing business models in SCM. There are several more technological solutions, such as Virtual Reality (VR), 3D printing, Simulations, Cyber security solutions, etc. but this paper focused on the most important technologies nowadays. The overall impact from implementation of these solutions will be presented in the next part of the research. Today’s technology innovations are rapidly becoming elementary part of every business model. There is a need for proactivity in the domain of adopting new solutions all the way downstream from supplier to consumer.

4. IMPACT OF LEADING INNOVATIVE TECHNOLOGIES ON DSC IN INDUSTRY 4.0 ERA

Companies need to integrate new technologies in their supply chain systems in order to be in race for lower operational costs of business (Eric – Dossou et.al., 2018). The overview impact of digital technologies can be seen in developing four key features: rapid, scale, intelligence and connection (Büyüközka, et al., 2018) So, the obvious question arise from an explanation of technologies mentioned above: what are crucial impacts of leading technologies in DSC? A change of course in business operations in supply chain nowadays cannot be imagined without digitalization of activities and processes within SC. According to **McKinsey and Company,** new leading technologies are making a new impact on SC in terms of:

Speed - Product distribution get new way of operating – its reducing the delivery time of high runners to a few hours. Advanced forecasting approaches, e.g. predictive analytics of internal (e.g. demand) and external (e.g. market trends, weather, school vacation, construction indices) data, as well as machine status data for spare-parts demand, and provides a much more precise forecast of customer demand. Forecast are updated to real time and generated into the new software. The customer order is later on matched with a shipment that is already in the logistics network (being transported towards the customer region) and the shipment is rerouted to the exact customer destination. In conclusion, it is necessary to improve speed of processes in order to reduce costs.

Flexibility - Real-time planning allows a flexible reaction to changing demand or supply situations. Planning cycles and frozen periods are minimized and planning becomes a continuous process that is able to react dynamically to changing requirements or constraints (e.g. real-time production capacity feedback from machines). Once the products are sent, increased flexibility in the delivery processes allows customers to reroute shipments to the most convenient destination. Transport management is relieving renaissance in terms of new approaches to navigating and monitoring trucks. Increase in flexibility in the supply chain organization is obvious than ever. There has been possibility to buy a supply chain as a service and to pay a members fee. Economy of scale is still one of leading focuses of SC managers.

Granularity – Customized production is always on rise. That gives a strong push towards micro segmentation, and mass customization ideas will finally be implemented. Customers are gathering in clusters, but with different individual preferences. This enables customers to select one of multiple "logistics menus" that exactly fits their need. Drone delivery allow companies to manage the last mile efficiently for single and high-value dense packages.

Accuracy - The next generation of performance management systems provides real-time, end-to-end transparency throughout the supply chain. New transport solutions are offering feature which show the overview of transport fleet with exact positioning in transport network. This range of data provides a joint information basis for all levels of seniority and functions in the supply chain. Supply chain cloud ensures that all stakeholders steer and decide based on the same facts. In digital performance management systems, clean-sheet models for warehousing, transport, or inventory are used to set targets automatically. To keep its maxim performance the machine automatically adjust any unpredicted appearance that cannot be achieved anymore to a realistic aspiration level. The AI systems are management systems that "learn" to automatically identify risks or exceptions and will change supply chain parameters in a closed-loop learning approach to mitigate them. Broad spectrum of activities could be realized without human involvement and to only leverage the human planner for the disruptive events/new events - with this, a supply chain is continuously developing towards its efficient frontier.

Efficiency - Boost in automation of processes is driver of efficiency. Robots handle the material (pallets/boxes, as well as single pieces) completely automatically along the warehouse process - from receiving/unloading to putting away to pick, pack, and ship. Autonomous trucks transport the products within the network. To optimize truck utilization and increase transport flexibility, cross-company transport optimization is applied to share capacities between companies. The network setup itself is continuously optimized to ensure an optimal fit to business requirements. To create an ideal workload in the supply chain, various transparency and dynamic planning approaches are leveraged to drive advanced demand shaping activities (e.g. special offers for delivery time slots with low truck utilization).

Listed improvements are result from high quality analysis conducted with goal to present positive impacts from digitalization in SC. In next table (Table 2), there is comparative analysis from between two types of SC in today's business.

Table 2. Improved activities and business operations in DSC

	Traditional supply chain model	**Integrated supply chain ecosystem**
Transparency	Limited view of supply chain	Complete view of supply chain
Communication	Information delayed as it moves through each organization	Information available to all supply chain members simultaneously
Collaboration	Limited visibility to the entire chain, hindering meaningful collaboration	Natural development of collaboration depth to capture intrinsic supply chain value
Flexibility	End customer demand distorted as information flows along the material path	End customer demand changes are rapidly assessed
Responsiveness	Different planning cycles resulting in delays and unsynchronized responses across multiple tiers	Real-time response on planning and execution level (across all tiers to demand changes)

Source:https://www.mckinsey.com/business-functions/operations/our-insights/supply-chain-40--the-next-generation-digital-supply-chain [access April 20, 2019]

The data in Table 2 shows comparison between operations in traditional and digital SCM. There are significant improvements in the managing of supply chain in Industry 4.0. With implementation of new technologies in business processes there is less uncertainty and potential risks which can arise. Trust is something which every member of SC wants to see, so transparency of activities is at most crucial significance. Nowadays, faster and more reliable communication between members of SC is the basic foundation of digital improvements. Flexibility, fast reaction and high quality service should be the final result of digitalization in SC. Defining true KPIs and using digital solutions for its accomplishment is right recipe for improvement of business decisions and after all measurable results. Synchronization within one SC is ultimate goal in Industry 4.0.

It has been considered that there are two dimensions which would be vital for quick shift to DSC: smart manufacturing and smart product (Frank et al., 2019). Smart manufacturing is referring to implementation of new technologies, and derived from the smart manufacturing is smart product. Smart product is product which has its primary characteristics upon which customers have been used to but with plenty additional features which is required to have on market.

In conclusion, there is a clear path for implementation of new technologies. Willingness of SC managers and CEOs as well is of vital importance for companies. Impacts of new technologies are showing that there is a need for new unlimited way for reach to customer, new flexible way of software implementation and installation of time saving features to already existing equipment. Therefore, companies will be able to improve their efficiency.

5. CONCLUSION

Industry 4.0 principles such as decentralization, information readiness, and prompt information exchange channels can help achieve optimized sustainable supply chain solutions including reduced resource utilization and environmental impacts. Industry 4.0 and CE together have motivated business organizations to evolve towards effective and prompt sustainable supply chain management (Jabbour et al.2018). Businesses have initiated design efforts for Industry 4.0 to help achieve CE principles (Kumar et al. 2018).

This paper relates to overview of most important digital innovations which are currently on the market and have impact on SCM. The main focus of paper is gathering information about digitalization in SCM and providing concrete overview about challenges, best practices and final impacts on SC. Throughout the paper it has been explained importance of DSC as a newly established concept. This concept and its implementation has given a profitable results with goal to improve existing processes in SC.

First part of paper has mainly been focused on DSC. Its definitions, vision and concept has been shown and demonstrated through various text, figures and tables. The aim of chapter is to make closer approach to reader in order to explain main foundations of concept.

Second part has been oriented on leading technologies in DSC at the moment. These technologies, such as blockchain, AI, AR, big data, drones, SDV and IoT, are changing business models of all members in SC. These solutions are mostly implemented in SC with proactive members. Also, there is free room for other innovative software and hardware designs to redefine shape of DSC, but at moment there is lack of significance.

Third part of paper is showing what are true beneficial impacts from Industry 4.0 and technological innovations. Some clear benefits can be identified from the implementation of Industry 4.0. The most relevant benefits are increased flexibility, quality standards, efficiency and productivity. This will enable mass customization, allowing companies to meet customers' demands, creating value through constantly introducing new products and services to the market. Moreover, the collaboration between machines and humans could socially impact the life of the workers of the future, especially with respect to the optimization of decision making (Tjahjono et al., 2017).

Further research can be focused on exploring the advantages and disadvantages of each technology individually and its effects on DSC; tracking of efficiency of blockchain in transport industry; usability of AI for end user promotion; renewed level of flexibility considering digital model of DSCM etc.

Industry 4.0 is bringing new solutions for business models in SCM. Visibility, transparency, collaboration, synchronization, responsiveness, quality and speed of communication and customer service is something what every digital innovation brings to business. Efficiency and accuracy of business operations are reaching highest levels in SC history. Established connection between SC and digitalization represents revolution in relationship between technology and supply chain business.

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INTEGRATION PLATFORM IN GLOBAL SUPPLY CHAINS - WHO IS BENEFICIARY AND WHO IS NOT

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Abstract

Being a supplier for no matter of what industry, companies have to deal with number of their customer solutions to supply or exchange information about orders, deliveries finally invoices. It often requires of adjustment to different portals, standards and sometimes additional work for customer service and extra charge. There are also the other way around situation where customers connecting to different integration platform of their suppliers and not to forget about transport and logistics sectors where LSP have to connect to different platform based solutions as their customers. The author provides different market related scenarios from different industries and branches examples (automotive, T&L, pharmacy, industry and retail) with showing who is a beneficiary and who in not these scenarios. The objective of an article is to outline what future possible solutions could be to overcome inconveniences and that all parties could get benefit from such business model. The article is based on professional experience and research on data exchange in global supply chains on Capgemini and Institute of Logistics and Warehousing.

Key words: global supply chain, integration platforms, EDI, transport, logistics, automotive, integration services

1. INTRODUCTION

Electronic data exchange is an extremely important element in the integration of information flows in the supply chain. Lack of electronic data exchange causes numerous errors which affect the logistics processes efficiency. Despite the fact that information integration brings a lot of benefits in terms of the logistics processes efficiency, there is a risk of IT systems functionality mismatch between business partners in terms of technology. The multitude of solutions for the electronic exchange of data between supply chain partners is also a serious problem.

Electronic integration EDI (Electronic Data Interchange), API (Application Programming Interface), Webedi (a WWW interface for EDI) is the key element of today's B2B sales and logistics. As for EDI which covers most of the electronic integration around the World in B2B is split mostly between x12, EDIFACT and others syntax standards, it has now in place also API which is even more shredded than EDI with two kinds of SOAP (Simple Object Access Protocol) Web services and JSON (JavaScript Object Notation) based API. There exists a common transmission protocols and API format structure like JSON but no standardization exists in this area as far as semantic model is concerned. It means JSON message format for the same purpose e.g. ordering transport can have different field names and different data model at two different transport services providers. The same situation exists for whole transport and logistics sectors but also for any other industries. On top of technical, syntaxes and semantic models in use, companies creating processes around their supply chains downstream and upstream. They very often use a third party solutions for logistics or supply management. Good examples of this are integration platforms for suppliers which optimizes their procurement processes in case they have hundreds of suppliers. In the following subchapters will be shown the examples of such integration platforms and will highlight the pros and cons of such solutions.

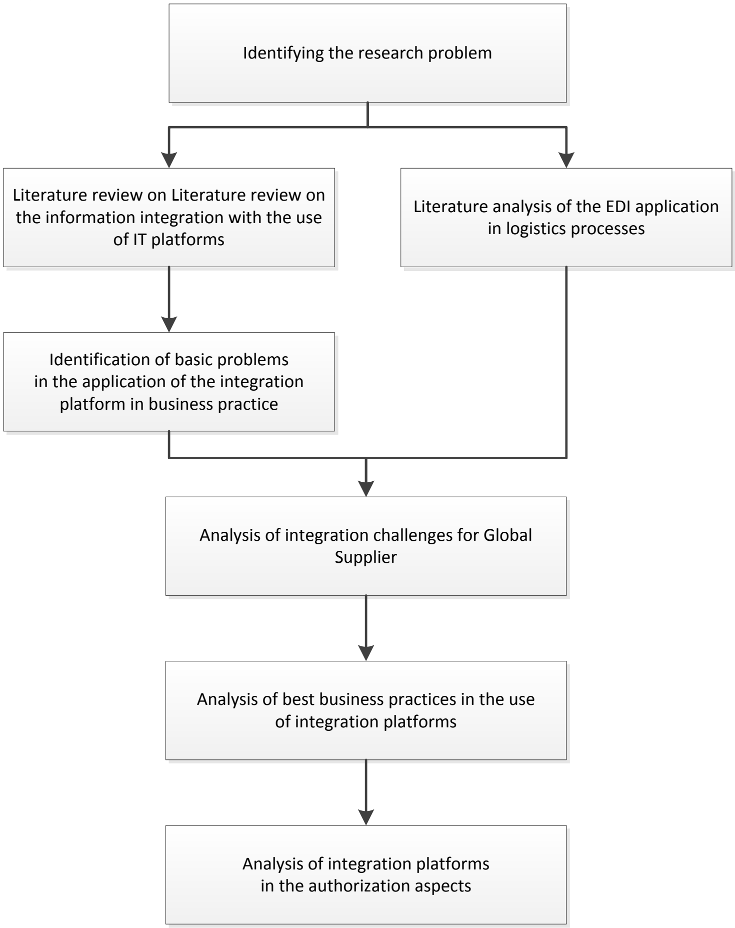
2. RESEARCH METHODOLOGY

The methodology proposed in this chapter is analogous to the previous research presented by the authors (Debicki & Kolinski, 2018). The present research should be treated as a continuation of the presented results. Figure 1 presents a general outline of the methodology of the conducted research.

The chapter is based on professional experience of integration management in global supplier from metal and mine industry. The presented business cases are the result of a literature review and interviews with companies within the framework of research projects carried out in the Institute of Logistics and Warehousing.

The research logic shown in the figure is consistent with the structure of this chapter. The specificity of the subject discussed forced to take into account mainly practical knowledge, which has not been ordered in methodological and scientific terms so far. Literature support concerns various links of the subject matter, not necessarily directly connected with the use platform integration, but based on the analysis of information integration in the supply chains. In addition, it proves that there are few references to literature and that it is necessary to organize literature in this field.

Figure 1. The research methodology



Source: own study

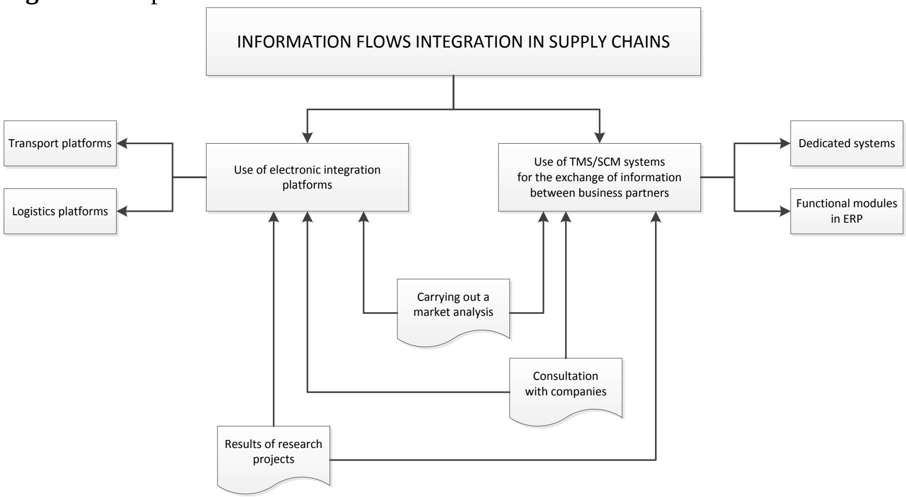
3. INTEGRATION PLATFORMS IN SUPPLY CHAIN

Information flow integration is a key factor in the integrated supply chain, which has a direct impact on the logistics processes efficiency. For this reason, it is necessary to analyse the supply chain integration opportunities. Literature review on the information integration in the supply chain and the application of EDI in business practice, the authors analyzed in detail in the publication (Debicki & Kolinski, 2018). This chapter focuses mainly on the use of integration platforms as a tool for the information integration in the supply chain.

The use of electronic integration platforms is a common business practice, especially in the implementation of transport processes (Kawa, 2012; Sliwczynski et al., 2012; Kawa & Zdrenka, 2016). Partners in the logistics supply chain are increasingly paying attention to the information flow (Tseng et al., 2011; Marinagi et al., 2014), which has a direct impact on the efficiency of processes (Prajogo & Olhager, 2012; Hadas et al., 2015; Adamczak et al., 2016). The issue of conducting research in this area is therefore justified, both in terms of research and business.

Due to the focus of business practice on the information flow efficiency between business partners, the definition of integration platforms has been weakened, as in many cases the customer connects directly with a dedicated system for a given company. Considering the fact that TMS/SCM class IT systems also enable communication between business partners, which meets the basic feature of information flow integration, the authors decided to include in this study not only the identification of the electronic integration platforms themselves and their functionality, but also the identification of dedicated TMS/SCM class of IT systems that enable information flow between business partners. The scope of research is illustrated in Figure 2.

Figure 2. Scope of research works



Source: own study

TMS IT systems are used mainly in internal processes, they can be implemented in any type of company, but they work best in transport, forwarding and logistics departments. Many companies use this type of solutions, they are often characterized by a high level of personalization, which corresponds to the needs of the transport process in the company (Helo & Szekely, 2005; Jacyna & Merkisz, 2014). These IT systems provide access to a range of functionalities facilitating the basic tasks of forwarders and carriers, as well as access to analytical and reporting modules. TMS cooperate with GPS systems - possibility of integration with telematics systems and digital maps (Barreto et al., 2017). They enable control of transport processes and their costs covering e.g. the amount of purchased fuel and its consumption level, drivers' working time, technical inspections Previously, data was stored mainly on a local server, but nowadays an increasingly popular solution is to build systems accessible via Internet platforms, which store data in the so-called cloud -software provider's server (Jun & Wei, 2011).

Data exchange between the links in the logistics supply chain is the primary responsibility of SCM (Supply Chain Management) IT systems. SCM deals with the flow of information, goods and services, supporting the management of the entire supply chain (Wong et al., 2011). The most important objectives for which SCM should be implemented in the supply chain include:

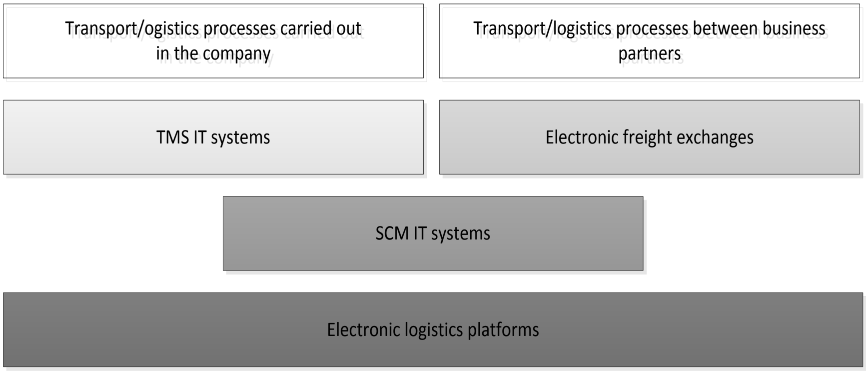
- optimization of efficiency, consisting in shortening the time of order execution, while at the same time increasing customer satisfaction,
- optimize productivity by reducing costs and capital supply chain involvement.

Electronic freight exchanges are used in the implementation of external processes, they are a tool used mainly for communication between the participants of transport processes (Fuks et al., 2015), search/order cargo, freight negotiation, conclusion of transport contracts, the user uses the tool without the need to personalize processes to the specificity of the company (Bohács et al., 2013). Increasingly, such tools offer additional functionalities typical for TMS systems, which brings them closer to logistic platforms (Robu et al., 2011). These systems do not require implementation, the user pays a subscription fee and uses the exchange via a website, or a computer installed program to operate the exchange, which connects directly to the server of the software provider.

Electronic logistic platforms cover both internal and external processes, this tool combines functionality of TMS systems and freight exchanges and their main task is not only communication between contractors but also organization of internal processes (Li et al., 2013). Most often they do not require installation of additional software or implementation, the user can use the tool after paying the subscription / purchase of a license tailored to individual needs of the enterprise.

A schematic comparison of the scope of operation of TMS, SCM, freight exchanges and logistics platforms is presented in Figure 3.

Figure 3. Scope of functionalities of analysed IT tools supporting the information integration in the supply chain



Source: own study

A detailed analysis of the functionality of the tested IT tools is presented in Table 1.

Table 1. Comparison of functionalities of analysed IT tools

Functionality/characteristics	*Freight exchanges*	*TMS*	*SCM*	*Logistics platforms*
Required Internet access	x			x
Searching, conversion, ordering of loads/vehicles	x			x
Negotiating the terms of carriage with the contractor	x		x	x
Conclusion of service contracts	x			x
Sending a transport order	x	x	x	x
Possibility of counterparty verification	x		x	x
Online communication with supply chain participants	x			x
Management of forwarding orders		x	x	x
Fleet and driver management		x		
Invoicing and payment		x	x	x
Planning and optimisation of transport routes	x	x		x
Vehicle monitoring with the use of GPS location		x		x
Analysis of transport indicators (analyses, reports)		x	x	x
Control of transport costs (working time of drivers, technical inspections)		x		

Source: own research

The presented issues are the result of research work carried out within the framework of research projects [1] carried out by the Institute of Logistics and Warehousing.

4. PROBLEMS WITH THE APPLICATION OF INTEGRATION PLATFORMS IN BUSINESS PRACTICE

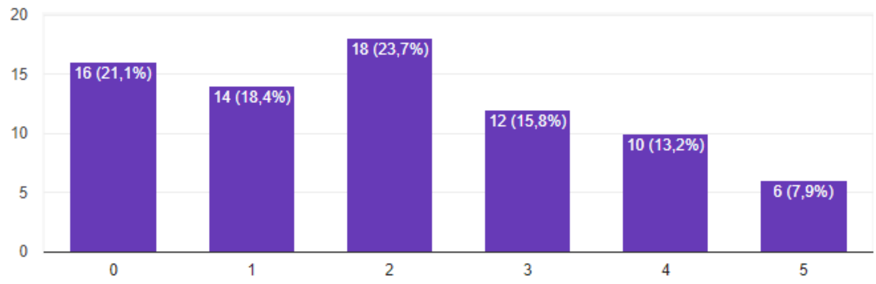
The first stage of the research was to analyze the needs of users of electronic integration platforms. Research in this area has already been initiated in 2017 within the framework of research conducted for GS1 Poland, concerning the degree of interest of enterprises in developing a new integration platform with the carrier. The study was conducted in the third quarter of 2017 in 76 logistics companies, which represented top logistic operators, carriers and manufacturers, conducting logistic

[1] e-Freight Implementation Action (e-Impact), No. 2014-EU-TM-0686-S, Institute of Logistics and Warehousing, Poznan 2015-2018; Analysis of the possibility of applying GS1 standards in the TSL industry, Institute of Logistics and Warehousing - GS1 Poland, Poznan 2017; Analysis of the possibility of applying GS1 standards in electronic transport platforms, Institute of Logistics and Warehousing - GS1 Poland, Poznan 2018-2019.

activity in Poland. The companies surveyed should be classified as medium or large. The research was conducted in the form of a questionnaire and direct research (visits in companies).

In the conducted research, the Likert scale was used, supplemented by the zero level, as a scale enabling not only a quantitative view of the use of particular tools, but also a qualitative one, determining the degree of their significance (0 - no significance; 3 - medium significance; 5 - very high significance). The basic element of the research was the identification of the needs of enterprises concerning the development of the concept of an integration platform. Figure 4 presents detailed results of the significance of implementation a new integration platform.

Figure 4. Identification of needs for the implementation of a new integration platform



Legend: 0 - no significance; 3 - medium significance; 5 - very high significance
Source: own research

When analysing the needs of enterprises, it should be stated that over 63% of enterprises do not see the need to introduce a new platform, or assess this need as very small and irrelevant. The research conducted in 2017 has been completed with the conclusion that there is no business need to develop a new integration platform, so it should be focus on the integration capabilities of the platforms already in use.

As part of the research work in this area, carried out in September 2018, it was decided to analyse the reasons for the lack of a business need for the development and implementation of a new platform aimed at integrating the flow of information within the transport processes of the supply chain. The research was carried out in the form of consultations and surveys in 24 companies, which also participated in last year's research and assessed poorly (on a scale from 0 to 2) their need for a new integration platform. The surveyed companies represented both carriers (8) and their contractors (16) - it was decided to expand the group of surveyed business roles (operator -10, manufacturer -6), as these roles are often crucial for the information integration of the supply chain.

During the consultation process, business representatives were asked to identify the problem that makes the use of electronic platforms and/or the development of a new integration platform ineffective. In addition, the degree of impact of the problem on the lack of interest from the perspective of developing a new integration platform was identified. The table 2 presents the detailed results of the studies carried out.

Table 2. Detailed analysis of the importance degree of problems related to the effective electronic platforms implementation

Problems related to effective implementation of electronic platforms	Importance degree of the problem						Average value
	0	1	2	3	4	5	
Necessity of entering data several times (into the system and on the platform)			1	7	7	9	4,00
Use of different communication standards by business partners					13	11	4,46
Little reflection of the economic benefits of using such platforms			3	8	9	4	3,58
Small number of contractors using the same communication platform			8	8	5	3	3,13
Fear of losing sensitive/critical data for the company				5	9	10	4,21

Source: own research

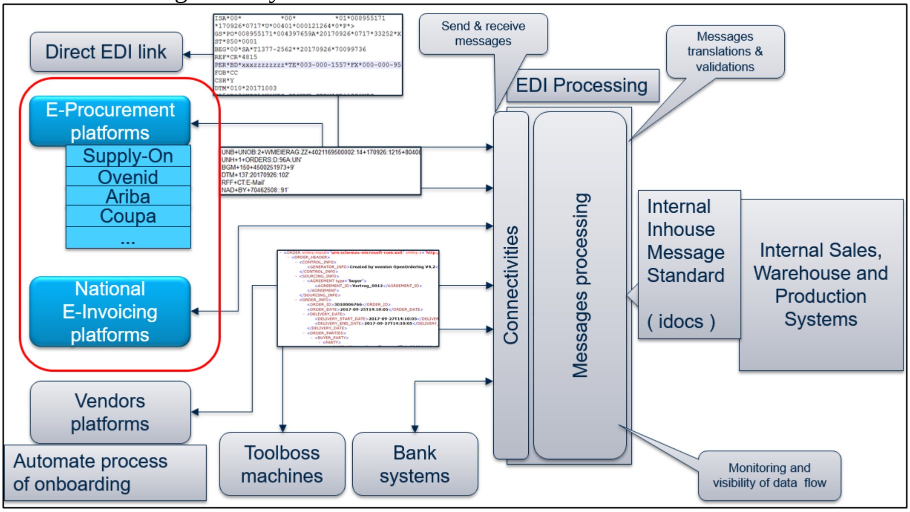
It should be noted that all of these problems are characterised by a high degree of importance in economic practice (all of them scored above 3.0 - average importance). The key problem is the incoherence of integration of platforms with IT systems of enterprises, which makes it necessary to enter data several times, data security issues and, above all, the diversity of communication standards available on the market.

5. GLOBAL SUPPLIER INTEGRATION CHALLENGES

As mentioned in the introduction, from the point of view of global suppliers that deliver their product worldwide to thousands of customers, electronic integration covering the entire flow of transactional information is an extremely important issue.

A global supplier uses not only traditional EDI, but also different purchasing platforms. It also has to comply with different invoicing rules around the world. For example, some countries require the use of national e-invoicing platforms.

Figure 5. Integration diagram in use by global supplier Kennametal Company for metal and mining industry[2]



Source: own study

When it comes to connecting to the customer's middleware platforms, it is often related again to integration with individual messages standard provided by this platform this is even not so bad for companies dealing with hundreds of standards this is not an issue. Much worse scenario is when platform which customer wish their supplier to use does not support any electronic integration towards supplier only between platform and customers. In this case the supplier is in the worst situation because sales operation needs double their activities in the ERP legacy system and customers' platform. In some cases, these platforms provide an electronic (EDI, API) integration towards suppliers but is not free of charge. Again, global supplier has to add to its integration costs other costs of dealing with such kind of platforms. From the above examples it becomes clear that one party takes benefits from integration via the platform and the other not. In case of global supplier, who is integrating with many platforms of his customers this is not an ideal situation, especially when some manual interventions are required or supplier is additionally charged for integration with such platforms. Then of course the benefits of this integration must be higher than costs. So only customers with big sales volume are considered here. For customer the suppliers' integration platforms for sure brings more benefits. They have all suppliers in one place, data flow from platform in companies' legacy system has the format. So actually inside the company only one data model is considered, all the translations are outside (in the platform).

Another important thing is the authorization as well as for automatic integration as for the users permission to perform some manual work in the platform. If suppliers, users have to deal with many different platforms of their customers, they need to provide authorization to each of this (login, passwords, SMS,…) it can become really

[2] The highlighted section is the subject for this chapter.

frustrating and annoying for all of us when on a daily basis we have to confirm the authorization. For automatic integration this process is set rather once when connectivity is being established. But we also may think that future integration would go into more automatic way of data exchange, hence the more use of common semantic model will be in place. Then switching to the new customer's platform should be also very easy without manually exchanging the certificates for authorization.

6. SUPPLIERS INTEGRATION PLATFORMS – BEST PRACTICES

In this chapter a few procurement and e-invoicing platforms examples are displayed. The key to show these platforms are differences in approach to the suppliers but also difficulties and obstacles to integration.

Amazon Vendor Central – from our experience and research on of the most advances business platform, it has a full manual operations available but includes all electronic integration aspects. Electronic integration is done via EDI messages in Europe – EDIFACT, in North America – x12. What is noticeable here the vendors get a full guide and testing tool when they can prepare their messages handlings. Only after successful test phase messages can be promoted to production environment. From business model perspective Amazon charges their vendors if they are not finish with electronic and logistics aspects (SSCC and labels) of integration.

SupplyOn connects – this for companies which would like to have all suppliers in one place, this is not a dedicated product for one company. In comparison to Amazon there is no automated way of running integration project. Each integration gets a dedicated project manager with whom the integration is being done. As for the business models it can vary here as it depends on individual agreements between the customer and Supply-ON and also customer and its supplier.

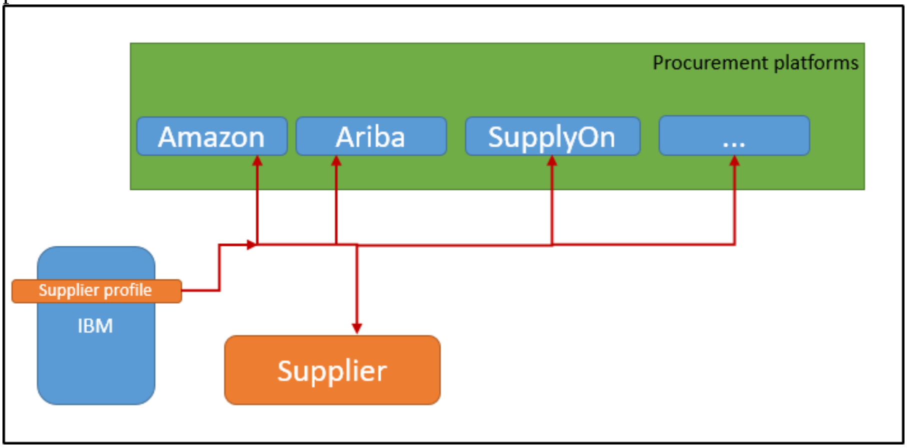
Spanish e-invoicing portal – this is a Spanish government initiative to improve and control invoices it is free to use. It supports only one standard of e-invoice an author's one, which is not a common EU e-invoice standard. The platform contains a validation tool for e-invoices, however, it is only in Spanish, which makes things complicated for foreigners.

Voith Supplier Portal – this is and dedicated portal for Voith company where they want all suppliers to use one. However, this portal is nothing else than Web-EDI where there is an automation between portal and Voith legacy systems, but there is no automated way of passing data between suppliers and Voith portal. So only manual data handling in both ways is possible, which could be a potential solution for small suppliers or those for whose Voith is on customer only. From the perspective of global supplier this tool is not beneficent at all and only brings additional costs related to handling this portal.

7. INTEGRATION PLATFORMS AUTHORIZATION ASPECTS

One of the solution for users, companies authorization on business portals and platforms also procurement platforms. Could be using a third party company / user profile for authorization. Something which is often used in e-commerce B2C, internet forums, fans zones and social media. Where often there is a possibility of using a third party profile for signing in. The same solutions should / could also be available for B2B authorization. Instead of Facebook or google profiles, the technological partners' profiles should be used, for example, if company strategic technology partner is Microsoft then there should be a Microsoft company profile in use for authorization, in other case maybe IBM, Oracle, Seaburger or any others. The only thing is these companies would need to make available the authorization services and procurement platforms and any other business platforms should have a possibility to use this third party authorization.

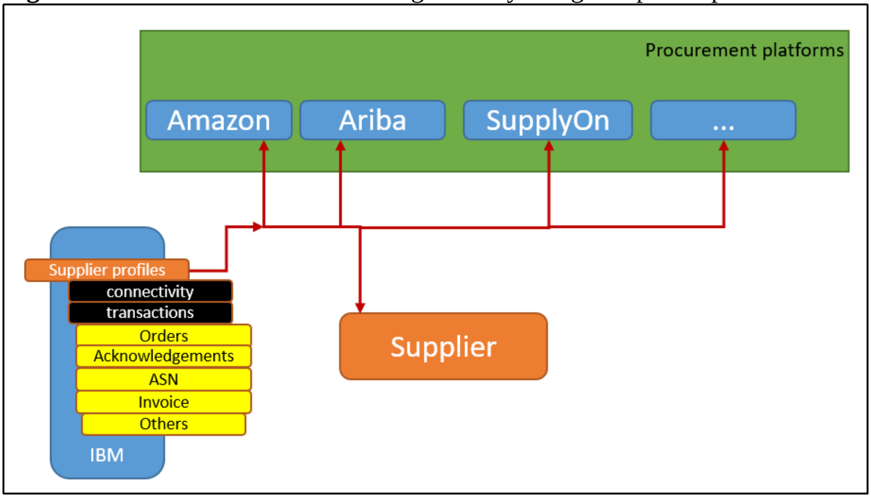
Figure 6. Users' authorization at procurement platforms using technology partner profiles



Source: own study

The same idea used for authorization of companies' users can be provided also for companies' profiles for electronic integration to other B2B users or platforms. However on certain, different level. For example when company is doing an electronic integration to a procurement platform the initial settings on both sides should be done based on companies profiles stored on the third party. These profiles should be shared when needed for integration. This will match the future idea of electronic integration based on semantic data models and process orchestration. This idea becomes more and more popular it has its application not only in transport and logistics sector, but everywhere where different standards and also different languages meet especially in transnational data exchange. This solution is also promoted in European projects related with transport and logistics and e-administration.

Figure 7. Automated transactions integration by using companies profiles



Source: own study

As far as automated B2B integration is concerned, this is not only connectivity setup with exchanging different certificates for communication protocols, but the most important things are the business transactions, which here must represented by a semantic data model which is common and understandable by every involved business partner. Only then partners can reach data elements which are crucial for executing business processes.

8. CONCLUSION

The World of integration platforms dedicated for different processes, industries is becoming bigger and bigger. In Authors opinion the authorization process would need to become more convenient as for users as for electronic integration which is going towards more automated way. The authorization is not the only problems and challenges related to integration platforms some of them were identified in this article: business models, insufficient support of messages standards, not standardized API, electronic integration not supported. The IT integration tools development as far as semantic data models and ontologies build around branches, industries should make possible very fast integration of different platforms and also changing them should be as easy as changing mobile telephony providers, it should take one or two days not three to six months.

The next step in the research will be to analyze the impact of using an integration platform on the logistics processes efficiency in the supply chain.

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BUILDING A MODEL FOR ASSESSING THE MATURITY OF POLISH ENTERPRISES IN TERMS OF LOGISTICS 4.0 ASSUMPTIONS

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Abstract

The major reason for creating presented maturity assessment model related to Logistics 4.0 assumptions is the growing importance of using Industry 4.0 tools and increase level of digitalization of logistics processes performed in activities of many global companies. A review of industry literature proves that Logistics 4.0 is a much less raised topic than the Fourth Industrial Revolution, hence it was considered that examining the level of maturity in relation to Logistics 4.0 assumptions can contribute to the development of the concept in Poland towards global enterprises successfully implementing digitalised processes. The constitutive aim of this paper was to build the model which should be used for investigating the level of maturity and implementation readiness of Polish enterprises from the TSL and manufacturing industry in relation to assumptions of Logistics 4.0. Enterprises were evaluated on the basis of research carried out in a pilot form. The article included indicating the assumptions of Logistics 4.0, tools used within its concept, as well as creating a maturity assessment model based on the analysis of a group of Polish enterprises. The conducted research indicated a small number of Polish companies effectively implementing solutions in the field of IV Generation Logistics, hence reasonable becomes the necessity of extending the research sample so as to improve the maturity assessment process, which will translate into an increase in the awareness of Polish companies regarding the requirements of digital transformation what will translate into an increase in their competitiveness and solutions used by them in the global logistics market.

Key words: Logistics 4.0, Supply chains and networks, Industry 4.0, Maturity assessment model

1. INTRODUCTION

In the industry digitisation era, it is unimaginable to have enterprises develop with no innovative solutions within modern technologies. The competitive advantage source becomes the ability to adapt final products to exact customer's requirements and to adjust to the unlimited customisation of created products or services. However, these effects are possible to be achieved only if there is a continuous improvement of processes fulfilled in factories by increasing the integration of actions performed both between particular enterprise processes and within supply chains. Only the factories, which are fully integrated with their business partners, will be able to respond to their recipients' needs in the future and will even obtain the ability to predict their requirements. These actions will be accompanied, among others, by real-time full access to data, full production robotisation or the integration of information exchanged between supply chain links which are the Fourth Industry Revolution components at the same time. The Industry 4.0 concept mostly refers to manufacturing factories in contrast to Logistics 4.0 which is focused on the entire supply chain integration. As the Industry 4.0 concept is of much bigger interest, authors decided to describe the most significant Fourth Generation Logistics features and elements that play a crucial role for contemporary supply chain participants (Gubán & Kovács, 2017).

With reference to literature overview the authors found that Industry 4.0 concept is discussed more often than Logistics 4.0, which prompted the authors of this article to examine the level of maturity of a selected group of Polish enterprises in relation to the Logistics 4.0 implementation. In addition, in the literature on the subject, you can find publications on the level of enterprise maturity in relation to Industry 4.0 while attempts to assess the maturity of factories in relation to Logistics 4.0 are not equally developing. In addition, the previously presented and used maturity assessment models related to Industry 4.0 indicate that the level of development in relation to the concept is quite low. Many enterprises are unable to fully adapt to the of the concept assumptions, which is required to increase the use of Industry 4.0 solutions and increase the efficiency of many processes performed by companies (Schumacher et al., 2016).

The major purpose of this paper is building a model for assessing the maturity level in relation to Logistics 4.0 assumptions in order to investigate the level of Polish enterprises' development. Created model can also contribute to the growth level of maturity of Polish enterprises with reference to components of the Logistics 4.0 concept. On the basis of the assessment of a selected group of Polish companies, a maturity assessment model for the processes implemented by them in relation to the Logistics 4.0 assumptions was created. Companies were investigated in relation to

Management, Information processes and Material flow. Presented in this paper model was created according to pilot research and will be developed in the future.

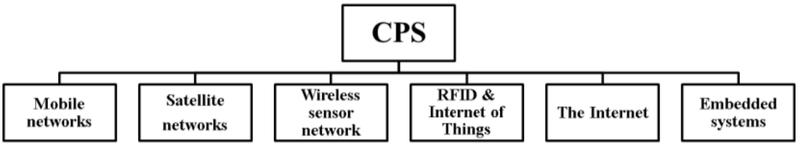
The presented article contains the most important aspects comparing and diversifying the concepts of Industry and Logistics 4.0. In the further part of this paper, the reasonableness of the maturity assessment model creating was determined in the context of the system's maturity models used in the literature. In the subsequent stages, the methodology of the conducted research was indicated, as well as their results and conclusions, indicating the necessity of further development of the model based on a larger test sample.

2. INDUSTRY 4.0

The development of particular industry branches would not be possible with no access to an unlimited amount of data. The required information availability led to improving the production planning methods and managing human resources, materials, or the material flow in a production process. The industry development that has been taking place in recent years is called the Fourth Industrial Revolution (Gubán & Kovács, 2017).

When defining the Industry 4.0, it should be noticed that the concept is intended to decentralise the course and control of production processes what ensures the possibility of their self-regulation. The Industry 4.0 task is to provide a digital support to products during all their life cycles. This support is referred not only to designing, manufacturing and management processes but is also related to the product reuse processes and thus, to reverse logistics and recycling (Bauer et al., 2018). As part of the objectives fulfilled as accompanied by the Fourth Industrial Revolution, it should be might additionally distinguish: communication between all the system participants, exact adaptation of production and provided services to a customer's requirements, fulfilment of highly efficient processes in terms of their elasticity and ecologicality or the application of self-learning machines that fulfil processes in an enterprise (Odważny et al., 2018). It is an idea that envisages the full automation of manufacturing processes, data analysis and information exchange between machines and employees and the use of modern digital technologies that make it possible to form Cyber-Physical Systems (Stăncioiu, 2017; Piątek, 2018). The CPS system controls physical processes that are fulfilled in the enterprise and enables communication among employees, machines and products. The system also makes it possible for individuals to make autonomous decisions (Gubán & Kovács, 2017; Stăncioiu, 2017). Such systems connect the virtual world with reality which leads to full synchronisation of information flow related to both physical manufacturing processes and virtual data processing (Hofmann & Rüsch, 2016). In Figure 1, there are CPS components presented.

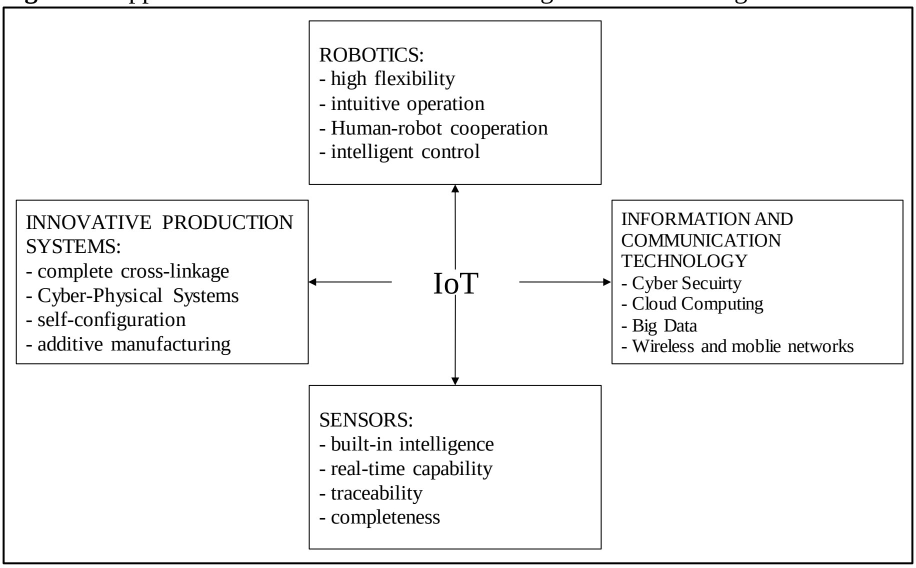
Figure 1. The main components of Cyber-Physical Systems



Source: Abosaq et al., 2016.

The next Industry 4.0 component is the Internet of Things which uses means of communication network (mostly frequently the Internet) so as to exchange and process data between objects, devices and machines which collect information on performed processes. (Stăncioiu, 2017). The Internet of Things makes it possible not only to exchange data within an enterprise but is also responsible for communicating with the supply chain partners (Tsuguio Okano, 2017). In Figure 2, there are the Internet of Things application areas presented.

Figure 2. Application areas of the Internet of Things in relation to logistics activities



Source: Hülsmann, 2015.

The IoT technology application ensures that it is possible to control the processes fulfilled by the enterprise which results in increasing the effective resource use (Gubán & Kovács, 2017).

In the Industry 4.0 concept, it should be additionally distinguish a variety of technologies that support the Fourth Industrial Revolution development. These technologies include: machine-to-machine communication, artificial intelligence, horizontal and vertical system integration, big data, cloud services or cloud computing, cyber security and virtual reality (Gubán & Kovács, 2017; Schlund & Baaij, 2018).

3. LOGISTICS 4.0

To define Logistics 4.0, it is necessary to notice similarities in both concepts. The Fourth Generation Logistics is based on the Industry 4.0 rules but certain significant differences should be noticed as they are necessary to identify the Logistics 4.0 assumptions correctly. The Logistics 4.0 notion is focused on moving away from logistics oriented only to IT equipment and logistic infrastructure in order to concentrate on ensuring customers so-called smart services within supply chains, while Industry 4.0 concept is mainly referred to production area (Timm & Lorig, 2015).

With reference to changeable customers' requirements and a higher complexity of fulfilled processes, it was also necessary to improve and develop the processes of planning, control and performing such actions as warehousing, transport, production, resource management and inventory management (Barreto et al., 2017).

Logistics 4.0 aims at ensuring all customers products and services exactly adapted to their needs in the possibly fastest way. In this concept, one used Industry 4.0 tools supported by modern technologies that are purposefully developed for digital logistics. It is essential to have a permanent interconnection of the IT systems of suppliers, producers, logistics operators and transport enterprises what enables constant monitoring and real-time data exchange ensuring the supply chain processes to be efficiently fulfilled (Kunz, 2016). The Industry 4.0 development also had an influence on forming new functioning rules of logistics itself and particular supply chain elements (Bujak, 2017).

In principle, Logistics 4.0 means a continuous exchange of very large amounts of data between enterprises in the supply chain. In a slightly narrower scope, a number of autonomous and mutually cooperating and communicating systems within fulfilled processes are specified in this concept. According to the process approach, Logistics 4.0 means all processes fulfilled within the supply chain. But in the technical approach, this concept means all kinds of devices and technologies that facilitate the processes taking place between companies in the supply chain (Szymańska et al, 2017). The Internet of Things utilization makes it possible to have easier and autonomous communication between the system machines, devices and users. This also leads to transferring part of employees' duties to the functioning of modern machines (Barreto et al., 2017; Goosens, 2017).

The Logistics 4.0 concept is linked to such notions as Smart Services and Smart Products, which might be generally named as Smart Logistics. Smart Logistics is a logistic system that is capable of improving the conducted action elasticity and synchronising them with market requirements in order to improve the relationship with customers.

As accompanied by technological changes related to the process digitation, it is required to change the method of providing logistic services in designing, planning, managing or fulfilling logistic processes. This is a response of Logistics 4.0 to the Fourth Industrial Revolution (Maslarić et al., 2016).

The logistic process digitization is predominantly linked to the possibility of localising and gaining information related to goods in transit. The transparency of data disclosed by particular enterprise activity areas is a very significant factor that influences the digital transformation fulfilment possibility what enables goods to be autonomously transported by respective transport units. This predominantly enables almost immediate satisfaction of customers' needs and the competitive advantage obtainment at the same time. With respect to organisational processes in logistics it should be also mentioned that the digital transformation ensures a greater autonomy of decisions made by particular companies in the supply chain (Schuh et al., 2017).

The tools used by enterprises in the Logistics 4.0 concept might include:

- RFID (Radio Frequency Identification), a technology that uses radio signals to wireless reading of information on goods or services put on labels (Palonka, 2007),
- RTLS (Real Time Locating Systems), real-time localisation systems used to identify objects at a given moment (Cyplik & Patecki, 2011; Dźwiarek, 2015),
- Cyber-Physical Systems that make it feasible to be fully integrated as in case of Industry 4.0 where two worlds: the real and virtual one are integrated. In Logistics 4.0, the CPS system consists of such elements as: machines, devices, objects, products, users and systems of warehousing, transport and picking that digitally cooperate with each other based on the ICT (Bauer et al., 2018; Basl, 2016),
- The Internet of Things and Services that makes it feasible to constantly monitor and control each products or service in the entire supply chain. A constant data exchange between the logistic supply chain participants is favourable to conducting analyses and measures that have an influence on making accurate decisions (Oleśków-Szłapka & Lubiński, 2016; Cedeño et al., 2018).
- Big Data is a source of analyses conducted without human intervention what enables increasing the fulfilled actions efficiency and prevent problems that might interrupt the processes performed in the supply chain (Oleśków-Szłapka & Lubiński, 2016).

The specification of tools applied in Logistics 4.0 was reflected in the enterprise maturity assessment model presented in this article as one of the factors that determines the degree of how its assumptions are fulfilled.

In this article, it should be also mentioned advantages and disadvantages of Logistics 4.0 shown in Table 1. The main Logistics 4.0 advantage is the possibility to adjust a product or service exactly to their customer's requirements in the shortest time by applying the latest technologies, such as 3D print or a Digital Twin that enable production of a ready-made product with no time-consuming phase of preparing prototypes. This seems to be a breakthrough factor that determines the final consumer's satisfaction from the viewpoint of elasticity and lead time (Domingo Galindo, 2016; Gubán & Kovács, 2017).

Table 1. Advantages and disadvantages of Logistics 4.0

The advantages of Logistics 4.0	The disadvantages of Logistics 4.0
Full integration of reality and virtual world	High implementation cost
Opportunity of real-time communication between system users, machines and other systems	Strict requirements concerning advanced IT hardware implementation

Improvement of all the processes performed in supply chain	Strict requirements concerning implementation of process-oriented management methods (i.e. Just in Time or Lean Management)
Opportunity of lead times decreasing for products and services directly responding to customers‘ needs	Requirements concerning implementation of Industry 4.0 technologies
Decrease in cost of product design thanks to implementation of Digital Twins	Problems with availability of data with no methods to process them with
Decrease in risk of structural or organizational mistakes in processes performed	
Availability of advanced technologies for analysis of unlimited amount of data	Novelty of the approach and low level of awareness among companies
Increased performance and availability of machines and operators	
Opportunity to make autonomous decisions by all the system users	Strict requirements concerning integration of company's sub-systems or supply chain elements
Increased visibility and flexibility of supply chains	

Source: Oleśków-Szłapka, Stachowiak, 2018.

The benefits related to the Logistics 4.0 concept implementation include the optimisation of all fulfilled processes, the increase in the efficiency of conducted actions, the increase in the time availability of machines and employees by autonomous actions undertaken by each system user and also the increase of efficiency of actions conducted in the enterprise. Logistics 4.0 concept creates the opportunity to transfer part of employees' duties to autonomous machines and this leads to increasing the quality of produced goods or provided services (Gubán & Kovács, 2017).

4. THE ENTERPRISE MATURITY MODEL IN RELATION TO LOGISTICS 4.0

The sake of presenting the maturity assessment model in relation to Logistics 4.0 in this article the notion of maturity should be defined. The maturity is defined as "a systematic improvement of the organisation abilities and its internal processes in order to obtain higher efficiency in a given period of time" (Kosieradzka & Smagowicz, 2016). A mature system is a perfect organisation, an enterprise that is able to fulfill all processes in line with previous plans. This results in increasing the efficiency of conducted actions at a satisfactory level for the enterprise (Wójcik, 2016; Kalinowski, 2017).

It should be mentioned here that the maturity of the organization is often considered in relation to the models of process maturity. Models of process maturity are used to determine the ways of implementing processes that enable achievement of goals set by the company and which support the organization in increasing the efficiency of performed activities. Maturity models also allow for an analysis of the current state of maturity of the enterprise along with an indication of future status (Kalinowski, 2017). According to another source, the maturity models consist of appropriate tools and actions to assess the company's skills in relation to management processes. System maturity can be defined as gaining of consecutive levels of its development. These models also allow to improve processes affecting the implementation of the intended goals. The concept of maturity models can also be understood as the process of implementing the most important activities under various activities carried out by the enterprise (Kosieradzka & Smagowicz, 2016). Maturity models enable a comprehensive assessment of the company's operations, and also allow to identify the most important processes whose correct implementation affects the increase of the organization's efficiency. The organization's maturity model should indicate solutions that contribute to the greatest extent to profits, as well as allowing to take a significant competitive position on the market (Kosieradzka & Smagowicz, 2016).

According to the literature review there are many maturity models created for different purposes. The most commonly used models are CMM (Capability Maturity Model) and CMMI (Capability Maturity Model Integration) models (Kalinowski, 2017). CMM and CMMI models are often the basis of many other models. CMM supports the increase in the efficiency of enterprise processes by determining the level of maturity and indicating activities leading to higher levels. The CMMI model is an extension of the CMM model, it is a tool used to assess the maturity of all business processes implemented by enterprises. Both models assume the creation of five maturity levels, where under the lowest level processes are characterised by low degree of structuring, while in the case of the fifth level, the processes are fully structured and improved continuously (Paulk et al., 1993; Gałuszka, 2011; Kosieradzka & Smagowicz, 2016).

In addition, it should also be mentioned that the CMM model assumes the indication of key areas of the company's activity due to the level of maturity achieved. These areas vary depending on the stage of maturity and the company's activity. However, it is important that increasing the effectiveness of actions in each of the key areas contributes to achieving the objectives set by the organization (Kosieradzka & Smagowicz, 2016).

The previously created maturity models were mostly related to the Industry 4.0 concept (Schumacher et al., 2016; Schuh, et al, 2017; Bibby & Dehe, 2018), however, also those related to Logistics 4.0 can be found in the literature (Oleśków-Szłapka & Stachowiak 2018; Gajšek & Sternad, 2018).

Referring to the commonly used models of system maturity as well as available in the literature on the subject models that refer to the concept of Industry and Logistics 4.0, it was decided to build a model with five levels of maturity defined on the basis of three groups of criteria. Created model is dedicated to both companies that implemented Logistics 4.0 assumptions with a success and also to that enterprises that do not perform highly integrated processes. Maturity assessment model created in relation to pilot research ought to be improved in the future so as to allow not only Polish but World Companies constant development contributing to logistics processes effectiveness and customer satisfaction increase.

With reference to the model created for this paper, subsequent levels of maturity refer to the level of enterprise development due to specific criteria required for effective implementation of the Logistics 4.0 assumptions. Authors decided to use the constructed model to assess the maturity level in relation to Logistics 4.0 due to the fact that the system readiness to implement innovations in new technologies and management might be stated when the system has become mature. It should be mentioned in this place that the implementation of the Fourth Generation Logistics rules is based not only on implementing the latest technologies but also on modern information exchange and decision-making processes (Tetlay & John, 2009).

As regards to the most significant Logistics 4.0 elements, not only technological innovations as self-dependent machines which make autonomous decision but above all information technology systems play an essential role. The information technology systems are responsible for communication among employees and making common decisions in supply chains. The application of modern Cyber-Physical Systems supported by such tools as the Internet of Things is necessary for communication purposes. These tools make it possible not only to have full communication between users but also to make common decisions in the entire supply chain. In addition, it seems to be significant to make use of methods to analyse large amounts of data that autonomously indicate the possibly best decision. A crucial matter is also to use modern solutions related to data storage and processing which make it possible for users to access their own data at any place with the Internet access and the entitled business partners' insight into certain information. At this point authors also mentioned the enterprise management supportive systems that support the management of all its departments and particular systems responsible for warehousing and supply chain management processes. It is necessary to ensure a full integration of management systems not only within one company but also in the entire supply chain. This will certainly lead to the possibility to autonomous decisions making adapted to their customer's needs and contribute to increasing the elasticity of performed actions.

5. RESEARCH METHODOLOGY

The first stage of the constructed model was linked to assigning a rating in percentages to the investigated enterprises with regard to advancement degree of their fulfilled processes in relation to the Logistics 4.0 assumptions. The values in percentages differ from one another solely in terms of the number and the content of answers to certain questions. If there were only two answers envisaged by a question, 100% were given for answer "Yes" and 0% for answer "No", respectively. Such a situation was in the case of questions only related to implementing certain tools. As regards to the level of automation and robotisation of processes fulfilled in the enterprise activities, there were the following answers to choose: "Lack of automation" (0%), "Partial automation" (50%), "Full automation" (100%). If there were a few answers to a given question to be chosen, 0% was given if none of the answers was chosen, 20% – if one element was marked and 100% – if all elements were marked. In order to enable comparison of all the questions from three analysed areas, weights were assigned to the questions. The sum of weights was 1. The weights were specified in consultation with a group of experts on logistics. A cumulative rating of each investigated area is maximum 100%. If an enterprise got the maximum rating in all the considered areas in the model, it should be acknowledged to be mature in terms of the Logistics 4.0 implementation, and, as a consequence, also ready. It was assumed for the sake of the constructed model that an enterprise is almost fully ready to have Fourth Generation Logistics tools implemented, if it obtained 75% of points from each area or the obtainment of an average value from 3 investigated problems is at the level of 80%. Thus, it was acknowledged that a cumulative assessment of all areas made it feasible to state whether an enterprise might be considered to be mature in relation to Logistics 4.0 or it is not sufficiently mature with respect to the assumptions of the concept. In Table 2, one presented the issues used in the maturity assessment model with assigned weights within the expert panel.

Table 2. Issues and weights of the maturity model

	ISSUE	WEIGHT
MANAGEMENT AREA	Utilization of ERP systems	0,3
	Utilization of WMS systems	0,1
	Utilization of Just in Time	0,1
	Utilization of SCM systems	0,5
PHYSICAL PROCESSES AREA	Automation of production	0,3
	Automation of warehouse processes	0,1
	Automation of internal transportation	0,2
	Robotization of processes	0,4
INFORMATION FLOW PROCESSES AREA	Utilization of RFID	0,05
	Utilization of RTLS	0,1
	Real-time data access	0,25
	Awareness of concept of Internet of Things	0,05
	Data analysis technologies	0,25
	Awareness of concept of Big Data	0,05
	Cloud Computing technologies	0,25

Source: own work

The model developed in this article was used to assess the maturity of 17 selected Polish enterprises in relation to Logistics 4.0. Cumulative ratings were specified in terms of 3 analysed areas and an average enterprise maturity assessment based on the given ratings and specified weights. This made it feasible to order the enterprises ratings to one of the five maturity levels of the constructed model as presented in Table 3.

Table 3. Logistics 4.0 maturity models

Area rating/Average rating	Level	Characteristics
Under 50% in each area or average under 60%	0	The company is characterised by a lack of maturity in relation to Logistics 4.0 assumptions, it does not perform the requirements in any examined area, it is characterised by low process maturity. The company does not recognize the need of integration in relation to Logistics 4.0. It cannot be considered as ready for the concept requirements.
Over 50% in each area or average above 60%	1	The company is characterised by low maturity in relation to Logistics 4.0 assumptions, the probability of effective implementation is close to zero. The company recognizes the benefits and the need of integration in relation to the Logistics 4.0 but does not take actions towards increasing the level of maturity. It cannot be considered as ready for the concept requirements.
Over 60% in each area or average above 70%	2	The company is characterised by a partial maturity in relation to the Logistics 4.0 assumptions, the probability of effective implementation increases. The company recognizes the benefits and the need of integration in relation to the Logistics 4.0 by implementing some of the assumptions of Logistics 4.0. It cannot be considered as ready for the concept requirements.
Over 75% in each area or average above 80% (both less than 100%)	3	The company is almost fully mature in relation to the implementation of the Logistics 4.0 assumptions. The company implements most of the solutions in the field of Logistics 4.0 effectively. The probability of implementation effectiveness is close to 100%. The company can be considered ready for the concept.
100% in both (each area and average)	4	The company is fully mature in relation to the implementation of the Logistics 4.0 assumptions. The company implements most of the solutions in the field of Logistics 4.0 effectively. The probability of implementation effectiveness is 100%. The company can be considered fully ready for the concept.

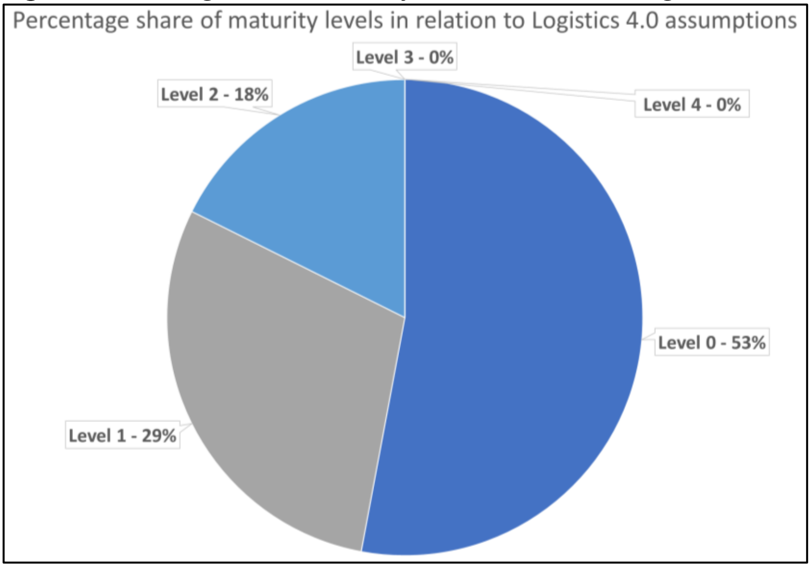
Source: own work.

The enterprises, which were given a rating over 75% in each of the investigated areas or an average rating at the level of 80% were considered to be nearly fully mature and those which were given an average rating (as well as in each of the investigated areas) 100% were considered to be fully mature. Contrary to them, the enterprises, which were given a rating below 50% in each of the investigated areas or an average rating below 60%, were considered to be immature.

6. RESULT ANALYSIS

In the pilot study for the sake of this article in there have participated 17 random enterprises from the production industry. The ratings and weights applied to the developed assessment model made it possible to give a number of mature enterprises in relation to the Logistics 4.0 assumptions. None of the investigated enterprises achieved the fourth, highest maturity level as well as the third level which also pointed out that the enterprise could be described as nearly fully mature. As many as nine enterprises achieved the lowest – zero maturity level which was 53% of the investigated enterprises. Only three Polish enterprises achieved the second maturity level which was 18% of the investigated enterprises whereas five enterprises achieved the first level of maturity.

Figure 3. Percentage share of maturity levels in relation to Logistics 4.0 assumptions



Source: own work

It might be stated based on the model constructed for the sake of research that minor part of the investigated enterprises factually knows and fulfills the Logistic 4.0 assumptions. This model needs to be assessed based on a greater number of analysed enterprises what would enable obtainment of more precise results and, as a consequence, would contribute to this concept development in Poland. The research should be developed in order to investigate a broader scope of enterprises based on a stratified sample. Thus, such factors as a brand, enterprise size, involvement of foreign capital should be regarded in order to specify a real maturity level in relation to Logistics 4.0. This would have its impact on the concept development strategy formation.

It should be noticed that construction of this model is a favourable process in terms of enterprises of various industries in Poland due to the fact that it is possible to investigate the real knowledge and awareness of using modern solutions related to technology and also to supply chain integration. It seems to be obligatory to recognise the maturity level of Polish factories and implement modern Fourth Generation Logistics solutions what might be soon decisive about the competitive position held by Polish enterprises compared to foreign enterprises. The existence of some enterprises might be conditioned by the recognition and implementation of the latest technologies that make it feasible to deliver products precisely meeting customers' needs at the required moment. Therefore, it should be stated that the implementation of modern Logistics 4.0 solutions will soon be a required and decisive condition that will determine the enterprise market position.

7. CONCLUSION

In this paper, one constructed the model of assessing the maturity level of Polish enterprises in relation to the Logistics 4.0 assumptions based on models of system maturity assessment operative in the literature. To investigate its functionality, one analysed a group of random enterprises from the production industry in terms of applying the Logistics 4.0 technology and assumptions. One formed 3 research scopes related to the area of management processes, physical processes and also information processes fulfilled by the enterprises. Based on the given ratings and weights determined by the expert panel, one specified a cumulative rating of each area. The conducted research showed that none of the investigated enterprises achieved the highest maturity level in relation to the Logistics 4.0 assumptions. This results in a small number of Polish factories that efficiently implement and fulfill processes within this concept. It should be also noticed that this model was used to assess the enterprises in the pilot study and therefore, it is necessary to conduct further analyses based on a larger research sample with respect to additional factors. They might considerably influence the enterprise maturity level. The research sample increase is necessary to ensure the tests to be appropriately reliably and objectively conducted.

The model created for the purpose of the paper will be addressed in the future both to enterprises that effectively use the tools in the scope of Logistics 4.0 as well as to those that have not yet implemented the assumptions of the concept to performed processes. The performed research led to drawing a conclusion that it was necessary to know a real maturity level of Polish enterprises. This level would predominantly enable specification of the development stage of the Logistics 4.0 concept and contribute to further concept development. Both the Fourth Industrial and Logistic Revolution seems to be unavoidable and consequently, will soon influence the market position held by particular enterprises. Therefore, it seems that the Logistics 4.0 implementation in industrial and logistic activities will be necessary and have a decisive impact on the existence of particular enterprises in their industry. Moreover, Polish enterprises are required to constantly investigate and advance the technological development level of Polish factories which make it feasible not only to develop and expand the entire market but also to compete with the strongest foreign enterprises which fulfill the Logistics 4.0 assumptions efficiently. The further development through the implementation of Logistics 4.0 tools is feasible only through identification the real level of maturity of Polish enterprises in relation to the concept and adjusting the improvement activities depending on the level achieved by companies as a result of the usage of the created model which ought to be improved in further research

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II. RISK AND EFFICIENCY ANALYSIS IN SUPPLY CHAINS

SUPPLY CHAIN RISK MANAGEMENT FOR SENSITIVE HIGH VALUE GOODS

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Abstract

Vulnerable high value goods require a particular risk-averse transportation along the whole supply chain. Pharmaceuticals and other lifesaving goods, such as medical equipment, are often sensitive to temperate deviations, shocks, delays or other risks that are less influential for consumer goods. Every, sometimes even minor, aberration might result in a significant risk for the end consumer, the patient.

In this article we develop a holistic supply chain risk management concept (SCRM) for vulnerable high value goods. We also apply this concept to evaluate pharmaceutical supply chains. Our approach maps the capabilities and the risks of all participants and their logistical processes, which define the specific supply chain, to a common operations model and ultimately derives a risk score for the entire supply chain.

To evaluate the risk of a certain supply chain for a specific good, the overall chain is modelled using the SCOR (Supply Chain Operations Reference) model, which describes every particular process and activity of a specific supply chain. The capabilities of the supply chain partners, the product-specific and legal requirements, as well as all risks implied by the routing are mapped to the SCOR-based process. Subsequently, all described factors enable the calculation of a single risk indicator for each step along the supply chain. The final model allows for evaluating the overall risk of a planned shipment, given a predefined routing.

Key words: Supply Chain Management, Risk Management, SCOR model, Pharma

1. INTRODUCTION

In today's global economy supply chains span all over the world – suppliers and customers are allocated worldwide. The manufacturing of products is divided and split over different locations across the world. Customers demand the same products around the globe.

The risks that have an impact on pharma supply chains are various. Temperature deviations during storage or transport of pharmaceutical goods account for losses of billions of dollars every year and, much worse, losses of lives (Sykes, 2018, pp. 154–170). Thefts of pharmaceutical goods, especially during transport, account for an estimated loss of about 31 million Euro in Europe every year (Ekwall et al., 2016, pp. 1-16). According to Kumar et al. (2018), between 6 and 10% of all pharmaceuticals are counterfeit products, posing another substantial risk to the pharma industry.

For pharmaceutical and other life-saving goods, this induces high requirements to the logistics and storage of these products. They can be temperature, shock or humidity sensitive. These conditions have to be met at all times, otherwise the items will be damaged. The consequences from damages can go from being medically less effective to adverse impacts negatively affecting the health of a patient, ultimately causing even loss of lives.

This is the main reason why production and transport of medical products are highly regulated all around the world with different regulation. The World Health Organisation and the European Union, for instance, implemented strict guidelines governing the manufacturing (World Health Organization, 2011; European Commission, 2004) and the distribution (World Health Organization, 2010; European Commission, 2013) of pharmaceutical goods.

The industry is obligated to assess the risks of a transport from source to sink prior to the shipment. Today this is a highly complex procedure in which all logistics service providers (LSP) need to be audited and evaluated based on their risks. In the procedure of implementing a new lane, it happens that more LSPs than necessary are audited, as some might not fit the requirements.

Since the evaluation of an LSP requires abundant resources, this study proposes a model that enables a pharmaceutical company to evaluate the partners along its supply lane prior to the auditing of the partners. With the proposed approach, suitable partners along the whole supply chain can be chosen based on a scientifically justifiable base and with significantly lower investments. Further, the approach does provide a full risk assessment along the supply chain, giving the decision-maker a powerful tool to anticipate risks connected to the routing and the partners involved.

2. LITERATURE REVIEW

To the best of our knowledge, there is no scientific literature that specifically explores the risk management of pharma supply chains by using a SCOR model. Thus, we will instead briefly review the existing literature that covers at least the combination of two of the aspect relevant to our work.

As Zsidin and Henke (2019, p. 1) state in the opening chapter: “throughout history we have been challenged with managing risk in our supply chain”. Naturally, scientific efforts to manage risks in supply chains are thus as old as supply chain management itself (Zsidin & Henke, 2019) and can be defined as the management of “any risks for the information, material and product flows from original supplier to the delivery of the final product for the end user” (Jüttner et al., 2003, p. 7). Managing such risks does, in particular, not mean that such risks are necessarily prevented or handled in any specific way. Supply chain risk management is more generally understood as identifying, assessing and mitigating risks to enable the supply chain management to be prepared for as many eventualities as possible and define strategies and make projections based on the inherit risks of the supply chain. This generic process is detailed e.g. in Tummala and Schoenherr (2011, pp. 474-483). The tools of supply chain risk management are diverse and range from very basic qualitative tools, such as brainstorming, to sophisticated quantitative methods, such as social network analysis. Huth et al. (2017) provide a catalogue of methods used in supply chain risk management, while Fan and Stevenson (2018, pp.205-230) review the existing scientific literature and concepts on supply chain risk management and Jereb et al. (2013, pp. 56-73) propose the use of a publicly available risk catalogue to identify supply chain risk. Düerkop and Huth (2018) give an extensive overview of risks concerning the logistical infrastructure. Mehralian et al. (2012, pp. 209–219) argue that such infrastructural risks are just one factor for pharma supply chain risks, with the choice of the right suppliers and logistical partners and their qualifications being similarly, or even more, crucial. Nevertheless, Bucalu and Jereb (2017, pp. 42-49) conclude, based on a regional survey in Slovenia, that risk management, even in the vulnerable and sensible pharma sector, is still not a prime focus of supply chain managers.

The literature on modelling pharma supply chains with the Supply Chain Operations Reference (SCOR) model is mostly modelling a specific national or regional pharma supply chain with the SCOR approach, e.g. for Morocco (Essajide & Ali, 2017), Iran (Rajabzadeh et al., 2013, pp. 193–205) or India (Kumar et al., 2015, pp. 743-770). Martinelly et al. (2009, pp. 436-456) describe a SCOR modelling approach in a broader scope, although only for the internal logistics of a hospital.

The SCOR model is, in contrast, regularly used as a supply chain risk management tool. Cagliano et al. (2012, pp. 817-840) use a SCOR model to identify and analyse risks along a supply chain. McCormack et al. (2008, pp. 1-32) develop a method to define internal and supply chain wide risk management strategies alongside a SCOR model. Finally, Badr and Stephan (2007, pp. 288-296) use the SCOR model to combine the two disciplines of supply chain risk management and security management and Abdolghasemi et al. (2015, pp. 280-302) develop a new supply chain risk management tool that maps the SCOR process to a Bayesian network.

3. OVERVIEW OF THE MODEL

The purpose of the model is to calculate a risk score for the entire transportation chain of a specific good on a specific supply lane, using specific partners and a specific routing. While the product itself and the supply lane, consisting solely of a source and sink relation, are usually fixed for any transportation planned, the exact routing and the potential logistical partners are not. Thus, varying the routing and partners, which are often interdependent, several options of shipping the same good from the same source to the same sink can be compared to minimize the overall risks of the logistical process.

The relevant risks may arise for a variety of reasons. They may be attributed to the lane, the geographic locations along the route, the specifics of the product or directly to the partners of the lane.

Therefore, the lane needs to be modelled in a generic way, so the partners are comparable and their out- and incoming processes can be matched. Since the Supply Chain Operations Reference (SCOR) model provides this with standard metrics to measure the performance, the SCOR-model was chosen as generic process modelling tool.

As influence parameters on the risk score three categories were determined: 1. Requirements, 2. Capabilities, and 3. External risk factors.

In the following sections these categories are explained and matched to each other. On that basis, an algorithm can be defined to calculate the risk score.

4. MODEL

In this chapter we explain the different elements which are then joined into the risk assessment model. First, we describe the SCOR model which is used to model the logistical process. Afterwards the influencing parameters are shown, and finally the model is developed.

4.1. SCOR for pharma transport

The SCOR model is a supply chain management model developed by the Supply Chain Council which was founded in 1996 and is now part of US-based company APICS.[1] The SCOR model consist of four levels. The first level defines the processes types, the second level is the configuration level and the third level describes the process elements (see **Error! Reference source not found.**; Huang et al., 2005, pp. 377-394). The fourth level is not in scope of SCOR, and can be used to model specific and detailed activities within the process elements.

[1] APICS – The Association for Operations Management (formerly American Production and Inventory Control Society)

Figure 1. The SCOR framework

	Level		Examples	Comments
	#	Description		
Within scope of SCOR	1	Process Types (Scope)	Plan, Source, Make, Deliver, Return and Enable	Level-1 defines scope and content of a supply chain. At level-1 the basis-of-competition performance targets for a supply chain are set.
	2	Process Categories (Configuration)	Make-to-Stock, Make-to-Order, Engineer-to-Order Defective Products, MRO Products, Excess Products	Level-2 defines the operations strategy. At level-2 the process capabilities for a supply chain are set. (Make-to-Stock, Make-to-Order)
	3	Process Elements (Steps)	• Schedule Deliveries • Receive Product • Verify Product • Transfer Product • Authorize Payment	Level-3 defines the configuration of individual processes. At level-3 the ability to execute is set. At level-3 the focus is on the right: • Processes • Inputs and Outputs • Process performance • Practices • Technology capabilities • Skills of staff
Not in scope	4	Activities (Implementation)	Industry-, company-, location- and/or technology specific steps	Level-4 describes the activities performed within the supply chain. Companies implement industry-, company-, and/or location-specific processes and practices to achieve required performance

Source: Supply Chain Council, 2012

Level 1 consists of the six core process types (see APICS 2018):

- Plan,
- Source,
- Make,
- Deliver,
- Return and
- Enable.

In order to implement the generic process, the used process steps need to be defined. The SCOR model was developed for production industry, where the focus lies on the production of goods. In this use case the post-production transport of pharmaceutical goods to the wholesaler or customer is in focus. Therefore, only logistical process steps were taken into account and clustered. The main used process types were “Source”, “Deliver” and “Enable”, and the level 2 process “make-to-order”, was presumed as “Make”-process. The process, however, was not entirely developed over all process steps, as only in such a simplified way it was feasible to test the model. However, the process is not in focus of this paper.

4.2. Requirements

In each process step, tasks need to be executed. The selection of the required tasks can derive from different sources. This is defined as requirements. The source of the requirements can be divided into three categories: requirements related to the specifications of the product, the specifications of the business or regulatory specifications. In this section, the different origins of the requirements are discussed and presented.

4.2.1. Regulatory

Depending on the good, the transport process can be highly regulated. In case of pharmaceutical transports there is a globally valid regulation of the WHO and, where applicable, additional national or regional regulations (European Commission, 2013; Silveira, 2017; USP, 2009). These regulations have a tremendous impact on the requirements a transport has to fulfill.

For a transnational shipment, several regulations may also be active and have to be fulfilled. In that case each process step has to be connected to a geographic location, which must be matched with the active regulation.

The splitting of the regulations developed around 500 requirements of different granularity for each regulation. Depending on the granularity of the risk algorithm the set of requirements has to be chosen.

In our research, we developed eight main categories the examined regulations had in common, thus which have to be fulfilled by the LSPs of pharmaceutical goods. These are:

1. Quality Management,
2. Personal & Training,
3. Premises & Equipment,
4. Documentation,
5. Returns/Complains/Theft,
6. Outsourcing,
7. Self-inspections, and
8. Transport.

4.2.2. Product

Product requirements are (transport-related) requirements indicated by the product specification. Pharmaceutical products consist of “living” ingredients, for example molecules, which can be destroyed when exposed to unfavorable conditions. Therefore, these have to be handled with special care. Different attributes have to be maintained during transport, for example temperature, humidity or vibrations. If the transport of a product does not match these requirements, the product might have to be scrapped to avoid any harmful impact to the patient. Such product requirements have to be fulfilled over the whole transport lane and by every partner at all times.

Furthermore, the packaging of the products has to be considered. The packing is the first protection against external impacts. Depending on the kind of packaging, it is possible, that product specifics are irrelevant to be further controlled during transport. For example, if a product is packed in an active cooling device, which energy source outlast the transport time by far, it can be assumed that any temperature-related requirements can be ignored.

4.2.3. Business

The final source of requirements is the business itself. Pharmaceutical companies usually have their very own corporate constraints, which can be different or stricter than possibly applied external regulations. These occur as a result of experiences made or based on the physical location of the company. These constraints, implicit or explicit, can have an influence on the transport and on the capabilities needed to be admitted serving another company.

Businesses can have multiple locations which are located in one or more countries. Therefore, business constrains need to be classified by the site for which they are applicable. Such classifications can range from "only for one location", over "only in one or more countries" to "global constraint", which applies for all business units.

They can also only be active for one process step, only special products or management processes. An example could be a special loading ramp or specifications for loading vehicles.

Each business has their own requirements documented. For the generic model, they should have a similar granularity as the external requirements and have to be created together with business experts who can deliver input. This is not discussed any further in this paper, since this is part of the development of the tool.

4.3. Capabilities

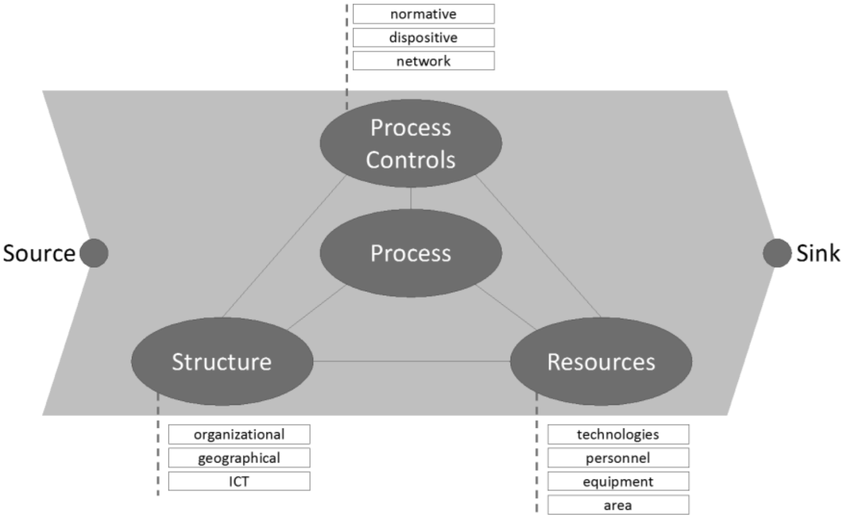
The requirements, arising from the process, have to be fulfilled by the LSPs. Requirements are fulfilled with capabilities. Capabilities are tools, processes, resources, structures, etc. a company can buy, implement or build in order to be capable to fulfill a task. Capabilities can be available in different variations and granularities. For the model, the granularity of the capabilities must be matched with the granularity of the requirements. Otherwise, a matching or risk calculation would not be feasible.

For the model, the capabilities of a company have to be matched to the sites of it. A company can have global capabilities, for example a quality management system which is implemented throughout the corporation, or site-specific capabilities, for example a loading or cooling feature or back-up system that is a physical infrastructure in place at a single or some sites.

A structure for process capabilities can be derived from the process chain model as shown in **Figure 1** (Käppner 2002). Three aspects have to be considered for capabilities, each supplied with subcategories:

- *Processes:* normative, dispositive, network;
- *Structures:* organizational, geographical, information- and communication technology; and
- *Resources:* technologies, personnel, equipment, area.

Figure 1. Process chain model



Source: authors' representation based on Käppner (2002)

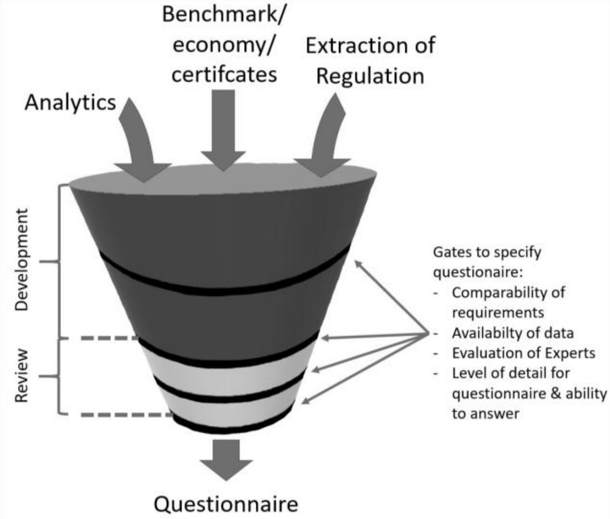
A company can match a requirement with a capability. If a requirement is not met, this implies a risk. In particular, unmet requirements do not necessarily lead to failure of the process; they just increase the risk of failure. A pharmaceutical good that has to be transported at room temperature might well meet that requirement even if the temperature is not actively or passively controlled at any point, if the transportation is geographically routed through regions with favorable climate conditions. If the same transport, however, is being placed on the tarmac of an airport in an extremely cold or hot region for hours, while in transit, it is likely to be heavily affected and will not meet the requirements anymore. Capabilities can meet one or more requirements; requirements can be met by one or more capabilities. Thus, requirements and capabilities are connected with a m-to-n connection with m,n $\in \mathbb{N}\_(> 0)\hat{}$.

For the model, the capabilities of a company have to be enquired and attributed to the relevant sites. To avoid a complex auditing process, the capabilities could be retrieved in a more efficient way, e.g. by using a questionnaire. This would be an efficient and easily applicable way to gather the main capabilities of a company, across various sites in different locations.

The required capabilities need to be developed for the model, as mentioned above in a suitable granularity. One approach to do this, is the use of the so-called funnel. This approach was used to address the wide scope of the research for different capabilities and to ensure nothing is missed out. The structure, which includes different quality gates to pass, enables a process to compress and sharpens them, so a matching granularity with the requirements can be found.

With this in mind, the funnel can be "filled" from different angles: with benchmarks, evaluations of regulations and certificates or analytics of different tools or companies, always considering the different process chain elements (see **Error! Reference source not found.**).

Figure 3. Schematic funnel, to develop questionnaire for capabilities



Source: authors

A certificate is a proof of the ability to perform a special task, the presence of certain knowledge or the compliance with certain standards in the overall operations.

Certificates can be considered as “stand-alone” capabilities or as “pre-selection” of the capabilities contained in the questionnaire. The use depends on the implementation of the algorithm and the complexity of the risk model. In the development phase of the model it was used as a pre-selection method. Subsequently, the certificates had to be matched with the capabilities. This connection can be established by analyzing the certificates in detail.

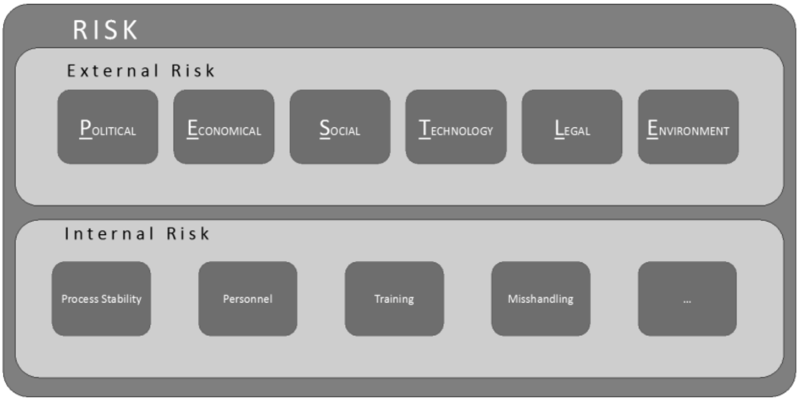
For the model, the possession of a certificate gives the company the connected capabilities. For example, in section 0 eight categories for regulatory requirements were developed, one category being “quality management”. ISO:9000 is a norm for a standardized quality management. Companies have the possibility to get certified by ISO:9000. Should a company be certified, the requirement for having a quality management would be satisfied. These questions can then be skipped in the questionnaire.

4.4. Risks

In this section the different risk categories are shown and explained (see **Figure 2**). Risks concerning the used logistical infrastructure, and the usage of it, are an additional threat to every transport, including those of pharmaceutical goods (see Düerkop & Huth 2017, p.14).

Apart from such external risks, a number of internal or internalized risks have an impact on the transportation process. There is a range of efforts to identify the best logistics partner or service provider to ensure a certain quality of the process (see Liu et al. 2013, pp. 3963–3976; Liu et al. 2014a, pp. 2327–2344; Liu et al. 2014b, pp. 6608–6626). As logistics outsourcing is already the norm rather than the exception, such risks of mismanagement or mishandling by a contracted partner is a major internal or, by contract, internalized risk. While the financial risk of any physical damage caused by a subcontractor can be mitigated by a sufficient regulatory and contractual framework, the possible damage to patients that mishandled pharmaceutical goods can cause cannot be mitigated.

Figure 2. Risk categories



Source: authors

4.4.1. External Risks

The external risks can be quantified by external, and often publicly available, datasets. While the following paragraph does describe a few of such external risks and does provide some possible datasets to use, it should be understood as being incomplete. As the scope of this work is mainly to provide an insight into the general setup of the supply chain risk management process, along the SCOR model, it cannot go into detail for most external risks.

4.4.1.1. Political Risks

The most relevant political risk for the transportation of pharmaceutical goods, as argued above, is theft or, more generally, crime. The most complete and reliable data sources, such as the UNODC (2017) statistic on homicide, however, do consider crimes that are not only not specific enough, but might lead to a gross miscalculation of risks. While the homicide rate in Poland, for example, is one of the lowest in Europe, the country is amongst the ones with the most cargo theft incidents in Europe, according to Morai Logistics (n.d.). Thus, the best available indicator for cargo theft risks remains the more specified Incident Information Service (IIS) of the Transported Asset Protection Association (2018), filtered to theft incidents. The nature of this source, however, which relies on incident reports by its members (Transportation Asset Protection Association, 2019) inherits a strong negative bias for countries and territories with more members who actively provide reports. As a result, analyzing the database indicates that cargo theft nearly exclusively occurs in North America and Europe as well, proving the negative bias.

To get an indicator of the security of a region or country, the travel security advice of the Foreign and Commonwealth Office (2019) of the UK government was used. While those official travel advice datasets are also occasionally politically motivated, as Sharpley et al. (1996, pp.1-7) argue, they do reflect the current overall security situation better than most comparable sources.

Measuring corruption, another major threat for logistics operations, Transparency Internationals (2018) Corruption Perception Index (CPI) is taken into account. The CPI itself is a meta-index, based on several data sources to avoid a bias as good as possible.

Finally, the ease of trading across borders is taken into account by analyzing the Ease of Doing Business report of the World Bank (2019b). While this report measures the time and costs associates to trades between the major cities in both concerned countries only, and thus must deviate a lot from the time and costs associates to trade between very rural regions of the same countries, it gives a very reliable indicator potent enough to allow a ranking of the ease of trading across borders.

4.4.1.2. Social Risks

Social risks are usually defined as all risks that inherit the risk for individuals and groups of individuals to lose their current social status. Thus, social risks, by definition, initially hit individuals or groups of individuals.

While individuals and even group of individuals usually are not potent enough to debilitate the logistical infrastructure or even successfully prevent a logistical transportation entirely, a realized loss of social status can eventually lead to severe reactions of individuals and groups of individuals who then directly turn against the successful fulfilment of a logistical operation, for example by labour strikes or active blockades.

A list of examples of such social risk realization can be found in Düerkop and Huth (2017).

Social risks are often individual events and there is no database that is able to be considered a base for a scientifically justified risk management. Thus, social risks will not be further considered.

4.4.1.3. Technological Risks

Accidents are a major source of risk for any logistical transportation. Not only may goods and loads directly be affected and damaged or entirely destroyed by accidents, but regularly hundreds of other trucks, vessels, trains or cargo planes are indirectly affected and sometimes severely delayed. Especially cool-chain goods might subsequently be damaged by such delays, if they are not actively cooled.

Data availability on accidents and crashes, however, remains a major challenge to consider such risks. For air cargo transportations, the International Air Transport Association (2015) publishes a safety report regularly. This report, in particular, lists all accidents by region and by airline for the last decade, including, but not limited to, air cargo flight incidents. As accident numbers are quickly and drastically decreasing over the last few decades, the data, however, became too scarce to be a valid base to predict the future. Additionally, the regions monitored are continental regions, which is a far too broad basis to derive detailed risk scores for specific subregions, countries or even airports.

Data for train or sea freight accidents is not available on a global or even continental level at all. Road accident statistics are available, published annually by the World Health Organization (2019), but only consider fatal accidents and might thus not represent the actual risk of the occurrence of an accident. While Germany, e.g., had less road fatalities than Italy and France in 2016, nearly twice as many people got injured by accidents than in Italy and nearly six times as many as in France, suggesting that Germany does not necessarily have less road accidents than Italy or France, but a lower rate of those end fatally, according to the European Road Safety Observatory (2019, pp. 205-230).

Other technological risks, such as the frequency and severeness of energy blackouts (World Bank 2019a)[2] and cyber-attacks (International Telecommunications Union 2017), are well available, but have less impact on transportations in general. Thus, they will be considered in the following, but are one of the less weighted factors.

Finally, statistics on airport performances and road congestions are only collected by private companies and regularly suffer either from a strong bias or a non-publication of the methodology underlying the published data.

4.4.1.4. Conclusion

While geographical risks, as mentioned above, are a major factor and well-researched, it is still difficult to retrieve reliable and scientifically justifiable data. Many datasets, including those of international institutions, are biased by design, and in many cases, the publishers do proactively admit that bias. It is simply impossible to get reliable and neutral data on car accidents or theft incidents in some places, especially in very restrictive countries that would not allow access to neutral international data mining institutions, such as the United Nations or World Bank. Thus, many data from countries like Eritrea[3] or Turkmenistan[4] is retrieved from local, sometimes governmental, institutions, who report data to the international institutions, while almost all data is missing from North Korea. Thus, such data, by design, is biased and could potentially be manipulated by the governmental institutions who mine the data on the ground.

Similar data uncertainties exist, often even to a bigger extend, for other risks that were considered within this study, such as the risk for strikes, currency devaluation risk, legal risks and weather and natural disaster related risks, which are not further

2 http://www.doingbusiness.org/content/dam/doingBusiness/media/Annual-Reports/English/DB16-

3 E.g. all data from the "Ease of Doing Business Reports" of the World Bank on Eritrea is mined by the local law firm "Berhane Gila-Michel Law Firm", see World Bank (2019c); p. 246

4 E.g. all car incident data on Turkmenistan is entirely reported by the Ministry of Health and Medical Industry of Turkmenistan and the State Committee on Statistics, see World Health Organization (2018); p.253

considered, as their description would not lead to significantly new insights for this study.

4.4.2. Internal Risks

Internal risks, and internalized risks, include all risks that directly stem from the quality of the operations of all partners in the supply chain. Due to the increased complexity of even a single supply lane from a single origin to a single destination, the number of LSP partners within such a chain is increasing rapidly. All partners within that supply chain, which are defined through the SCOR model, do inherit own risks. While a worker in the origin warehouse might make an erroneous labelling of a shipment, a worker of an airline might place a temperature-controlled shipment on the apron for too long to guarantee the temperate restrictions are still met. Similarly, all other partners could potentially damage pharmaceutical goods or cause delays.

Subsequently, potential partners along a supply lane need to be graded in some way to allow the supply chain manager of the pharmaceutical company to choose the right partners along a pre-defined lane. While capabilities of potential partners, often guaranteed by the compliance with certain regulatory frameworks, like the EU GDP, give an indication which risks are addressed by the potential partner, they are not sufficient to take a qualified and risk-averse decision alone. An airline could, e.g., have the capability of doing all transports 100 % actively temperature-controlled at all times. At the same time, however, the company could be well-known for using badly trained employees that regularly set the wrong temperature for the active-cooled transportation boxes. Then, subsequently, the capability of the availability of active-cooled transport boxes at all times does not necessarily lead to a likelihood of 0 % for a temperature deviation.

To take internal and, by cooperation internalized, risks into account, the model does consider rather subjective ratings and risk estimations for potential partners along the supply chain. Those risk estimations, which are an input to the model, are weighted and taken into account during the core algorithm to result in the output overall risk assessment of the supply lane.

4.5. Model definition

The developed model (see **Error! Reference source not found.**) is supposed to be able to calculate a risk score for using a specific supply chain. In the previous sections, the different elements of the model are explained. In this section, the elements are connected to form the overall model and show the result of the research.

Different partnering companies perform single or multiple steps of the process chain. Depending on these processes, requirements, stemming either from the process, the product, the business, or the regulation, arise and need to be fulfilled. Thus, a link between the process and the requirements need to be established.

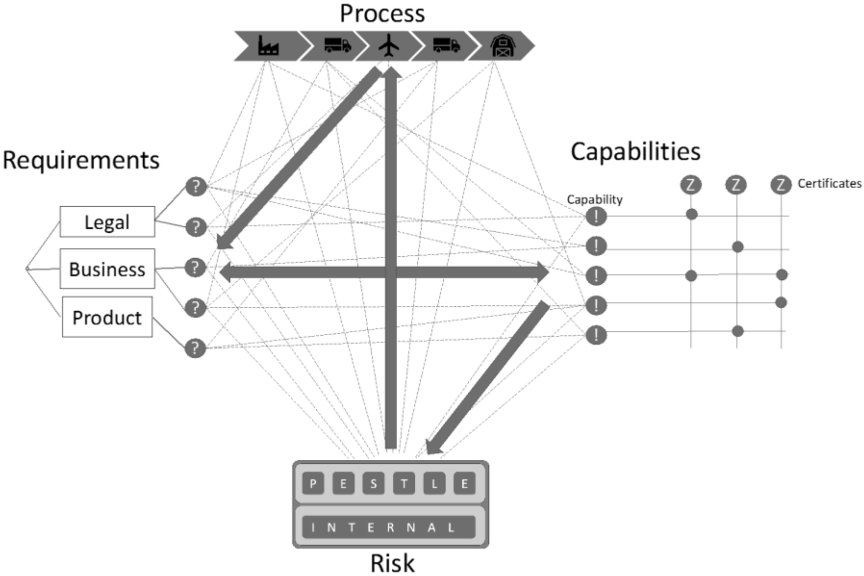
The availability to fulfill the requirements is demonstrated by the present capabilities of the company. Therefore, as stated previously in section 0, the connections between the requirements and the fulfilling capabilities have to be known.

If requirements can or cannot be fulfilled, this must be reflected in the risk score.

In summary, the following links were identified during the research:

- *Process ⇔ Requirement*
- *Requirement ⇔ Capability*
- *Capability ⇔ Risk*
- *Risk ⇔ Process*

Figure 5. Model for supply chain risk management



Source: authors
* the lines symbolize the many connections, the arrows one connection thread

Links can have different parameters, depending on the link and the algorithm. Via the link information, like a geographic- or process-location, can be transmitted or dependencies, like the need for a specific capability, can be implemented. This depends on the specific modulation and implementation of the model.

In order to implement the model, the following steps have to be taken, assuming all requirements, capabilities and risks-factors are already developed:

1. Development of process
   A generic process, in this use-case the pharma-lane, has to be developed. All relevant process steps need to be identified, so risk scores can be calculated for these.
2. Matching of process and requirements
   For each process steps, the requirements have to be formulated.
3. Matching of requirements and capabilities
   For all requirements, the possible “solving”-capabilities have to be identified and connected. Depending on the algorithm, these capabilities have to be weighted.
4. Calculation of risk / learning algorithm
   The risk calculation needs to be applied. Depending on whether the algorithm is self-learning or not, two approaches could lead to success:

a. Self-learning-algorithm: the algorithm has to be trained with real data of transports
b. Trained algorithm: evaluation and weighting of the capabilities and connections between requirements and capabilities need to be done by experts.

4.6. Algorithm

While not within the scope of this publication, it will be briefly outlined how an algorithm can derive a risk score RS_k for each process-step P_k of a selected routing inside a supply chain and thus, ultimately, for the whole supply chain.

For every step of the supply chain, the following sets of parameters P_i present the input of the algorithm:

- the geographical location of the process
- the product, including its container or packaging
- the selected logistics partner performing the specific step
- the type of the process

Based on this input, a risk assessment algorithm can now derive the following secondary parameters:

- the external risks based on the geographical location
- the internal and internalized risks based on the selected partner and the type of process
- the capabilities based on the selected partner
- the requirements based on the product

The algorithm now compares those secondary parameters to derive the risk score RS_k for the specific step of the SCOR process **Error! Reference source not found.**). The calculation of the specific risk score has dependencies to the specific modelling of the risk, requirements and capabilities and is not further discussed. Jereb (2013, pp.86-93), for example, shows how a specific risk score can be calculated.

$$\boldsymbol{RS_k} := \boldsymbol{Risk}\ (\boldsymbol{P_k}) := \boldsymbol{\Phi} \begin{pmatrix} \boldsymbol{ExternalRisk}(\boldsymbol{P_k}) \\ \boldsymbol{InternalRisk}(\boldsymbol{P_k}) \\ \boldsymbol{Capabilities}(\boldsymbol{P_k}) \end{pmatrix} \tag{1}$$

with

$$ExternalRisk\ (P_k) := \Phi_{ext} \begin{pmatrix} Location(P_k) \\ Requirements(P_k) \end{pmatrix};$$

$$InternalRisk\ (P_k) := \Phi_{int} \begin{pmatrix} SC-Partner(P_k) \\ Requirements(P_k) \end{pmatrix} \quad \text{and}$$

$$Capabilities\ (P_k) := \Phi_{Cap}\big(SC - Partner(P_k)\big)$$

with

$$Requirements\ (P_k) := \Phi_{req}\begin{pmatrix} Location(P_k) \\ Product(P_k) \\ SC-Partner(P_k) \end{pmatrix}$$

Hereby, risks are one-dimensional and can are understood as the product of probability and severity. Φ, Φ_{ext}, Φ_{int}, Φ_{cap} and Φ_{req} are functions, which map its parameters to a risk score, which are not further discussed here.

As an example, we can assume that the lane is a ground transport on a truck from Osijek, Croatia to Timisoara, Romania via Serbia with one cross-docking point. The product is a pharmaceutical good that needs to be transported and stored in a temperature range between two and eight degree Celsius and is stored in a simple box, that is not actively cooled. The chosen partner shall be a logistics company called "OsiTimLog". The secondary parameters in this example are thus:

- all geographical risks for crossing the border from Croatia to Serbia and from Serbia to Romania,
- all geographical risks that apply to Osijek, Northern Serbia and Timisoara,
- the risks linked to the company OsiTimLog,
- the capabilities of OsiTimLog,
- all requirements for chilled products in simple boxes.

Any of such parameters will now significantly influence the outcome of any algorithm. Should OsiTimLog, for example, have the capability "uses only chilled trucks" it would get a significantly better risk score than without such capability. If the Serbian-Romanian border is known to cause massive delays, the risk rating might become much worse, etc.

Once every single step of the SCOR process is assessed in the described way the S_{lane} is setup $\boldsymbol{RSlane = RS1, RS2, \dots, RSi}$

(2). The whole supply lane can be assessed by simply taking either the mean risk score $\boldsymbol{RiskScore} := \sum_{k=1}^{n} \boldsymbol{w_k R_k}$ with $\boldsymbol{w_k}$ being weight parameters.

(3) or the worst risk score along the supply lane $\boldsymbol{RS_{lane,worst}} := \boldsymbol{max}(\boldsymbol{RS_{lane}})$ (4). The weights w_k can be chosen by the supply chain manager of the company and are company specific.

Given the mechanisms of the algorithm, it is further capable of displaying the "worst leg" of and the "worst partner" along the supply lane, giving the decision maker an important base to mitigate the overall risks by changing either the routing or the partner for a part of the supply lane.

In **Error! Reference source not found.** a mockup of a possible algorithm is shown.

$$\boldsymbol{RS_{lane}} = \{\boldsymbol{RS_1}, \boldsymbol{RS_2}, \dots, \boldsymbol{RS_i}\} \tag{2}$$

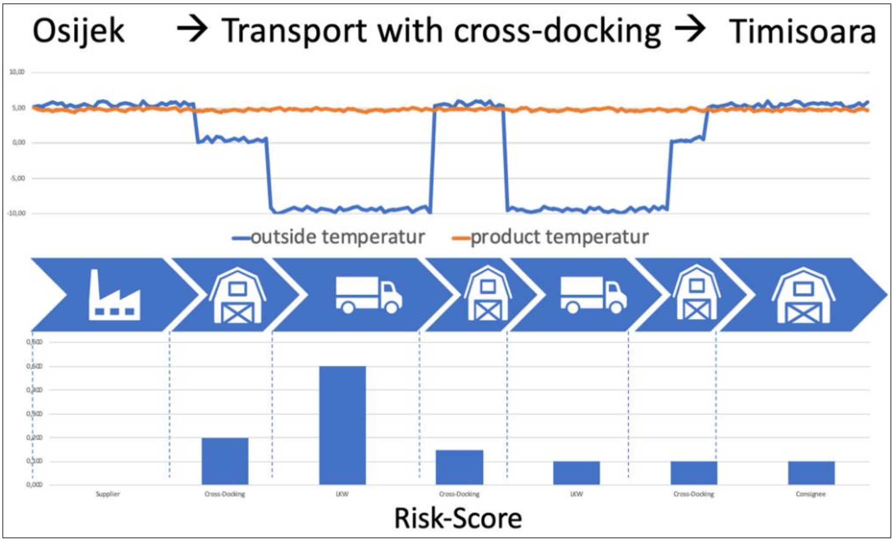
$\boldsymbol{RiskScore} := \sum_{k=1}^{n} \boldsymbol{w_k R_k}$ with $\boldsymbol{w_k}$ being weight parameters. (3)

with

$$\sum_{k=1}^{n} w_k = 1$$

$$RS_{lane,worst} := max(RS_{lane}) \quad (4)$$

Figure 6. Mock-Up of the algorithm



Source: authors
*On the top the outside and inside temperature of the shipment is shown. Below the different, generic process steps with the associated, specific risk-scores.

5. CONCLUSION

In this paper, a basic model for the risk calculation of a transport supply chain was developed. Considering all processes and requirements, a path was shown to develop capabilities to address these and to implement an algorithm to compute a risk score.

Going forward, this model needs to be implemented and tested with detailed, real data. The considered use-case was from the pharmaceutical industry, which could be generalized for other sensitive high-value goods as electronics, livestock or perishable goods (e.g. flowers, vegetables).

Furthermore, the used SCOR-process is a good model for comparison of industrial companies but is not yet adapted to logistical process were the production is not in focus. Either the SCOR model could be adapted to a “logistic-SCOR” or a logistics reference model should be developed instead.

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EVALUATION OF EFFICIENCY OF TRADE COMPANIES IN SERBIA USING THE DEA APPROACH

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Abstract

In recent years, the concept of company efficiency and its measurement using Data Envelopment Analysis (DEA) has received a great deal of attention in the professional literature. Keeping this in mind and taking into account that, to our knowledge, there is no comprehensive study on the efficiency of trade companies in Serbia using the DEA model, the paper seeks to explore this topic. The results of the research into the efficiency of the top 14 retailers in Serbia, suggest that, considering the existing macroeconomic environment, the overall efficiency of the commercial sector in Serbia is satisfactory. To promote the efficiency of trade companies in Serbia in the future, it is necessary to take full advantage of new business models, contemporary concepts of cost management, information and communication technologies, and the concept of sustainable development, by following the example of global retail chains. Developing a private label is another useful tool for increasing corporate efficiency. Companies would also benefit greatly from developing a private label and increasing organic food sales.

Key words: efficiency, technology, environment, DEA models, Serbia.

1. INTRODUCTION

In recent years, the concept of company efficiency and its measurement using Data Envelopment Analysis (DEA) has received a great deal of attention in many countries by scholars and practitioners alike. Keeping this in mind and taking into account that, to our knowledge, no comprehensive studies have been conducted on the efficiency of trade companies in Serbia using the DEA model, the paper seeks to explore this topic. Thus, the principal aim of the current research is to provide an assessment of the efficiency of the top 14 retailers in Serbia so that adequate measures for improvement of the overall performance of the commercial sector in Serbia can be developed and implemented. This is, among other things, the main contribution of the paper.

There is a wealth of international literature devoted to evaluating the efficiency and productivity of companies using the DEA method (Malmquist, 1953; Andersen & Petersen, 1993; Donthu & Yoo, 1998; Tone, 2001; Tone, 2002; Tone & Tsutsui, 2009; Tone & Tsutsui, 2010; Asmild et al., 2004; Fare et al., 1994; Fare eta al, 1995; Moreno, 2010; Vaz et al, 2010; Wang, 2011; Moreno & Sanz-Triguero, 2011; Vaz & Camanho, 2012; Lau, 2013; Gandhi & Shankar, 2014; Al-Refaie et al, 2015; Anand & Grover, 2015; Majumdar & Asgari, 2017; Bambe, 2017; Qiu & Meng, 2017; Sarmento et al, 2017 ; Ko et al, 2017; Hsu, 2018; Haidar, 2018). However, this topic has not been sufficiently explored by Serbian authors (Lukic, 2015). To our knowledge, research aimed at exploring the efficiency and productivity of trade companies in Serbia using the DEA is almost non-existent. Hence, this paper aims to address the gap in the extant literature.

The main hypothesis of this research is that in order to improve the efficiency and productivity of trade companies, it is necessary to continuously assess these two factors using the DEA approach. Based on the results of the research, adequate measures can be developed and implemented to better control the factors affecting the efficiency of such companies. The paper is primarily focused on retailers in Serbia.

To measure retailer efficiency, various DEA models have been used in parallel, including the CCR model, the BCC model, the Super-Efficiency DEA model, and the Super Slacks-Based Model (SBM).

For the purpose of this research, the original empirical data were obtained from the Serbian Business Registers Agency. The data conform to International Accounting Standards and International Financial Reporting Standards and are thus comparable to similar data for the advanced economies. Therefore, the results of the research can be compared against the data for global retail chains, which will provide a good insight into the position of trade companies in Serbia in terms of their efficiency.

2. DEA MODELS

The paper provides a brief theoretical analysis of the DEA models including the CCR model, the BCC model, the Super-efficiency DEA model, the Slacks-Based Model, the Super Slacks-Based Model (Super SBM model), the radial super-efficiency model, and the DEA projection.

(A) CCR model

The CCR model is based on constant returns-to-scale. This means that a proportionate increase in all inputs results in a proportionate increase in all outputs. The dual of the multiplier from CCR is:

$$Min\ \theta$$

subject to constraints

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io} \qquad i = 1 \ldots..m$$

$$\sum_{j=1}^{n} \lambda_j y_{kj} \geq y_{ko} \qquad k = 1 \dots s$$
$$\lambda \geq 0 \qquad j = 1 \dots n$$

where θ means the technical efficiency of a decision-making unit (DMU), and λ is the dual variable for identification of comparable inefficient units. If θ* equals to one, this means that a DMU is technically efficient.

(B) BCC model

The CCR model was modified by introducing the BCC model (proposed by Banker-Charnes-Cooper), wherein the constant returns-to-scale (CRS) were replaced with variable returns-to-scale (VRS). A DMU operates under variable returns-to-scale assumption if an increase in input does not result in proportionate changes in output. The BCC model is expressed as follows:

$$Min\ \theta$$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io} \qquad i = 1 \dots m$$
$$\sum_{j=1}^{n} \lambda_j y_{kj} \geq y_{ko} \qquad k = 1 \dots s$$
$$\sum_{j=1}^{n} \lambda_{j=1} = 1 \qquad j = 1 \dots n$$
$$\lambda_j \geq 0$$

The BCC model divides technical efficiency (TE) obtained under the CCR model into: 1) pure technical efficiency (PTE), which ignores the impact of scale size by comparing a DMU to a unit of similar scale, and measures how a DMU utilizes inputs under exogenous conditions; and 2) scale efficiency (SE), which shows how scale size impacts efficiency. The latter is formulated as follows:

SE = TE / PTE

(C) Super-efficiency DEA model

Super-efficiency DEA model (Andersen and Petersen, 1993) can be formulated as follows:

$$\theta^* = \min \theta_0$$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta_0^S x_{io} \quad i = 1, \dots, m$$
$$\sum_{\substack{j=1 \\ j \neq o}}^{n} \lambda_j y_{rj} \geq y_{ro} \quad r = 1, \dots, s$$
$$\lambda_j \geq 0 \quad j = 1, \dots, n$$

The super-efficiency DEA model enables the ranking of efficient DMUs similar to ineffective DMUs, based on an efficiency ratio which can be greater than or equal to one.

(D) Slacks-Based Model

Assuming that the number of DMUs (n) is linked to the number of inputs (m) and the number of outputs (s). X_{ji} denotes the input of i[th] DMU_j, and Y_{jr} is the output of r[th] DMU_j. Next, assuming that all data are positive, i.e. X_{ji} and $Y_{jr} > 0$ for all possible i = 1, ... , m; r = 1, ... , s; j = 1, ... , n. The Slacks-Based Model proposed by Tone (2001) can be formulated as follows:

$$\min \rho_k = \frac{1 - \frac{1}{m} \sum_{i=1}^{m} S_i^- / X_{ki}}{1 + \frac{1}{s} \sum_{r=1}^{s} S_r^+ / Y_{kr}}$$

subject to

$$\sum_{j=1}^{n} \lambda_j Y_{ji} = Y_{ki} - S_i^-, i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j Y_{jr} = Y_{kr} + S_r^+, r = 1, \dots, s$$

$$\lambda_j \geq 0, j = 1, \dots, n$$

$$S_i^- \geq 0, i = 1, \dots, m$$

$$S_r^+ \geq =, r = 1, \dots, s$$

The reference point identified in the SBM model is ($X_{ki} - S_i^{-*}, Y_{kr} + S_r^{+*}$).

The essence of the SBM model is that by reducing input or increasing output, an inefficient DMU can be transformed into an efficient unit.

(E) Super Slacks-Based Model

Super SBM, proposed by Tone (2002), can be formulated as follows:

$$\min \rho_k^{ssbm} = \frac{1 - \frac{1}{m} \sum_{i=1}^{m} \frac{\overline{X}_i}{X_{ki}}}{1 + \frac{1}{s} \sum_{r=1}^{s} \frac{\overline{Y}_r}{Y_{kr}}}$$

subject to

$$\sum_{j=1}^{n} \lambda_j X_{ji} \leq \overline{X}_i, i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j Y_{jr} \geq \overline{Y}_r, r = 1, \dots, s$$

$$\lambda_j \geq 0, j = 1, \dots, n$$

$$X_{ki} \leq \overline{X}_i, i = 1, \dots, m$$

$$Y_{kr} \geq \overline{Y}_r, r = 1, \dots, s$$

$$\overline{Y}_r \geq 0, r = 1, \dots, s$$

The reference point identified in the Super SBM model is ($\overline{X}_i^*, \overline{Y}_r^*$).

Output-oriented Super SBM can be formulated as follows:

$$minimize\ \delta = \frac{\frac{1}{m}\sum_{i=1}^{m} X_i^*/X_{iq}}{\frac{1}{r}\sum_{i=1}^{r} Y_i^*\ /Y_{iq}}$$

subject to

$$\sum_{j=1,\neq q}^{n} X_{ij}\lambda_j + S_i^- = X_{iq}, i = 1, 2, \dots, m$$
$$\sum_{j=1,\neq q}^{n} Y_{ij}\lambda_j - S_i^+ = Y_{iq}, i = 1, 2, \dots, r$$
$$X_i^* \geq X_{iq}, i = 1,2, \dots, m$$
$$Y_i^* \leq Y_{iq}, i = 1, 2, \dots, r,$$
$$\lambda, S^+, S^-, Y^* \geq 0$$

Input-oriented Super SBM can be formulated as follows:

$$minimize\ \delta_I = \frac{1}{m}\sum_{i=1}^{m} X_i^*\ /X_{iq}$$

subject to

$$\sum_{j=1,\neq q}^{n} X_{ij}\ \lambda_j + S_i^- = X_{iq}, i = 1, \dots, m$$
$$\sum_{j=1,\neq q}^{n} Y_{ij}\lambda_j - S_i^+ = Y_{iq}\ , i = 1,2, \dots, r$$
$$X_i^* \geq X_{iq}, i = 1, \dots, m$$
$$Y_i^* = Y_{iq}\ , i = 1,2, \dots, r$$
$$\lambda, S^+, S^- \geq 0$$

3. EFFICIENCY OF TRADE COMPANIES IN SERBIA

The current chapter evaluates the efficiency of the top 14 retailers (DMUs) in Serbia in 2017 using the DEA approach. Table 1 shows input/output data. For the purpose of this evaluation, the cost of goods sold, earnings per employee, and capital are considered as inputs, while revenue and profit are considered as outputs.

Table 1. Input/output data

DMU	(I) Cost of goods sold (in RSD million)	(I) Earnings per employee (in RSD million)	(I) Capital (in RSD million)	(O) Revenue (in RSD million)	(O) Profit (in RSD million)
Delhaize Serbia	69,345	8,347	53,740	94,884	4,264
Mercator-S	73,310	6,135	14,147	90,747	-6,851

Nelt Co.	69,520	3,159	11,481	78,024	1,330
Mol Serbia	37,001	354	9,770	40,369	759
Knez Petrol	36,473	638	1,888	39,218	592
Phoenix Pharma	34,823	878	4,750	37,689	738
Mercata	35,143	610	866	36,360	342
Veletabak	29,092	786	775	31,610	556
OMV Srbija	26,196	178	8,427	30,406	109
Lukoil Srbija	25,094	414	7,837	29,158	1,880
Delta Agrar	20,899	684	16,612	27,772	829
Metro Cash & Carry	22,811	1,278	4,185	26,660	-203
Dis	19,093	934	6,229	22,623	131
Jugoimport - SDPR JP	11,563	972	16,705	21,977	3,133

Source: Serbian Business Registers Agency

Table 2 provides descriptive statistics of input/output data.

Table 2. Descriptive statistics of input/output data

Statistics of input/output data (in RSD million)

	Cost of goods sold	Earnings per employee	Capital	Revenue	Profit
Max	73,310	8,347	53,740	94,884	4,264
Min	11,563	178	775	21,977	-6,851
Mean	36,454.5	1,811.93	11,243.7	43,392.6	543.5
SD	19,227.5	2,356.47	12,863.9	24,091.8	2,371.8

Source: Authors' calculations using the DEA model - DEA-Solver LV8.0/CCR (CCR-I)

The data in Tables 1 and 2 show that earnings per employee were above the average only in three retail companies: Delhaize Serbia, Mercator-S and Nelt Co. This is a significant efficiency factor, especially when measured as profit per employee.

Table 3 shows the correlation matrix of input/output data.

Table 3. Correlation matrix of input/output data

Correlation	Cost of goods sold	Earnings per employee	Capital	Revenue	Profit
Cost of goods sold	1	0.82335	0.47488	0.97876	-0.292
Earnings per employee	0.82335	1	0.80089	0.91461	-0.1254
Capital	0.47488	0.80089	1	0.62628	0.36623
Revenue	0.97876	0.91461	0.62628	1	-0.2304
Profit	-0.292	-0.1254	0.36623	-0.2304	1

Source: Authors' calculations using the DEA model - DEA-Solver LV8.0/CCR (CCR-I)

The data in Table 3 show that there is a significant positive correlation between earnings per employee and the cost of goods sold, capital, and income. Moreover, there is a weak negative correlation between the earnings per employee and profit. Considering that profit per employee is a major efficiency indicator, it is necessary to increase the efficiency of human resources management in trade companies in Serbia. There is also a significant correlation between capital and earnings per employees and income. However, the relationship between capital and the cost of goods sold and profit is weak. This suggests the need for more effective management of capital.

Table 4 shows a comparative analysis of the efficiency of the top 14 retailers in Serbia in 2017 using the DEA approach.

Table 4. Efficiency of the top 14 retailers in Serbia using DEA models SSR and BCC

No	DMU	Model = SSR - I		Model = SSR - O		Model = BCC - I		Model = BCC - O		RTS of projected DMU
		Score	Rank	Score	Rank	Score	Rank	Score	Rank	
1	Delhaize Serbia	0.885	14	0.885	14	1	1	1	1	Decreasing
2	Mercator-S	1	1	1	1	1	1	1	1	Constant
3	Nelt Co.	0.9508	11	0.9508	11	1	1	1	1	Decreasing
4	Mol Serbia	1	1	1	1	1	1	1	1	Constant
5	Knez Petrol	1	1	1	1	1	1	1	1	Constant
6	Phoenix Pharma	0.9541	10	0.9541	10	0.9574	14	0.9619	14	Decreasing
7	Mercata	1	1	1	1	1	1	1	1	Constant
8	Veletabak	1	1	1	1	1	1	1	1	Constant
9	OMV Srbija	1	1	1	1	1	1	1	1	Constant
10	Lukoil Srbija	1	1	1	1	1	1	1	1	Constant
11	Delta Agrar	0.9431	12	0.9431	12	0.9687	13	0.977	13	Decreasing
12	Metro Cash & Carry	0.9724	9	0.9724	9	1	1	1	1	Increasing
13	Dis	0.9333	13	0.9333	13	1	1	1	1	Increasing
14	Jugoimport - SDPR JP	1	1	1	1	1	1	1	1	Constant
	Statistics									
	Mean	0.9742			0.9742	0.9947		0.9956		
	Max	1			1	1		1		
	Min	0.885			0.885	0.9574		0.9619		
	SD	0.036			0.036	0.0136		0.0115		

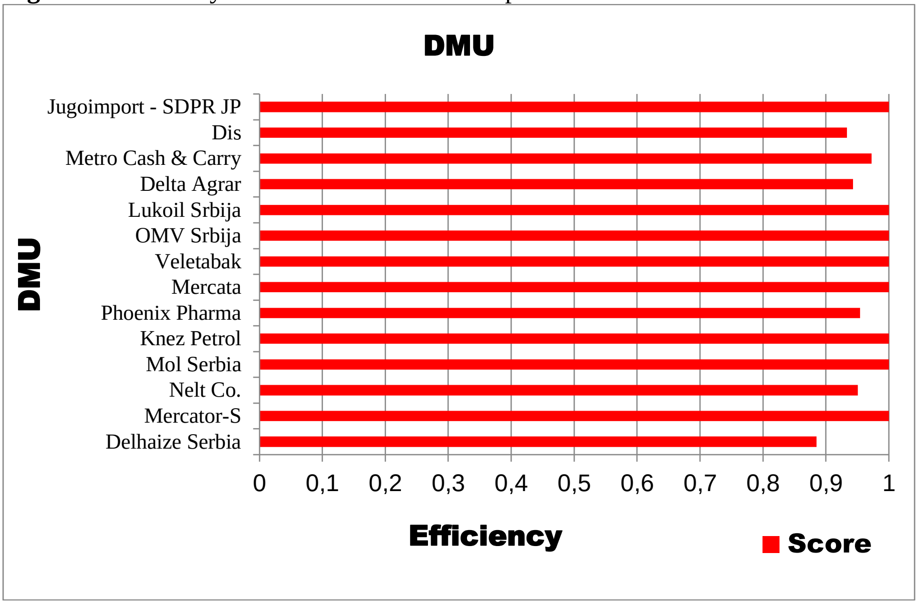
Authors' calculations using the DEA model - DEA-Solver; Returns-to-Scale (RTS)

The data in Table 4 show that in the input-oriented model SSR - I with constant returns to scale, eight of the 14 companies are efficient, while six are inefficient. The output-oriented model SSR – O with constant returns to scale shows the same results. In the input-oriented model BCC – I with variable returns to scale, twelve companies are efficient, while two are inefficient. The output-oriented model BCC – O with variable returns to scale shows the same results. Delhaize Serbia retail chain is efficient in the BCC - I model and the BCC – O model, but inefficient in the SSR - I and SSR – O models. In order to improve its efficiency, Delhaize Serbia needs to manage its inputs better, i.e. optimise the usage of inputs. Mercator-S is efficient in both DEA models. Delhaize Serbia and Mercator-S, as the top two companies in

Serbia, control the retail market. Such market position has had a positive impact on their efficiency. Companies engaged in the trading in petroleum products (Mol Serbia, Knez Petrol, OMV Srbija, Lukoil Srbija) are efficient in both DEA models. The results of these calculations indicate that, in general, the efficiency of companies in Serbia is satisfactory.

Figure 1 shows the efficiency of the observed trade companies in Serbia in the CCR – I model.

Figure 1. Efficiency of the observed trade companies in Serbia in the CCR – I model



Source: Figure created by the authors

Naturally, the issue of inefficiency must be addressed so as to increase the overall efficiency of companies in Serbia. Efficiency can be enhanced by decreasing inputs or increasing outputs. Table 5 shows the results of the analysis of slacks identified in trade companies in Serbia using the slacks-based measure (CCR – I) for 2017.

Table 5. Slacks-based measure of the efficiency of the top 14 retailers in Serbia (in RSD million)

CCR - I model				Slack	Slack	Slack	Slack	Slack
No.	DMU	Score	Rank	Cost of goods sold	Earnings per employee	Capital	Revenue	Profit
1	Delhaize Serbia	0.885	14	0	2,240.67	0	0	3,467.78
2	Mercator-S	1	1	0	0	0	0	0
3	Nelt Co.	0.9508	11	0	0	0	0	732.273
4	Mol Serbia	1	1	0	0	0	0	0
5	Knez Petrol	1	1	0	0	0	0	0

6	Phoenix Pharma	0.9541	10	0	0	0	0	400.613
7	Mercata	1	1	0	0	0	0	0
8	Veletabak	1	1	0	0	0	0	0
9	OMV Srbija	1	1	0	0	0	0	0
10	Lukoil Srbija	1	1	0	0	0	0	0
11	Delta Agrar	0.9431	12	0	0	1,897.08	0	1,017.93
12	Metro Cash & Carry	0.9724	9	0	0	0	0	551.5
13	Dis	0.9333	13	0	0	0	0	986.878
14	Jugoimport - SDPR JP	1	1	0	0	0	0	0
	Statistics							
	Mean	0.9742	5.5	0	160.048	135.506	0	511.213
	Max	1	14	0	2,240.67	1,897.08	0	3,467.78
	Min	0.885	1	0	0	0	0	0
	SD	0.036	5.5157	0	598.844	507.016	0	935.528

Source: Authors' calculations using the DEA model - DEA-Solver

The Data in Table 5 indicate that, for example, for Delhaize Serbia to be even more efficient, it should reduce spending on salaries by RSD 2,240.67 million (26.84%) and increase profit by RSD 3,467.78 million (81.32%). The same should be done by other inefficient companies in Serbia (Nelt Co., Phoenix Pharma, Delta Agrar, Metro Cash & Carry, and DIS). In order to increase the overall efficiency of the commercial sector in Serbia, it would be necessary to reduce spending on salaries by RSD 160,048 million, reduce capital by RSD 135,560 million, whereas profit should be increased by RSD 511,213 million. All of these are average values.

To gain a detailed insight into the efficiency of the top 14 retailers in Serbia, the authors have also employed the Super - SBM model (Table 6).

Table 6. Efficiency of the top 14 retailers in Serbia in the Super - SBM model

No	DMU	Super – SBM oriented (Super – SBM – I – C)		Super – SBM oriented (Super – SBM – O – C)		Super – SBM oriented (Super - SBM – I – V)		Super – SBM non-oriented (Super - SBM - C)		Super – SBM non-oriented (Super - SBM - V)	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
1	Delhaize Serbia	0.682196	14	0.556994	11	1	1	0.433695	12	1.76411	1
2	Mercator-S	1.017366	7	1.023063	6	1	1	1.017366	6	1.068651	9
3	Nelt Co.	0.729452	13	0.585817	10	1	1	0.484675	10	1.234287	6
4	Mol Serbia	1.016094	8	1.014256	8	1	1	1.014256	8	1.115402	8
5	Knez Petrol	1.01861	6	1.017843	7	1	1	1.015747	7	1.056217	10
6	Phoenix Pharma	0.743666	12	0.679277	9	0.7449	14	0.655812	9	0.731884	13
7	Mercata	1.170516	5	1.140862	5	1	1	1.140862	5	1.155133	7
8	Veletabak	1.474926	2	1.342994	2	1	1	1.31646	3	1.372624	5
9	OMV Srbija	1.187271	4	1.19934	4	1	1	1.171159	4	1.432274	3
10	Lukoil Srbija	1.371338	3	1.335672	3	1	1	1.334685	2	1.383081	4
11	Delta Agrar	0.823307	10	0.489737	12	0.8474	13	0.446335	11	0.481604	14
12	Metro Cash & Carry	0.836835	9	0.136337	14	1	1	0.116342	14	0.999166	12
13	Dis	0.754688	11	0.164536	13	1	1	0.132975	13	0.999635	11

14	Jugoimport - SDPR JP	1.872204	1	2.159292	1	1	1	1.668972	1	1.737511	2
	Statistics										
	Mean	1.049891		0.917573		0.9709		0.853524		1.180827	
	Max	1.872204		2.159292		1		1.668972		1.76411	
	Min	0.682196		0.136337		0.7449		0.116342		0.481604	
	SD	0.328668		0.51511		0.0767		0.459274		0.336286	

Source: Authors' calculations using the DEA model - DEA-Solver

This measurement method also points to the conclusion that, overall, the efficiency of trade companies in Serbia is satisfactory.

An even more detailed insight into the efficiency of the top 14 retailers in Serbia in 2017 has been obtained using radial super-efficiency DEA (Table 7).

Table 7. Efficiency of the top 14 retailers in Serbia in the radial super-efficiency model

No	DMU	Super – Radial - SSR - I		Super – Radial - SSR - O		Super – Radial - BCC - I		Super – Radial - BCC - O	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank
1	Delhaize Serbia	0.885043	14	0.885043	14	1	12	1.905309	2
2	Mercator-S	1.047215	6	1.047215	6	3.065721	2	1.147423	5
3	Nelt Co.	0.954873	10	0.954873	10	2.789806	3	1.519595	3
4	Mol Serbia	1.024983	8	1.024983	8	2.13251	5	1.239417	4
5	Knez Petrol	1.026054	7	1.026054	7	1.319677	9	1.083332	6
6	Phoenix Pharma	0.954087	11	0.954087	11	0.957356	14	0.961933	14
7	Mercata	1.327915	5	1.327915	5	1.697337	7	1	7
8	Veletabak	1.871808	2	1.871808	2	2.246235	4	1	7
9	OMV Srbija	1.49794	4	1.49794	4	1.988744	6	1	7
10	Lukoil Srbija	1.573848	3	1.573848	3	1.607623	8	3.093739	1
11	Delta Agrar	0.943087	12	0.943087	12	0.968747	13	0.976961	13
12	Metro Cash & Carry	0.975074	9	0.975074	9	1.019476	11	1	7
13	Dis	0.933311	13	0.933311	13	1.114605	10	1	7
14	Jugoimport - SDPR JP	3.616612	1	3.616612	1	4.715518	1	1	7
	Statistics								
	Mean	1.330846		1.330846		1.901668		1.280551	
	Max	0.69633		0.69633		1.024029		0.564381	
	Min	3.616612		3.616612		4.715518		3.093739	
	SD	0.885043		0.885043		0.957356		0.961933	

Source: Authors' calculations using the DEA model - DEA-Solver

The data in Table 7 show that all 14 companies are inefficient in the Super - Radial - SSR - I and Super - Radial - SSR – O models. In the Super - Radial – BCC model, only one of the 14 companies is efficient. In the Super - Radial - BCC – O model, six of the 14 companies are efficient. This suggests that it is imperative to manage inputs and outputs more efficiently in order to achieve the efficiency frontier.

When measuring efficiency, it is important to consider the deviation of current input/output data from their projections. Table 8 shows this data for the top 14 retailers in the CCR - I model for 2017.

The data in Table 8 indicate that, for example, in the case of Delhaize Serbia, the costs of goods sold, earnings per employee, and capital increased by -11.496%, -38.34%, and -11.496%, respectively, while profit decreased by 81.327%, in comparison to projections. This has negatively impacted the company's effectiveness. Similar results were obtained for other inefficient companies. As far as efficient companies are concerned, for example Mercator-S, the input/output data match the projections.

Table 8. Projections of efficiency of input/output data of the top 14 retailers in Serbia using the CCR – I model

Model = CCR-I				Cost of goods sold			Earnings per employee			Capital			Revenue			Profit		
No.	DMU	Score	Rank	Data	Projection	Diff. (%)	Data	Projection	Diff. (%)	Data	Projection	Diff. (%)	Data	Projection	Diff (%)	Data	Projection	Diff. (%)
1	Delhaize Serbia	0.885	14	69,345	61,373.3	-11.496	8,347	5,146.79	-38.34	53,740	47,562.2	-11.496	94,884	94,884	0	4,264	7,731.78	81.327
2	Mercator-S	1	1	73,310	73,310	0	6,135	6135	0	14,147	14,147	0	90,747	90,747	0	-6,851	-6,851	0
3	Nelt Co.	0.9508	11	69,520	66,098.6	-4.921	3,159	3,003.53	-4.921	11,481	10,916	-4.921	78,024	78,024	0	1,330	2,062.27	55.058
4	Mol Serbia	1	1	37,001	37,001	0	354	354	0	9,770	9,770	0	40,369	40,369	0	759	759	0
5	Knez Petrol	1	1	36,473	36,473	0	638	638	0	1,888	1,888	0	39,218	39,218	0	592	592	0
6	Phoenix Pharma	0.9541	10	34,823	33,224.2	-4.591	878	837.688	-4.591	4,750	4,531.91	-4.591	37,689	37,689	0	738	1,138.61	54.284
7	Mercata	1	1	35,143	35,143	0	610	610	0	866	866	0	36,360	36,360	0	342	342	0
8	Veletabak	1	1	29,092	29,092	0	786	786	0	775	775	0	31,610	31,610	0	556	556	0
9	OMV Srbija	1	1	26,196	26,196	0	178	178	0	8,427	8,427	0	30,406	30,406	0	109	109	0
10	Lukoil Srbija	1	1	25,094	25,094	0	414	414	0	7,837	7,837	0	29,158	29,158	0	1,880	1,880	0
11	Delta Agrar	0.9431	12	20,899	19,709.6	-5.691	684	645.072	-5.691	16,612	13,769.5	-17.111	27,772	27,772	0	829	1,846.93	122.79
12	Metro Cash & Carry	0.9724	9	22,811	22,181	-2.762	1,278	1,242.7	-2.762	4,185	4,069.41	-2.762	26,660	26,660	0	-203	348.5	-271.68
13	Dis	0.9333	13	19,093	17,819.7	-6.669	934	871.713	-6.669	6,229	5,813.6	-6.669	22,623	22,623	0	131	1,117.88	753.342
14	Jugoimport - SDPR JP	1	1	11,563	11,563	0	972	972	0	16,705	16,705	0	21,977	21,977	0	3,133	3,133	0
	Statistics																	
	Mean	0.9742	5.5	36,454.5	35,305.6	-2.5807	1,811.93	1,559.61	-4.4981	11,243.7	10,505.5	-3.3964	43,392.6	43,392.6	0	543.5	1,054.71	56.7947
	Max	1	14	73,310	73,310	0	8,347	6,135	0	53,740	47,562.2	0	94,884	94,884	0	4,264	7,731.78	753.342
	Min	0.885	1	11,563	11,563	-11.496	178	178	-38.34	775	775	-17.111	21,977	21,977	0	-6,851	-6,851	-271.68
	St Dev	0.036	5.5157	19,953.3	18,793.4	3.6024	2,445.42	1,864.4	10.0632	13,349.6	11,795.3	5.2685	25,001.2	25,001.2	0	2,461.33	2,989.59	219.061

Source: Authors' calculations using the DEA model - DEA-Solver

4. REGRESSION ANALYSIS OF THE EFFICIENCY OF TRADE COMPANIES IN SERBIA

Using regression analysis, the authors have investigated the impact of specific factors on the efficiency of the observed companies in Serbia. The linear regression equation is:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + e$$

where X means profit, a and b are coefficients, and e is the random error.

From this equation it follows that the efficiency is a function of the cost of goods sold, the earnings per employee, capital, revenue, and profits.

Table 9 and Figure 2 show the results of regression analysis.

Table 9. Regression analysis of the efficiency of the observed companies in Serbia

Model summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.846[a]	.716	.538	.02448	.716	4.033	5	8	.040	2.510
a. Predictors: (Constant), Profit, Earnings Per Employee, Cost Of Goods Sold, Capital, Revenue										
b. Dependent Variable: Model = SSR – I, Score (efficiency)										

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.012	5	.002	4.033	.040[b]
	Residual	.005	8	.001		
	Total	.017	13			
a. Dependent Variable: Model = SSR – I, Score (efficiency)						
b. Predictors: (Constant), Profit, Earnings Per Employee, Cost Of Goods Sold, Capital, Revenue						

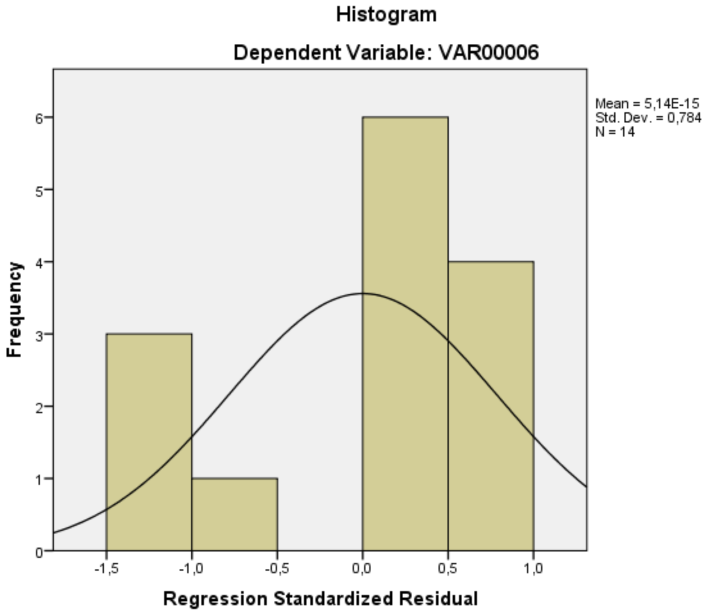
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Partial
1	(Constant)	.956	.026		37.238	.000			
	Cost of goods sold	-1.145E-005	.000	-6.342	-2.183	.061	-.312	-.611	-.411
	Earnings per employee	-2.826E-005	.000	-1.918	-2.028	.077	-.557	-.583	-.382
	Capital	-4.016E-006	.000	-1.488	-1.815	.107	-.700	-.540	-.342
	Revenue	1.226E-005	.000	8.505	2.255	.054	-.395	.623	.425
	Profit	3.889E-007	.000	.027	.075	.942	-.385	.027	.014
a. Dependent Variable: Model - SSR – I, Score (efficiency)									

Source: Authors' calculations using the SPSS

The impact of these factors on the efficiency of the observed companies in Serbia is significant (adjusted R Square .538; Sig. F Change .040). This applies in particular to the costs of goods sold and revenue.

Figure 2. Histogram of the efficiency of the observed companies in Serbia (Note: VAR00006 - Efficiency)



Source: Figure created by the authors

5. CONCLUSION

The conducted empirical research using the DEA approach shows that in the SSR - I model with constant returns to scale, eight of the 14 companies are efficient, while six are inefficient. The SSR – O model with constant returns to scale shows the same results. In the BCC - I model with variable returns to scale, twelve companies are efficient, while two are inefficient. The BCC – O model with variable returns to scale shows the same results. Delhaize Serbia retail chain is efficient in the BCC - I and the BCC – O models, but inefficient in the SSR - I and SSR – O models.

To improve its efficiency in the future, Delhaize Serbia needs to manage its input more efficiently, i.e. to optimise it. Moreover, the research results indicate that this company should reduce earnings per employees by RSD 2,240.67 million (26.84%) and increase profit by RSD 3,467.78 million (81.32%). The same should be done by other inefficient companies in Serbia (Nelt Co., Phoenix Pharma, Delta Agrar, Metro Cash & Carry, and DIS). Mercator-S is efficient in both DEA models. Delhaize Serbia and Mercator-S, as the top two companies in Serbia, control the retail market. Such market position has had a positive impact on their efficiency. The results further show that, in the case of Delhaize Serbia, the cost of goods sold, earnings per employee, and capital increased by -11.496%, -38.34, and -11.496%, respectively, while profit decreased by 81.327% in comparison to projections. This has negatively impacted the company's effectiveness. Similar results were obtained for other inefficient companies. As far as efficient companies are concerned, for example Mercator-S, the input/output data match the projections.

Companies engaged in the trading in petroleum products (Mol Serbia, Knez Petrol, OMV Srbija, Lukoil Srbija) are efficient in both DEA models.

In order to increase the overall efficiency of the commercial sector in Serbia, it is necessary to reduce spending on salaries and capital by RSD 160,048 million and RSD 135,560 million, respectively, and increase profit by RSD 511,213 million.

The results of the regression analysis demonstrate that the factors considered (the cost of goods sold, earnings per employee, capital, revenue and profit) have a major impact on the efficiency of the observed companies in Serbia.

In the radial super-efficiency model, the number of inefficient trade companies in Serbia is significantly higher. However, based on the results of the empirical research, it may be concluded that, overall, the efficiency of these companies in Serbia is satisfactory. In order to increase their efficiency in the future, it is necessary to employ contemporary methods for the management of costs, human resources, capital, assets, financial leverage, sales revenues, and profits. In addition, companies need to take advantage of the benefits of modern information and communication technologies, some Japanese business concepts, multichannel retail, and organic product sales. Developing a private label is another useful tool for increasing corporate efficiency.

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THE EFFECTIVENESS EVALUATION OF INDUSTRIAL ENTERPRISES LOGISTICS SYSTEMS

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Abstract

The article is devoted to the research of indicators for evaluating the efficiency of industrial enterprises logistics systems. The author proposed four assessment parameters, such as logistics costs, logistics service, logistics cycle and logistics risks. As a result of the research, a list of logistics costs of industrial enterprises, a list of logistics risks for these enterprises were developed. Based on which indicators of levels of logistics costs efficiency, system resilience to logistics risks, the quality of logistics services and the duration of the logistics cycle were proposed. These levels allowed to develop the integral efficiency assessing indicator of the industrial enterprises logistics systems.

Key words: logistics system, industry, logistics service, logistics risks, logistics costs, logistics cycle.

1. INTRODUCTION

One of the key concepts used in the framework of the research is the concept of "efficiency of the logistics system". According to M. N. Grigoriev, A. P. Dolgov, and S. A. Uvarov, the effectiveness of a logistic system is “the ratio between a given (the target indicator of the result of the functioning of the system and the actually realized one” (Grigoriev et al., 2014), that is, the degree of actual achievement of the result logistics activity. In addition, the effectiveness of the logistics system can be interpreted as an indicator (or a system of indicators) that characterizes the quality level of the logistics system at a given level of overall logistics costs (Dybskaya & Sergeev, 2016).

Currently, there is no universal system of indicators and methods for evaluating the effectiveness of the micrologistical system of the building materials industry enterprises, which would take into account the specific features of a particular enterprise, the quality of logistics services to consumers and the threat of the external environment. The most common tool for evaluating the effectiveness of the functioning of logical systems is the determination of logistics costs or profits from the implementation of logistics operations (Sergeev, 2011). So, there is an approach according to which “the efficiency of a logistics system is a criterion characterizing the profitability of its work. To compare logistic or transport-technological systems, it is advisable to calculate their effectiveness relative to gross income or average income" (Salum, 2006). However, this approach does not take into account the logistics services to consumers and focuses only on the costly component of the efficiency of the logistics system.

Some scientists (Sergeev, 2011; Baranovsky & Shishlo, 2008), agree that in the conditions of the formation of a market economy, the assessment of the efficiency of the logistics systems of enterprises must be carried out taking into account the assessment of logistics services to consumers. The authors M.N. Grigoriev, A.P. Dolgov and S.A. Uvarov hold a similar opinion, therefore they developed an integral criterion of optimality, or a criterion of the minimum of the total logistic costs of the logistic system, taking into account the quality of customer service.

There is an approach (Yashin & Ryashko, 2014), where in addition to the specified indicators for evaluating the performance of micrologistical systems, indicators of the total duration of logistic processes in the system and the overall performance of the business system are included.

However, in modern conditions of a rapidly changing external environment of an enterprise, assessing the efficiency of its micrologistical system, it is necessary to take into account and analyze the risks that arise in the implementation of logistic operations. These differences lie in a significant variation of such parameters as the time for the implementation of logistics operations and the quality of logistics services. In addition, there are various types of logistical risks that affect the receipt of finished products in time and the required quality. Therefore, approaches to evaluating the performance of micrologistical systems, based only on the assessment of logistics costs, profits from logistics activities and quality of service, are already insufficient for a comprehensive analysis of the functioning of the micrologistical system.

In this paper the method of effectiveness evaluation of industrial enterprises logistics systems is represented based on sequential calculation levels of logistics costs, quality of logistics service, logistics cycle and logistics risks.

2. THE METHOD OF EFFECTIVENESS EVALUATION OF INDUSTRIAL ENTERPRISES LOGISTICS SYSTEMS

The method developed by the author for assessing of the effectiveness of industrial enterprises logistics systems includes the definition of the following levels:

1) the effectiveness of logistics costs C;
2) the quality of logistics services S;
3) the duration of the logistic cycle D;
4) system resilience to logistical risks R.

Further, we will analyze in detail the steps of determining the indicated indicators for evaluating the effectiveness of the micrologistical systems and an integral indicator of the efficiency.

2.1. Determination of the logistics costs efficiency level

The study of logistics costs first began in foreign literature in the 60s. XX century M. Kufel. He considered them as the costs of moving materials in the enterprise. From his point of view, "logistics costs are a category of costs, meaning the monetary expression of the use of the property of an enterprise caused by planning, execution and control (except for technological processes) of movement in time and space of all forms of materials" (Kufel, 1990). At the same time, the author did not single out the costs of maintaining stocks of raw materials, materials, finished products, packaging, post-sale service. Since the 90s. XX century the problem of studying and determining logistics costs was addressed in the work of such scientists as D. R. Stoke and D. M. Lambert (Stoke & Lambert, 2001), D. D. Bowersox, D. Closs (Bowersox & Closs, 1996), I. A. Elovoi (Elovoi, 2008), R. B. Ivut (Ivut, 2004), I. I. Poleshchuk (Poleshchuk, 2007) and others.

Some scientists (Elovoi, 2008; Poleshchuk, 2007) note that "a significant part of the logistics costs are transaction costs", i.e. the costs associated with the conclusion of transactions in the logistics chain. According to N. K. Moiseeva, logistics costs represent "the monetary expression of the used labor, means and objects of labor, financial costs and various negative consequences of force majeure events, which are caused by the pro-movement of material values in the enterprise and between enterprises, as well as maintaining stocks" (Moiseeva, 2008). Thus, this author adds the possibility of force majeure situations in the logistic system. Thus, it can be said that logistic costs are the cost of resources acquired and (or) required by an organization in the process of carrying out logistic activities.

There are many different approaches to the selection of characteristics of the classification of logistics costs. In the framework of the developed method for assessing the micrologistical system of the industrial enterprises, it is proposed to use simultaneously two such attributes to determine logistical costs, such as:
1) the functional area of logistics;
2) the level of management of the logistics system.

At present, when calculating the logistics costs of an enterprise, difficulties may arise due to the inability of the existing accounting and statistical reporting system of enterprises to isolate many components of logistics costs, and the lack of methods for calculating logistic risks. Therefore, employees associated with all elements of the micrologic system of an enterprise should be involved in calculating and allocating logistics costs, while managing the overall logistics costs remains with the management of the enterprise.

The experience of the companies shows that the analysis of logistics costs can be carried out as a percentage of standard, volume or resource indicators, for example:

– "logistics costs in terms of sales;
– individual components of logistics costs in relation to common of carving;
– enterprise logistics costs in terms of standards or environments his level in the industry;
– logistical costs in relation to the relevant items of the enterprise budget;
– current budget logistics resources in relation to estimated costs " (Sergeev, 2011).

According to research conducted by Herbert W. Davis, a logistics consultant for a number of years, the share of logistics costs in sales of industrial enterprises in foreign countries is approximately 9% (Herbert, 2015). This value is proposed to be taken as the standard (optimal) and taken into account when determining the level of efficiency of logistics costs as follows:

$$C = 1 - \frac{P_{act} - P_{norm}}{P_{norm}}$$

where P_{norm} – the industry average (normative) value of the share of total logistic costs in the revenue from the sale of products of the industrial enterprise;
P_{act} – the actual value of the share of total logistics costs in revenue from the sale of industry products:

$$P_{act} = \frac{C_{log}}{R_s}$$

where C_{log} – total logistics costs, R_s – revenue from sales.

2.2. Determination of the logistic service quality level Q

"Service" is understood as customer service, which, in turn, creates added value for all participants in the supply chain. Many links in logistics systems and logistics intermediaries are service organizations, in which services are inextricably linked with the product. These links include various shipping companies, wholesalers and retailers, physical distribution organizations, etc. At the same time, the cost of services can significantly exceed the costs directly on production.

Currently, there is no single definition that reveals the essence of taking a logistics service. Based on the sources studied, it can be said that the logistic service is a complex of logistic services accompanying the movement of the logistic flow from the supplier of raw materials and materials to the consumer.

For logistic optimization of the service, it is necessary to accurately assess the quality of services using a system of indicators ranked according to their importance to consumers, and to minimize negative differences between expected consumers and actual values of service quality indicators.

Based on the research conducted, it is proposed to use the following system of the logistics services quality indicators for industrial enterprises (table 1).

Table 1. Developed system of the logistics services quality indicators for industrial enterprises

Indicator	Definition	Calculation formula
1	2	3
Completeness of logistics service K_1, %	An indicator that reflects the ratio of the number of logistic services provided to the number of potential logistics services.	$K_1 = \frac{m}{M} \cdot 100$ %, where m – the number of logistic services provided;

		M - the number of theoretically possible logistics services.
Reliability fulfillment of the order, K_2, %	Indicator that reflects the reliability of management of all logistic flows in the system.	$K_2 = \frac{O_{cont}}{O_{comp}} \cdot 100$ %, where O_{cont} – the number of orders executed in full compliance with the contract; O_{comp} – number of completed orders
Flexibility K_3, %	Indicator that reflects the ability to consider the wishes of customers by manufacturers: the ability to change the way the order is delivered, the possibility of obtaining information about the status of the order, etc.	$K_3 = \frac{N_{ch}}{N_{req}} \cdot 100$ %, where N_{ch} – the number of changes made to orders; N_{req} - the number of customer requests for changes in the order
Reliability K_4, %	The indicator that determines the ability of the system to maintain the ability to work for a certain time	$K_4 = \frac{O_{ex}}{O_{total}} \cdot 100$ %, where O_{ex} – number of orders accepted for execution; O_{total} – total orders
The share of "ideal orders" K_5, %	The indicator of the number of “ideal orders”, i.e., those orders that were delivered to customers according to their bids in the right quantity, at the right time and of ideal quality	$K_5 = \frac{O_{ideal}}{O_{total}} \cdot 100$ %, where O_{ideal} – number of "ideal orders"; O_{total} – total orders
Ready for order fulfillment K_6, %	An indicator that determines the ability of an enterprise to perform its functions when equipment, personnel is in working condition	$K_6 = \frac{O_{term}}{O_{comp}} \cdot 100$ %, where O_{term} – the number of orders, the terms of which correspond to the terms of the contract; O_{comp} – number of completed orders

Order Fulfillment Ratio K_7, %	Indicator of the volume of materials and products produced in relation to the ordered value	$K_7 = \frac{T_p}{T_o} \cdot 100\ \%$, where T_p – quantity of materials and products ordered and produced, м^3; T_o – total number of ordered materials and products, м^3
No claims K_8, %	Indicator reflecting the number of orders completed without customer complaints about the delivery, quantity, quality of materials and products, disruptions in delivery times, delays in delivery, driver behavior, shipping documents, etc.	$K_8 = 1 - \frac{C_{rec}}{O_{total}} \cdot 100\ \%$, where C_{rec} – number of claims received; O_{total} – total orders

Source: Lapkouskaya, 2017.

To determine the level of logistics services, it is also necessary to calculate the rating (weight) of each indicator (Bi), where the sum of the weights of the indicators of the quality of the logistics service; i is the index of a specific indicator; n is the number of indicators. The determination of the weights should be carried out by a qualified group of experts from among the specialists and consumers of the enterprise under study. The group should be a representative sample of the total number of professionals and consumers. For this purpose, a matrix is created that allows you to prioritize among indicators. Comparison of indicators produced by the method of pair (binary) ratios. From the point of view of experts, the more important criterion is assigned the value “1”, the less important - “0”. After that, the result for each of the indicators is summed up and all amounts are reduced to one denominator, i.e., to the total number of indicators. Thus, we get the weight of each indicator. The matrix for calculating the rating of each indicator has the form presented in table 2.

Table 2. The matrix for calculating the weights of the logistics service quality indicators

Indicator	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
K_1								
K_2								
K_3								
K_4								
K_5								
K_6								
K_7								
K_8								
Sum								

The calculation of the logistics services quality indicators is carried out according to the formulas presented in table 1. After calculating the private indicators $K_1 – K_8$, it is proposed to calculate the integral indicator of the quality level of the logistics service based on the arithmetic average weighted by the following formula, since the average value is calculated in this case using grouped data.

$$S = \frac{\sum_{i=1}^{8} K_i \cdot B_i}{\sum_{i=1}^{8} B_i}, \qquad \sum_{i=1}^{8} B_i = \frac{n-1}{2}.$$

The developed approach to assess the quality of logistics services can also be used separately, outside the assessment of the enterprise's logistics system.

2.3. Determination of the logistics cycle duration level D

The unification of logistics processes, which is aimed at improving the quality of logistics services and reducing logistics costs, is to a greater extent realized through the typification of logistic technologies of operational and transactional components. Typing of economic relations in the logistics system leads to the recurrence of relations, which streamlines the process of product distribution and helps reduce risks. In this case, we can talk about the presence of a cyclic connection between the links of the logistics system. Cyclic communication not only provides for the presence of feedback in the control system of each link, but in general is itself a complicated, mediated type of feedback.

Cyclic communication is present in all logistic systems in various forms and combinations. Thus, a high level of logistic services to the manufacturer of products with raw materials and materials contributes to the normal flow of the production process, which in turn leads to the creation of conditions for a high level of supply of finished products. In this case, the competitiveness of the manufacturer increases, its market position improves, which leads to an increase in demand for materials from the supplier. Such processes are studied by the theory of cycles — a systems theory that studies patterns in the formation of the structure of cycles in the processes of functioning of various types of systems.

Logistic cycles are formed due to the repetition in time and space of the necessary and sufficient sequences of logistic operations. A full logistic cycle is one of the basic concepts in logistics — this is the “order lead time — the time interval between placing an order and delivering an ordered product or service to an end user” (Dementiev, 2013). The logistics cycle, as a rule, includes the time of transfer, processing, placement, production and (or) picking, transportation of the order and the time of receiving goods by the consumer. Each of these steps takes time. The duration of the stages and the total duration of the logistic cycle may have temporary deviations.

The duration of the stages of the logistics cycle, according to D. Bowersox and D. Kloss, J. Stock and D. Lambert, are given in table 3.

Table 3. The duration of the stages of the logistics cycle in the organization

Stage of logistics cycle	D. Bowersox, D. Closs		J. Stock, D. Lambert	
	Value range	Expected range	Value range	Expected range
	0,5–3,9	1	0,5–3,9	1
Preparation of the order and its transfer, h	1–4	2	1–4	2
Order receipt and processing, h	1–20	2	1–9	1
Picking or making an order, h	2–10	4	1–5	3
Order transportation, h	0,3–3,0	1	0,3–3,0	1
Order receipt by the consumer, h	5–40	10	3,5–20	8

Source: Bowersox & Closs, 1996; Stock & Lambert, 2001.

In the structure of a full logistic cycle for industrial enterprises, time can be allocated for the preparation of products for production requirements. For the consumer, the most important is the execution time of the four last points, since for him they are either partially controlled or unmanaged.

The main goal of managing the logistics cycle of an industrial enterprise is to ensure coherence in all levels of the logical system to meet the deadlines for order fulfillment. Any delay at any stage will be in danger at all subsequent stages of the cycle. If such delays or, on the contrary, premature execution of logistic operations occur periodically, this leads to the creation of additional stocks of raw materials and finished products. At the same time, high performance of each element of the logistic system is important only if it contributes to increased integration in the logistic system.

Thus, an increase in the efficiency of the duration of a complete logical cycle leads to an increase in the efficiency of the functioning of the entire logistics system of an industrial enterprise.

The duration of logistic processes in the T_{lc} logistics system includes the total time from receiving an order to the delivery of finished products to consumers, which can be presented:

$$T_{lc} = T_o + T_s + T_{pr} + T_{tr} + T_{st} + T_d,$$

где T_o– time of the order, h; T_s– time of supply of raw materials, h; T_{pr} – time of production of materials or products (including design), h; T_{tr}– time of domestic transport operations, h; T_{st}– time of storage of raw materials and finished products, h; T_d – time of delivery of finished materials and products, h.

To go to the specific indicator of the duration of the logistics cycle, it is proposed to use the indicator of the level of the duration of the logistics cycle D, which is determined by the formula.

$$D = \frac{T_{pr}}{T_{lc}}.$$

At the same time, as a compared parameter, time of production was chosen because it is governed by technical maps for production processes, standards and technical regulations and is relatively constant.

2.4 Determination of the system resilience level to logistics risks R

Logistics activity, starting from the process of moving goods and ending with the processes of their movement in the market space, includes various elements, the functioning of which is influenced by many factors, which means that certain risks arise.

In order to assess the logistics risks of industrial enterprise and the level of stability of the system to them, it is proposed to apply an integrated approach to risk classification and combine parameters such as an element of the enterprise logistical systems and a type of logistic flow within the framework of this method. Thus, each functional area of logistics is accompanied by material, informational and financial flows, each of which has certain logistical risks.

Assessment of the *resilience level of industrial enterprises logistics systems to logistical risks* is proposed to be carried out according to next formula.

$$R = 1 - \frac{\sum_{i=1}^{n} \sum_{j=1}^{m} S_{ij}}{V_e},$$

where R – the level of system resilience to logistical risks;

S_{ij} – the maximum possible amount of loss (loss, loss of profit) on the logistical risk of the i-th flow of the j-th element of the system, monetary unit;

V_e – the amount of equity, monetary units.

Quantitative assessment of losses S_{ij} for an individual logistics risk of the i-th flow of the j-th element can be determined by the formula "loss assessment" (Ivut, 2004), interpreted for logistics risks:

$$S_{ij} = (p_{нij} \pm \Delta_{ij}) \times K_{tij} \times C_0 \times D_{ij} \times p_{cij},$$

where $p_{нij}$ – the normative probability of the occurrence of the logistical risk of the i-th flow of the j-th element, the fraction of a unit;

Δ_{ij} – the share of increase or decrease in the logistical risk of the i-th flow of the j-th element for a specific case, the share of a unit

K_{tij} – coefficient taking into account the time of occurrence of the logistical risk of the i-th flow of the j-th element in relation to the normative probability, the share of a unit;

C_o – the volume of investment in the logistics system, monetary units;

D_{ij} – the share of the part of the logistic system to which the given case of the logistical risk of the i-th flow of the j-th element, the unit share, is applied

p_{oij} – the probability of covering the negative impact of a specific logistical risk of the i-th flow of the j-th element in a given part of the logistic system, a fraction of a unit.

The most difficult moment in assessing the level of logistical risks is the determination of the probability of occurrence of each logistical risk taken for analysis. This problem can be solved in two ways:
1) on the basis of expert opinions, accept the likelihood of a situation causing a logistical risk;
2) to accept some standard level of probability of logistical risk in the logistic system with its possible increase or decrease considering the actual time level of risk manifestation (Lapkouskaya, 2018).

Within the framework of the developed methodology, it is proposed to establish a standard level of probability p_{Hij} of logistical risk in the logistic system with its possible increase or decrease considering the actual time level of risk manifestation using expert opinions. To do this, the following scales can be used (tables 4, 5, 6).

Table 4. The scale of probabilities of occurrence of risk p_{Hij} in the industrial enterprises logistics systems

Risk probability	Very low	Low	Medium	High	Very high
Probability value	0,05	0,10	0,20	0,40	0,80

Table 5. The scale of accounting for the occurrence time of logistical risk in the industrial enterprises logistics systems

Time of risk	Absolutely known	Known	Predictably	Unpredictable	Suddenly
The value of the time coefficient of risk occurrence K_{tij}	0,01	0,05	0,1	0,15	0,2

Table 6. Probability scale of coverage of the logistical risk negative impact in the micrologistical system links

Coverage of the negative risk effect in the link of the logistics system	Minor	Small	Medium	Significant	Full Coverage
The value of the probability of coverage of the risk negative impact p_{oij}	0,05	0,10	0,20	0,40	0,80

The share of the part of the logistic system to which this case of logistical risk Dij applies is assumed to be 0.2, since the developed method for assessing the micrologistical system provides for the evaluation of the five main elements of the industrial enterprises logistics systems.

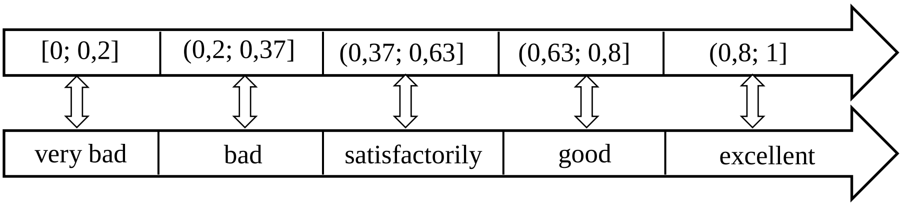
Thus, the efficiency index of the industrial enterprises logistics systems, can be calculated by the following formula based on the geometric mean, since the components of the index are in this case represented as relative values:

$$I_{ls} = \sqrt[4]{C \times S \times D \times R} .$$

The integral index is in the range from 0 to 1, the closer it is to 1, the more effective the micrologistical system. If it is impossible to determine one of the components of the integral indicator, its value is assumed to be 0.5.

The evaluation of the industrial enterprises logistics systems and the interpretation of the resulting micrologistical system efficiency index can be made on the Harrington desirability scale (Figure 4).

Figure 1. The scale of desirability for effectiveness evaluating of the industrial enterprises logistics systems



The developed method for effectiveness evaluating of the industrial enterprises logistics systems in contrast to the existing methods:

– is based on logistic integration, that is, it includes indicators of the efficiency of all functional elements in the industrial enterprises logistics system;

– considers the logistical risks emerging in the industrial enterprises logistics system at its main links and the ability of the system to withstand these risks;

– includes the use of quantitative, qualitative and temporal indicators for evaluating the effectiveness of the industrial enterprise logistics systems.

This method includes the sequential determination of four indicators for evaluating the effectiveness of logistics system:

– the level of efficiency of logistics costs based on their aggregate developed for industrial enterprises for all elements of the micrologistical system;

– the level of quality of logistic service using the developed system of private indicators of its quality (total number - 8) and integral indicator based on weighted average arithmetic using the expert method and the method of pair comparisons;

– the level of the duration of the logistics cycle on the basis of determining the temporal characteristics of its stages in the enterprise (purchase, transportation, production, warehousing, distribution) for the main types of products;

– the level of resilience level of industrial enterprises logistical systems to logistical risks based on the developed systems' risk for the industrial enterprise, assessment of losses from these risks for all logistic flows (material, informational and financial) and system elements, as well as on the basis of the developed scales in the micrologistical system, scales for accounting for the time of occurrence of risk, scales for the probability of covering the negative impact of logistical risk in a specific element of the system);

– the integral indicator of the efficiency of the micrologistical systems in industry based on the geometric mean, since the component values of this efficiency index are presented as relative values.

3. CONCLUSION

The developed author's method of the logistics system effectiveness evaluation of industrial enterprises allows:

– to analyze the performance of micrologistical systems in the industry;
– to conduct a comparative analysis of the development of micrologistical systems of various industries;
– to determine the value and weight of each link of the logistics system of the enterprises;
– to identify the weak links of the enterprise logistical system in terms of logistics costs, logistics services and logistics risks;
– to find growth reserves in the development of the enterprise logistical system by comparing the results of the work of the systems links.

The presented assessment method can be used to develop strategies for the development of logistics systems of industrial enterprises, as well as to justify investments in certain elements of logistics systems. Further research will concern the development of economic and mathematical models for assessing the relationship between the development of the four developed indicators of the effectiveness of logistics systems and economic indicators of enterprise development based on multiple regression analysis.

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BUSINESS LOGISTICS AND ITS IMPORTANCE IN COMPANY´S COMPETITIVENESS

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Abstract

This paper focuses on business logistics, its importance and areas of solution. Nowadays, businesses are forced to increase efficiency and to optimize their processes because of high competition and demanding customers. Business logistics plays a key role here. The primary objective of business logistics is to ensure optimal material, information and value flow in the company's transformation process. Business logistics is essential for securing products or services from supplier to consumer because it includes everything from acquisition from wholesalers and suppliers to manufacturing, storage and delivery to customers. Company´s owner should have a strong knowledge of its logistics systems to ensure maximization of profits and to be able to give customers the most positive experience possible. There is a need to constantly monitor the functioning of individual supply chain articles because the occurrence of an error can affect the entire chain and the product or service may not reach its customer in the required time, quality, quantity and at the optimal cost. It all depends on responsible employees and owners, as they perfectly know the logistics processes and can detect the waste and inefficiency in them. In this paper, the authors will provide the results of the research that has been realized in the Slovak manufacturing company and the authors will point out how the specific solution in business logistics can save the company's costs, which of course also affects the profit. In future research, the authors will deal with the use of individual methods to optimize logistics flows and processes in the same company. Successful business logistics provide a competitive edge against other organizations and customer needs can be fulfilled in a more efficient manner. For all of this reasons, the authors think it is very important to deal with business logistics at present and it is very actual topic.

Key words: logistics, business logistics, effective logistics processes, logistics flows, competitiveness.

1. INTRODUCTION

In an advanced market economy, only a business that can meet the increasingly demanding customer needs can succeed with a solid supply of new and high quality goods or services. However, it is not sufficient to buy or produce quality goods or to provide quality service. Care should be taken to ensure that the right product is available, with the right quality, at the right customer, in the right amount, at the right place, at the right time, and at a reasonable cost. Just logistics helps to solve so-called "Seven Rs".

The role of logistics in today´s and tomorrow´s profitable companies will change as the value of products changes, and also as the value that buyers or customers ascribe to product changes. This statement represents a new concept for many logistics managers, who were trained in transportation, warehousing, and other such functions to conduct their activities based on lease-cost or other hand measure priorities. Modern logistics managers must find innovative ways to help their companies improve profits, increase market share, improve cash flow, open new territories and introduce new products. However, logistics neither creates demand nor product. Logistics is the organization that responds to demands, and creates a bridge between that demand and those who supply it. A professional and integrative approach is clearly needed (Quayle & Jones, 2001).

Currently, logistics is a recognized scientific discipline in Slovakia, which, as a relatively comprehensive theory of minimizing logistics costs in providing maximum logistics services under the condition of environmental friendliness, models the flow of materials and services (Bartosova & Kral, 2016). Logistics is a modern science discipline that enables to optimize processes of material security, to realise the storage of material and dispose of it, and related activities. At present, information plays an irreplaceable role a component of logistics that aims to provide comprehensive information not only on quality and quantity, but also on destination, method of transport, method of the use, and other attributes of the logistics process.

To the organization, business logistics is important in several ways. First, business logistics provides an opportunity for the firm to create a sustainable competitive advantage for itself by designing a system which fulfills customers' needs better than the competition. For example, the company could offer faster, more accurate, and more consistent order filling and delivery than competitors are capable of providing. Secondly, due to its complexity, a superior logistics system is a proprietary asset that cannot be easily duplicated. Many companies have begun to view business logistics as an effective competitive weapon.

In the paper, the authors will focus primarily on business logistics and try to demonstrate how a particular business logistics solution can significantly reduce costs and thus increase the company's competitiveness.

The paper is composed of 8 sections. In the first chapter, *Introduction*, authors emphasize the importance of logistics in today's modern world and describe business logistics as the basis for business competitiveness. The second chapter, *Logistics and system approach*, deals with the system approach, which is one of the most important foundations of logistics. Then it includes division of logistic systems, micrologistics and macrologistics systems are described. Term of business logistics is mentioned as a subset of micrologistics. The third chapter, *Business logistics and its subjects*, deals in detail with the theory of business logistics and describes its individual subjects - purchasing and supply logistics, production logistics and distribution logistics. In the fourth chapter, *Analysis of production batches in the particular manufacturing company*, the authors realize the analysis of production batches in particular manufacturing company and provide results of this analysis with calculation of costs on current production batches. The fifth chapter, *Suggestions and recommendations***,** contains suggestions and recommendations for merging production batches and calculation of costs for new level of production batches. In the sixth chapter, *Results*, authors provide comparing before and after merging production batches and calculation of potential cost savings. The goal of the seventh chapter, *Conclusion*, is to summarize of all results the research realized by authors. The eighth chapter, *References,* consists of references of literature resources used by writing the paper.

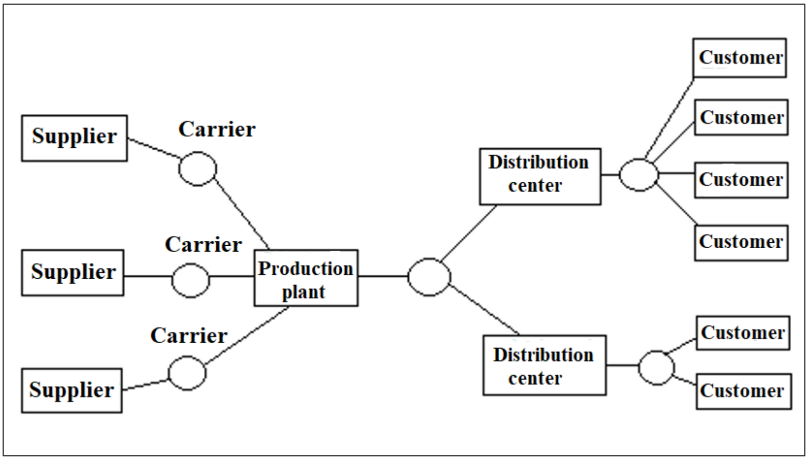
2. LOGISTICS AND SYSTEM APPROACH

Before the authors focus on business logistics, they have to define logistics in general. Pernica (2005) defines logistics as a discipline that deals with the overall optimization, coordination and synchronization of all activities whose concatenation is essential to the flexible and cost-effective achievement of a given final (synergistic) effect.

The importance of logistics is increasing with increasing globalization. Companies are under intense competitive pressure, and logistics takes a strategic position in this situation (Chijioke, Vu & Olatunji, 2018). It helps businesses to improve customer service, on which is the primary focus since of the early 1990s. It allows to reduce costs and thereby achieve higher profits. The effectiveness of this scientific discipline increases with the development of information technology. A system approach is absolutely necessary for its success. Understanding the interrelationships plays a key role in increasing the efficiency of the system as a whole (Drahotský & Řezníček, 2003).

System approach is one of the most important foundations of logistics. It is itself a system; it is a network of related activities designed to manage the flow of material and personnel within the logistics channel. This system is shown in Figure 1. It shows a simplified example of a network of relationships and links that logistics must manage in a distribution channel (Drahotský & Řezníček, 2003).

Figure 3. Distribution channel

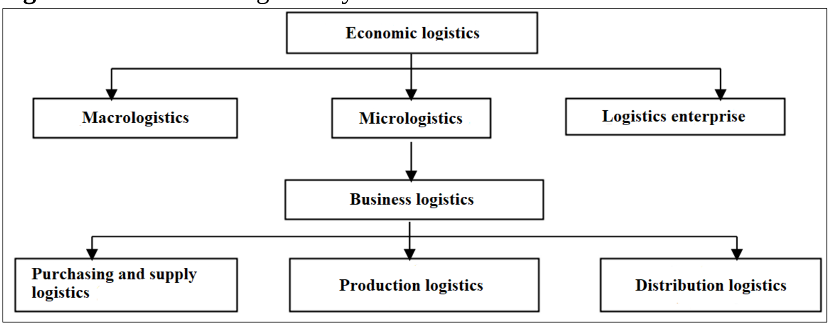


Source: Lambert, Stock & Ellram, 2005

Customer demands continue to grow (Cyrus & Vogel, 2018). An integrated logistics system, supported by an integrated logistics information system, is required to meet their requirements. Information technology has a significant impact on the development of logistics. The basis of the logistics system is the handling of orders. Imperfect communication can result in loss of customers, increased transportation and storage costs, or increased inventory maintenance costs. Therefore, to support logistics activities, computers are used to a great extent in order handling, inventory management, performance measurement, but also in the transport process (Drahotský & Řezníček, 2003).

Logistics systems can be broken down from the perspective of different experts but also from different economic interests. For the purposes of the paper, the authors will be guided by the following figure, with which they will continue to work.

Figure 4. Division of logistics systems



Source: Sixta & Mačát, 2005

Macrologistics systems solve the problems of mass movement from the point of view of national economy, so their view goes beyond the boundaries of individual companies and sometimes even states. Most macrologistics decisions affect logistics costs and hence business profits (Sadaf et al., 2018).

Micrologistics deals with logistics chains inside an industrial plant or between plants within a single enterprise. The subject of the research is a pre-production process (purchase of materials from suppliers), own production process (handling means, company warehouses, transport technology, information and decision-making system) and post-production processes (sale and delivery of products to customers) (Křížová et al., 1994).

Business logistics is a subset of micrologistics that includes business systems in circulation and in production. Within these systems, we deal with issues of material flow, energy and information, both in terms of time and space, inside and outside, as well as storage, handling, transportation, and so on.

3. BUSINESS LOGISTICS AND ITS SUBJECTS

The micrologistics system of business logistics is being built with the aim of comprehensive optimization of material and information flows within the company. Its task is to plan, organize, manage and control these flows from suppliers to customers. In the area of supply, distribution and return flows, it acts as a link to the company's external environment (procurement and sales markets) (Seidl & Tomek, 2012).

Business logistics serves to support business goals, a set of tasks that provide measures to ensure optimal material, information, and value flows in the company's transformation process (Sponte, 2018).

The basis of business logistics is considered to be the material flow, which is mainly composed of movement:

- auxiliary and consumables,
- production aids,
- work items,
- rejects,
- means of transport,
- waste.

We understand the material flow as an organized movement of all the objects that are necessary to realize the production process in the production system and between the elements of the production system and its surroundings (Dupaľ & Brezina, 2006).

The content of enterprise logistics is (Dupaľ & Brezina, 2006):

1. Organizing, planning, securing, implementing and controlling all relocation and storage processes in the enterprise.

2. The actual realization of physical processes, which are expressed by material flow.

3. All those activities that relate to, respectively, related to information flow.

For business logistics to play its primary role, to optimize the movement of material in the enterprise, it is necessary to integrate the sub-systems into an integrated system that coordinates and manages the material and relevant information flow (Dupaľ & Brezina, 2006).

Entities determining business logistics are as follows:

- purchasing and supply logistics,
- production logistics,
- distribution logistics.

3.1. Purchasing and supply logistics

It presents a summary of logistical tasks and measures in the preparation and implementation of the purchase. Its essential task is to secure the production process and the entire business operation of the enterprise with the necessary resources. Consequently, it must deal with:

- market-oriented tasks linked to contracting,
- physical tasks and material flow management; goods.

These tasks are related to problems that must be addressed in purchasing and procurement logistics (Dupaľ & Brezina, 2006):

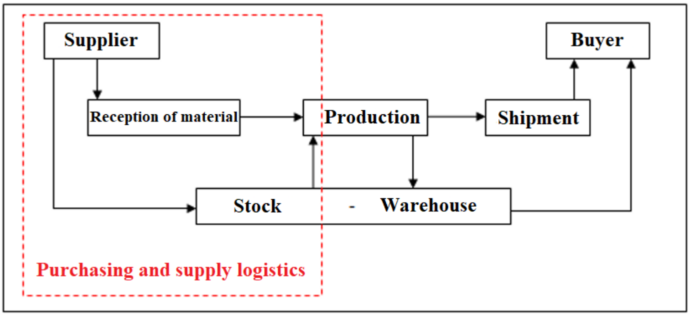
- reconciliation of purchasing and supply with production,
- checking the quality of purchased material,
- minimizing purchasing and shipping costs,
- choosing an appropriate purchasing and supply strategy,
- qualitative selection of the supplier.

A group of authors has developed a supplier evaluation model where it defines the basic approaches, guidelines and principles for assessing their quality. The aim of this model is to increase the efficiency of supply chain management, which allows for a better response to emerging situations and calms the needs of the logistics company (Kovacova & Kliestik, 2017).

A selected supplier should be the one who meets the best criteria in a combination of quality and price. A supplier, manufacturer and customer should be involved in the process of increasing competitiveness, creating a new, complex process. The authors are talking about so-called controlled cooperation, which exceeds society, this approach is called "supply chain management - SCM". The supplier is evaluated on the basis of multi-criteria analysis, using the following criteria (Lizbetin et al., 2015):

- price,
- quality (quality certificate, number of complaints),
- reliability (delivery deadline),
- delivery time,
- flexibility (supplier's willingness to accept change),
- responsibility (for poorly rendered service),
- identification/prevention of risks (willingness to identify and prevent risks),
- development of the supplier (willingness of the supplier to innovate and modernize the development of cooperation).

Figure 5. The boundaries of purchasing and supply logistics



Source: Dupaľ & Brezina, 2006

3.2. Production logistics

Business logistics comprises logistical tasks and measures that are necessary to prepare and run the production process. It includes all activities related to the material and information flow of raw materials, production and auxiliary materials from the input warehouse to production, from the stock of semi-finished products and purchased parts through individual production stages, intermediate storage and assembly to the finished goods warehouse. These activities then need to address issues related to (Dupaľ & Brezina, 2006):

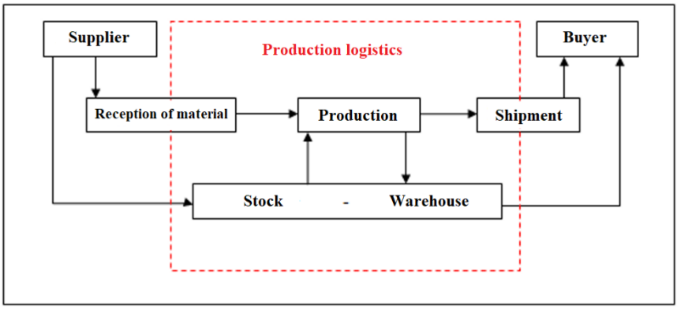
- production planning,
- structuring production from a logistical point of view,
- MAKE OR BUY strategy,
- arranging physical and information flows,
- newer production management systems.

Production logistics is basically a subset of the complex logistics of supplier-customer relationships or chains. Its complexity, the scope of the engagement are directly proportional to the complexity of the production process (Valaskova et al., 2018).

Currently, manufacturing companies are exposed to demanding customers and constantly increasing their requirements. Customers demand high quality, a variety of special product modifications, fast delivery and so on. For this reason, the company must look for new strategic concepts in order to respond flexibly to customer wishes and ensure high availability, reliability of supply, flexible production, etc. (Kanovska, 2018).

The desired flexibility can be achieved mainly by deliberately influencing the production time of a particular product, which also includes unwanted high non-productive times. In particular, storage, inter-operation transport and handling, unsuitable production technology have a share on them (Křížová et al., 1994). For illustrative purposes, the share of storage and transport costs is on average up to 15% of the product's selling price (Lehutova et al., 2013).

Figure 6. The boundaries of production logistics



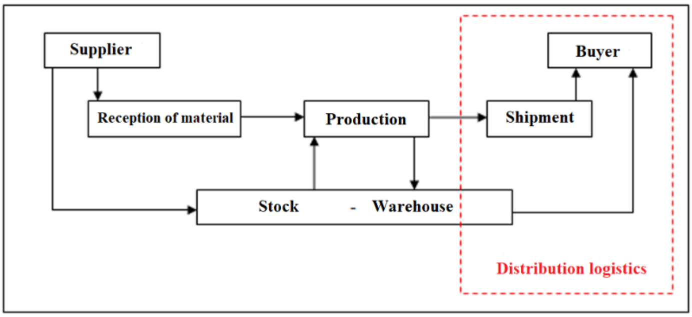
Source: Dupaľ & Brezina, 2006

3.3. Distribution logistics

Distribution logistics deals with all activities related to the flow of goods from finished goods warehouses to the sales market, including information. It presents a summary of logistical tasks and measures for the preparation and implementation of distribution. In particular, it addresses the following issues (Křížová, Gregor & Rakyta, 1994):

- where are the stocks,
- where are the warehouses,
- how to cost-effectively share deliveries,
- what storage and picking systems will be used.

Figure 7. The boundaries of distribution logistics



Source: Dupaľ & Brezina, 2006

4. ANALYSIS OF PRODUCTION BATCHES IN PARTICULAR MANUFACTURING COMPANY

When processing the paper, the authors cooperated with the Kinex Bearings, which produces rolling bearings. It is a manufacturing plant situated in the territory of the Slovak Republic, namely in Bytča. It belongs to the bearing group KINEX BEARINGS, which, with its portfolio, has become one of the world's leading suppliers of standard and special rolling bearings for use in various industrial applications.

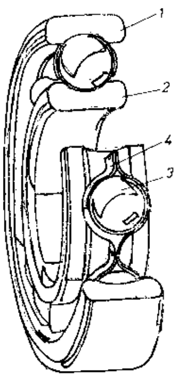
The main task and objective is to ensure the delivery of a complete bearing range produced in individual plants, to develop cooperation with customers and to provide them the services according to their requirements. In order to maximize their satisfaction and achieve a flexible response to market demands, KINEX BEARINGS integrates R&D, planning, production and business activities. Almost all production is oriented through KINEX BEARINGS, a. s. to foreign markets. Kinex Bytča, a. s. is currently focusing on three major bearing application segments: automotive, textile and aerospace.

4.1. Characteristics of rolling bearings

Rolling bearings are components that serve to transfer forces between moving and fixed machine parts and reduce friction between them. They have many advantages over sliding bearings, such as less friction coefficient and associated lower power losses, simplified machine design and maintenance, less lubricant consumption, and the ability to produce with higher revolutions.

Usually, a rolling bearing consists of an inner and an outer ring, between which rolling elements roll along the integrated raceways. Rolling elements are required to be kept at the same distance from each other and do not touch. This feature is provided by a cage. The inner ring is mounted on the shaft pin, the outer ring is housed in the machine body (frame). Rolling bearings can be used in virtually all machines. Their main task is to reduce the friction between the shaft and the part in which the shaft is mounted by means of the rolling rotating elements between the outer and inner rings of the bearing. There is also a second possibility of rolling bearing design - it can consist of an outer sleeve and a shaft. In this case, the raceways are integrated on both the shaft and the outer sleeve. The following figure shows the cross-section of the rolling bearing and its individual parts: 1. outer ring, 2. inner ring, 3. rolling element, 4. cage.

Figure 8. Parts of rolling bearing



Source: http://www.sossoukyjov.cz/data/file/Strojnictvi/VY_32_INOVACE_5c/VY_32_INOVACE_5c19.pdf

4.2. Specification of the selected bearing group

Because of the fact that Kinex Bearings, a. s. produces a huge number of types and designs of bearings, for the purpose of the paper, the authors have chosen a group of special double row bearings for water pumps of type R (with one row of rollers and one row of balls) and type K (two row of balls), which they will focus on in the analysis of the production process.

Bearings are identified by type (K or R) and a three or four digit number. The following figure shows a range of bearings within this selected group.

Figure 9. List of dimensional types for customer METELLI

• BR863G-2TIH	• BR675M-2TIH
• BR603M-1TIH	• BR980G-2TIH
• BK249M-1TIH	• BR173.1M-1TIH
• BK2057M-1TIH	• BR076M-1TIH
• BK2233M-2TIH	• BR2084-1TIH
• BK512M-1TIH	• BK352-BM1TIH
• BK608M-1TIA	• BR2082-2TIH
• BK2159M-2TIH	• BR220M-1TIH
• BK621M-2TIH	• BR045M-1TIH
• BR2043G-2TIH	• BR2128G-2TIH
• BK360-BM1TIH	• BR082M-1TIH
• BK279M-1TIH	• BR192.1M-2TIH
• BR2031M-1TIH	

Source: own processing by author

This group is delivered to Italian customer METELLI S. P. A., the largest automotive customer. The bearings then become part of the water pump component at the customer´s manufacturing plant.

4.3. Analysis of production batches of a selected group of bearings

In analyzing production batches for each month, the authors base on „budget" on 2019, which was firmly accepted by the company. Budget is derived from a specific customer's demand (METELLI in this case). Production batch sizes are sorted by type into individual months to meet the required order for the entire year. Production batches are not the same in individual months, such a distribution was carried out by the sales department and subsequently shifted to production. Production deparment is already responsible for planning individual inputs that are needed in specific periods to produce a given number of bearings. The determination of the production batch size was based on empirical estimation. The company does not use any of the relationships to calculate the optimal production batch.

Table 1. Production batch size for the first half of 2019 in pieces

Size of production batches for individual months (pcs) / Dimensional types	JANUARY 2019	FEBRUARY 2019	MARCH 2019	APRIL 2019	MAY 2019	JUNE 2019
BR863G-2TIH	37 600	37 900	52 500	48 400	45 500	52 600
BR603M-1TIH	13 300	9 300	15 200	18 150	21 000	15 200
BK249M-1TIH	32 000	19 700	42 600	32 000	30 200	34 000
BK2057M-1TIH	14 000	10 000	20 700	16 800	17 800	19 800
BK2233M-2TIH	25 200	18 800	27 700	27 300	29 000	29 500
BK512M-1TIH	11 800	9 800	11 800	11 700	13 700	11 700
BK608M-1TIA	11 800	11 400	13 500	14 600	9 400	18 500
BK2159M-2TIH	12 000	8 400	13 000	13 800	14 000	12 700
BK621M-2TIH	8 400	12 000	9 500	11 200	9 500	8 400
BR2043G-2TIH	4 700	4 200	5 100	5 600	8 000	7 900
BK360-BM1TIH	10 800	9 800	12 800	13 500	12 700	11 700
BK279M-1TIH	7 700	6 600	11 300	9 400	12 300	9 400
BR2031M-1TIH	7 000	4 000	5 500	7 500	7 000	5 500
BR675M-2TIH	4 700	5 100	6 000	5 600	5 800	6 200
BR980G-2TIH	1 500	2 800	1 350	2 500	2 500	1 200
BR173.1M-1TIH	5 300	3 800	5 200	5 000	5 400	5 100
BR076M-1TIH	2 000	2 500	3 500	2 500	3 000	2 000
BR2084-1TIH	2 500	2 700	3 500	2 100	2 850	3 000
BK352-BM1TIH	7 500	6 100	7 800	8 000	8 500	6 800
BR2082-2TIH	3 200	2 000	3 100	3 000	2 700	2 500
BR220M-1TIH	2 200	1 900	2 300	2 100	2 300	2 400
BR045M-1TIH	2 800	2 600	2 800	2 900	2 800	2 900
BR2128G-2TIH	1 700	1 800	1 700	1 600	1 700	1 700
BR082M-1TIH	9 800	7 500	9 900	10 500	12 700	10 300
BR192.1M-2TIH	1 900	3 300	2 800	3 300	1 800	3 300
TOTAL AMOUNT	**241 400**	**204 000**	**291 150**	**279 050**	**282 150**	**284 300**

Source: own processing by author

Table 2. Production batch size for the second half of 2019 in pieces

Size of production batches for individual months (pcs) / Dimensional types	JULY 2019	AUGUST 2019	SEPTEMBER 2019	OCTOBER 2019	NOVEMBER 2019	DECEMBER 2019
BR863G-2TIH	45 500	18 800	46 000	45 100	45 200	42 400
BR603M-1TIH	15 300	9 500	17 100	15 200	20 900	12 400
BK249M-1TIH	28 500	14 100	36 000	31 100	39 150	31 500
BK2057M-1TIH	14 700	10 000	19 000	20 700	17 900	16 000
BK2233M-2TIH	19 000	18 600	31 200	23 900	28 800	23 600
BK512M-1TIH	11 700	7 000	11 800	11 800	11 800	11 700
BK608M-1TIA	13 200	7 500	19 500	13 200	14 100	13 200
BK2159M-2TIH	12 400	6 900	13 000	14 000	14 500	11 700
BK621M-2TIH	6 500	7 000	8 000	10 000	7 500	7 500
BR2043G-2TIH	7 600	5 800	9 400	7 500	7 000	4 300
BK360-BMITIH	12 200	7 500	13 200	12 700	12 700	11 500
BK279M-1TIH	9 400	4 700	8 900	9 400	9 400	7 000
BR2031M-1TIH	5 000	4 000	5 000	7 500	6 500	6 000
BR675M-2TIH	5 600	4 300	6 200	5 600	5 800	4 700
BR980G-2TIH	1 350	1 400	2 200	2 100	1 450	1 500
BR173.1M-1TIH	6 000	3 300	5 500	5 600	5 500	4 500
BR076M-1TIH	3 000	2 500	2 500	2 500	3 000	2 500
BR2084-1TIH	3 000	2 100	3 000	2 500	2 000	3 200
BK352-BMITIH	7 500	3 800	8 000	8 500	8 900	7 000
BR2082-2TIH	3 300	2 000	3 000	2 700	3 500	3 200
BR220M-1TIH	2 200	1 400	2 500	2 300	2 300	1 800
BR045M-1TIH	2 800	1 400	3 300	3 000	3 100	2 700
BR2128G-2TIH	1 800	2 000	1 900	1 900	1 800	1 500
BR082M-1TIH	9 800	7 000	11 300	9 000	10 400	10 000
BR192.1M-2TIH	3 700	2 400	2 800	2 300	2 800	2 800
TOTAL AMOUNT	**251 050**	**155 000**	**290 300**	**270 100**	**286 000**	**244 200**

Source: own processing by author

Based on the above tables, we can see that not all bearings are produced in large batches because annual orders are not in such volumes. In this paper, the authors are focusing on production batches of smaller volumes and then they become the subject of improvement. They think it is unnecessary to move with larger batches because there would not be enough capacity. They have set the "signaling number" to 5000 pieces because the production of the shaft starts on the machine SAY 8/32, whose output power is just around 5000 pieces. This means that in improving production in terms of production batches, they will focus on those batches that do not exceed this volume.

Based on the above tables, the authors could calculate the total number of bearings for all dimensional types for the entire year 2019. The planned number of produced bearings for the whole year for selected type dimensions was 3 078 700 pieces.

From the annual data, they calculated the average monthly production batch:

3 078 700/12 = 256559 pieces rounds after rounding.

Machine capacities are needed to produce enough amount of bearings. When determining the capacities, the authors based on the calculated average monthly production batch size and then they adjusted the capacities.

The capacity of the workplace (in a particular operation) depends on the following factors: machine performance, number of machines, number of shifts per day, number of days of machine operation per month and machine availability. Machine performance is determined by the number of components produced per shift (7.5 h). The machines are usually operated only during working days (20 days per month), but some of them are operated in continuous operation (based on an average of 30 days). Usability of the machine is given by the coefficient - most machines work with an efficiency of 85%. The authors do not count with 100% efficiency, because they take into account the average loss of production equipment, production equipment failures, absence of personnel due to holidays and sick leave, which is in the long term 15 - 20%. An exception is the ADASH machinery, whose coefficient is up to 0.95, which means that there is a minimum of losses on this machine.

The authors got the capacity numbers after multiplying all these factors. They had to calculate the number of capacity to every machine needed for production selected bearings.

The production of a particular group of bearings consists of the production of its components - the production of the shaft and the production of the outer sleeve and then the assembly is following. The authors had to recalculate the capacities of the production facilities involved in all these operations (totally 27 machines).

After recalculating capacities, they came across a lower number than the one required for three machines. While the S50CNC and SEL101C have a capacity lower than required, it is sufficient because only 80% of the components pass through these machines. The lower capacity of the JUS PV 2 is also sufficient, because the operations on this machine relate only to the R-type.

By adjusting the production batches, the authors can mainly reduce the cost of setting up the machines. The machine must always be adapted to the bearing currently being manufactured.

The total time to set up the machine is as follows: number of settings per month * length of time to set one machine in man-hours. The result is also in man-hours.

The authors have to consider, that they have to set up every machine 25 times a month, because the company produces 25 dimensional types of bearings. For every machine are stated how many man-hours it take to set up a machine. While the machine is being set up, the costs of individual employees (downtime in production) and adjusters are generated. The costs of individual employees (production operators) represent the hourly wage (McKinlay, 2018). Direct personal costs per one setting are the product of the length of one setting in man-hours, the direct unit wage, and the coefficient of statutory deductions. The coefficient of statutory deductions is 1.4 for operators and also for adjusters. The authors then calculate the total cost on setting as the product of the number of setting for a given month and the direct personal costs per one setting. They do not take into account the number of machines in this calculation, because only one machine is always setting by type.

In this way, the authors have calculated the cost of setting up the machine for the production of shaft, for the production of outer sleeve and assembling for both the production operator and the adjuster. The calculation for these employees was similar, the difference was only in wage per man-hour. Here are summary tables for both operator and adjuster.

Table 3. Total cost and capacity loss per operator

Production section	Costs per operator per month (€)	Costs per operator per year (€)	Monthly loss of capacity (man-hour)	Annual loss of capacity (man-hour)
Shaft	1804,95	21659,40	312,50	3750,00
Outer sleeve	1405,60	16867,20	255,00	3060,00
Assembling	397,43	4769,10	72,50	870,00
TOTAL	**3607,98**	**43295,70**	**640,00**	**7680,00**

Source: own processing by author

Table 4. Total cost per adjuster

Production section	Costs per adjuster per month (€)	Costs per adjuster per year (€)
Shaft	1297,45	15569,40
Outer sleeve	1603,35	19240,20
Assembling	0,00	0,00
TOTAL	**2900,80**	**34809,60**

Source: own processing by author

Loss of capacity is the time in man-hours during which the company could not produce, but there were downtimes due to machine setting. The authors do not take into account all machines when calculating the cost of the adjusters, because, for example, the machine MLL 30 is setting by the operator, so they would calculate the costs in duplicate. There are no costs per adjusters during assembly.

The following table shows the total monthly and annual costs in € for both employees and the loss of capacity in man-hours per operator. The authors did not calculate the capacity loss per adjusters because they only lose capacity once.

Table 5. Calculation of monthly and annual costs for individual employees

Employee	The amount of monthly costs (€)	The amount of annual costs (€)	Loss of capacity per month (man-hours)	Loss of capacity per year (man-hours)
Operator	3607,98	43295,70	640,00	7680,00
Adjuster	2900,80	34809,60	x	x
TOTAL	**6508,78**	**78105,30**	**640,00**	**7680,00**

Source: own processing by author

According to the amount of costs the authors can say that these are considerable amounts. Analysis of production batches gave the scope for improvement and reduction of costs on setting of machines. They will provide some solution for improvement in next chapter.

5. SUGGESTIONS AND RECOMMENDATIONS

This chapter is based on the analysis of production batches planned for 2019. The authors focused on those batches that are below 5000 pieces (machine performance of SAY 8/32 - production of the shaft). They decided to merge the production batches by quarters (3 months), so Kinex Bearings Bytča, a. s. would produce instead of 8 production batches per month 3 production batches. This distribution of production batches will lead to savings from the original number of produced production batches 25 on 20, respectively 19.

From the original table of all 25 dimensional types of bearings from customer METELLI S. P. A., the authors selected 8, which do not meet the volume of 5000 pieces.

Table 6. Size of production batches of the selected group of bearings for the first half of 2019

Size of production batches for individual months in pcs / Dimensional type	JANUARY 2019	FEBRUARY 2019	MARCH 2019	APRIL 2019	MAY 2019	JUNE 2019
BR2084-1TIH	2 500	2 700	3 500	2 100	2 850	3 000
BR220M-1TIH	2 200	1 900	2 300	2 100	2 300	2 400
BR045M-1TIH	2 800	2 600	2 800	2 900	2 800	2 900
BR2128G-2TIH	1 700	1 800	1 700	1 600	1 700	1 700
BR2082-2TIH	3 200	2 000	3 100	3 000	2 700	2 500
BR192.1M-2TIH	1 900	3 300	2 800	3 300	1 800	3 300
BR045M-1TIH	2 800	2 600	2 800	2 900	2 800	2 900
BR2128G-2TIH	1 700	1 800	1 700	1 600	1 700	1 700

Source: own processing by author

Table 7. Size of production batches of the selected group of bearings for the second half of 2019

Size of production batches for individual months in pcs / Dimensional type	JULY 2019	AUGUST 2019	SEPTEMBER 2019	OCTOBER 2019	NOVEMBER 2019	DECEMBER 2019
BR2084-1TIH	3 000	2 100	3 000	2 500	2 000	3 200
BR220M-1TIH	2 200	1 400	2 500	2 300	2 300	1 800
BR045M-1TIH	2 800	1 400	3 300	3 000	3 100	2 700
BR2128G-2TIH	1 800	2 000	1 900	1 900	1 800	1 500
BR2082-2TIH	3 300	2 000	3 000	2 700	3 500	3 200
BR192.1M-2TIH	3 700	2 400	2 800	2 300	2 800	2 800
BR045M-1TIH	2 800	1 400	3 300	3 000	3 100	2 700
BR2128G-2TIH	1 800	2 000	1 900	1 900	1 800	1 500

Source: own processing by author

The authors have merged the production batches as follows. They took three dimensional types (or 2), merged their production batches in three months and planned to produce them in the first month of the quarter. Another trio would be produced in the second month of the quarter, etc. The final sum for the year is unchanged. The procedure is well visible in the following tables.

Table 8. Merged production batches for the first half of 2019

Size of production batches for individual months in pcs / Dimensional type	JANUARY 2019	FEBRUARY 2019	MARCH 2019	APRIL 2019	MAY 2019	JUNE 2019
BR2084-1TIH	8 700			7 950		
BR220M-1TIH	6 400			6 800		
BR045M-1TIH	8 200			8 600		
BR2128G-2TIH		5 200			5 000	
BR2082-2TIH		8 300			8 200	
BR192.1M-2TIH		8 000			8 400	
BR045M-1TIH			8 200			8 600
BR2128G-2TIH			5 200			5 000

Source: own processing by author

Table 9. Merged production batches for the second half of 2019

Size of production batches for individual months in pcs / Dimensional type	JULY 2019	AUGUST 2019	SEPTEMBER 2019	OCTOBER 2019	NOVEMBER 2019	DECEMBER 2019
BR2084-1TIH	8 100			7 700		
BR220M-1TIH	6 100			6 400		
BR045M-1TIH	7 500			8 800		
BR2128G-2TIH		5 700			5 200	
BR2082-2TIH		8 300			9 400	
BR192.1M-2TIH		8 900			7 900	
BR045M-1TIH			7 500			8 800
BR2128G-2TIH			5 700			5 200

Source: own processing by author

In every month, thanks to the merger of production batches, 5 times of machine setting fell out. In March, June, September and December, the number of setting the machines was even 19. Now the authors recalculate the individual cost of setting for both operator and adjuster at 20 setting for 8 months and then recalculate the individual cost of setting for both operator and adjuster at 19 setting for 4 months. The calculations are shown in the following summary tables.

Table 10. Quantification of costs per month and 8 months for individual employees

Employee	The amount of monthly costs (€)	Amount of costs per 8 months (€)	Loss of capacities per month (man-hours)	Loss of capacities per 8 months (man-hours)
Operator	2886,38	23091,04	512,00	4096,00
Adjuster	2320,64	18565,12	x	x
TOTAL	**5207,02**	**41656,16**	**512,00**	**4096,00**

Source: own processing by author

The authors determined all costs per 8 months when the machines would be setting 20 times. The same procedure will be used to determine the costs for the remaining four months when the number of setting the machines will be 19.

Table 11. Quantification of costs per month and 4 months for individual employees

Employee	The amount of monthly costs (€)	Amount of costs for 4 months (€)	Loss of capacities per month (man-hours)	Loss of capacities per 4 months (man-hours)
Operator	2742,06	10968,24	486,40	1945,60
Adjuster	2204,61	8818,43	x	x
TOTAL	**4946,67**	**19786,68**	**486,40**	**1945,60**

Source: own processing by author

After merging the production batches, the annual costs for both employees were 61 442,84 €. The total lost capacity by operator on the machine amounted to 6041,60 man-hours.

Table 12. Quantification of annual costs and capacity loss after merging of production batches

Employee	The amount of annual costs (€)	Loss of capacity per year (man-hours)
Operator	34059,28	6041,60
Adjuster	27383,55	x
SPOLU	**61442,84**	**6041,60**

Source: own processing by author

6. RESULTS

After comparing the costs before and after the merging the production batches, the authors found that if the company merged production batches, it would save up to 16 662,46 € per year. Capacity losses decreased by 1639 man-hours per year. If they turn them into man-minutes, they get 98 340 man-minutes. The production of one bearing lasts on average 3,5 man-minutes, which means that in case of such savings the company could produce 28 097 bearings more per year. In case of their sale, if the average price of the bearing is 2,2 € per piece, the company sales would be higher by 61 813,71 €.

Table 13. Comparison of costs and capacity losses before and after merging of production batches

Original costs of setting the machines in €	Costs of setting the machines after merging production batches in €	Savings	Original capacity losses in man-hours	Capacity losses after merging production batches in man-hours	Savings
78105,30	61442,84	16662,46	7680,00	6041,00	1639,00

Source: own processing by author

The authors encourage the company not to accept orders below 5000 pieces of bearings from its customers because it unnecessarily increases the cost of setting the machines due to small batches and generates capacity losses.

7. CONCLUSION

In this paper, the authors provided the results of the research that has been realized in the Slovak manufacturing company and they pointed out how the specific solution in business logistics can save the company's costs, which of course also affects the profit. The greatest emphasis was placed on production logistics and production batches. The 25 dimensional types of bearings that the company sells to its largest automotive customer METELLI S.P.A were the subject of a thorough analysis.

In this case, the authors have encountered a problem of too small monthly production batches for certain dimensional types of bearings that have been subject of improvement. Production batches over 5 000 pieces remained unchanged due to insufficient capacity in case of mergers.

So the authors chose 8 types, which they gradually merged for each quarter. In this way, the company would "pre-produce" bearings for a few months ahead. The whole suggestion is also documented by numerical characteristics. The costs of setting the machines have always been calculated by the operator at the machine and the adjuster. The operator at the time of setting the machine has a downtime and cannot produce, but is rewarded by wage per hour and the company pays for it. The adjuster is directly involved in process of setting the machine. Some machines can be set by the operators on their own, so there are no costs per the adjusters in this case. An enterprise could save up to 16 662,46 € per year in the case of a merging of production batches.

These savings are related to only to the dimensional types of bearings that METELLI buys from the company. The company produces about 80-90 production batches per month, which accounts for about 40% of its total production. If the company would continue in the authors` suggestion and would also merge other small batches of other dimensional types, it would generate a great deal of cost savings.

Too small and frequent production batches are inefficient in terms of costs of setting the machines and capacities. That is why the company should also impose a restriction that it will accept orders greater than 5000 pieces.

Small batches can be seen as some way of wasting. The company should certainly solve this problem in the foreseeable future, and it could save the financial funds and later use them to develop the company.

This study in a particular manufacturing company provides one of the many proofs why business logistics is important for business performance and its competitiveness. When a company is interested in the functioning of individual parts of business logistics - purchasing and supply, production and distribution logistics - this approach can greatly reduce the company's costs that will affect its profits.

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FORECASTING OF FINANCIAL HEALTH IN TRANSPORTATION AND STORAGE SECTOR

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Abstract

The paper's aim is the forecasting of corporate financial health. It is focused on the specific sector of economic activity – Transportation and Storage in the Czech Republic which is labelled as CZ-NACE H. There could be used various tools for forecasting. In the case of finance, models predicting financial distress are widely used for fulfilling this purpose. They provide an answer if the company is exposed to the risk of bankruptcy or if its financial health reaches a satisfying level. In a period of economic expansion, models should classify most businesses as healthy with a very low risk of bankruptcy. There is one obstacle because no universal model exists. Some models provide better results for manufacturing companies, others for services, emerging markets or transition economies. Transportation and Storage Sector has its own specifics from different points of view and financial perspective is no exception. Although the main aim of the paper is forecasting of corporate financial health, another goal is detecting the prediction model or models best fulfilling the aforementioned aim.

Key words: models predicting financial distress, prediction formulas, Czech Republic

1. INTRODUCTION

Forecasting and predicting of the future state of the world is the foundation of business and entrepreneurship. Companies try to predict consumer demand, development of prices or costs but also the future development of their business relations. No manager wants to cooperate with partners who are at risk of closure or bankruptcy. Prediction of bankruptcy became a serious research question back in 1960's (Altman, 1968 or Beaver, 1966). Efforts ended with the creation of models predicting financial distress also called bankruptcy models. These models usually use corporate financial data for their prediction because the current state influences the future. These approaches provide their users a quick and inexpensive prediction about the future of the related company whose development can affect one´s own business.

There have been created thousands models fulfilling purpose discussed aforementioned since 1960's. Many of them created a know-how of their users and therefore were never published. Some models lost their prediction ability during years and therefore new models have been created. The debate about the models predicting financial distress always increases due to serious political or economic changes. The last global economic crisis was no exception. In the Czech Republic papers by Klečka & Scholleová (2010), Pitrová (2011), Karas & Režňáková (2013), Machek (2014) or Čámská (2015) addressed this issue. These papers generally tested the explanatory power of the already existing models and discussed the necessity of new models. This paper continuous these efforts. For its analysis, it uses models predicting financial distress which had high explanatory power tested by Čámská (2016). The tested models will be introduced in the following chapter. These traditional approaches are mainly used for an evaluation of the companies belonging to manufacturing. But let's ask if these models can be used for the companies operating in Transportation and Storage in the Czech Republic which is labelled as CZ-NACE H.

The models predicting financial distress can have a variety of users. First, managers might use them for the evaluation of their own company. It shows a time development and improvement or worsening of the financial situation. It must be noted that this is not the real models' purpose. The managers mostly evaluate related companies as suppliers, customers or even competitors. It enables them to mitigate business risks. Banks and other financial institutions usually create their own models and tools predicting financial distress or potential default. Their goal is to assess the financial situation when they decide about credit providing and conditions of loan contracts. Previous years especially in the new EU member countries have shown the importance of this issue in an area of subsidies and other kinds of support. The financial situation of each applicant is evaluated by various models.

There does not exist any universal model, hence the company's specifics (such as maturity, ownership structure, industry, share of tangible assets etc.) influence the results. This paper focuses on one company's specific and that is its belonging to a particular industry branch.

2. TESTED MODELS

This chapter will present the models which will be tested. As was previously mentioned, these models have already proven their accuracy in Čámská (2016). The analysed models arise from different political, economic and geographical environments. A data sample will work with the Czech data and therefore there is a significant focus on the Czech predicting approaches. The Czech models are accompanied by the models from other European countries which were called transition economies in 1990's. The whole group is completed by the world-famous models by Altman (1993), Taffler (1982) fully published in Agarwal & Taffler (2007), Bonita model (in the German original Bonitätsanalyse, Wöber and Siebenlist, 2009) or Kralicek model (Kralicek, 2007) which are still very popular in the environment of the Czech Republic.

The basis of Czech models is concentrated around the IN index family, specifically IN01 (Neumaierová and Neumaier, 2002) and IN05 (Neumaierová and Neumaier, 2005). Other Czech approaches which will be verified are Grünwald Bonita Index (Grünwald, 2001) and Balance Analysis System by Rudolf Doucha

(Doucha, 1996). The models arising from the transition economies are represented by the Polish models Prusak 1, Prusak 2, PAN-E, PAN-F, PAN-G, D2 and D3 (Kisielinska and Waszkowski, 2010), the Hungarian model Hajdu & Virág (2011) and the Baltic approaches Šorins/Voronova (Jansone, Nespors and Voronova, 2010), Merkevicius (Merkevicius et al, 2006) and R model (Davidova, 1999). This paper does not list formulas of each tested model because the extension of the paper would be too long. Interested readers can find the formulas in the relevant mentioned literature.

3. METHODOLOGY AND OBJECTIVES

This chapter is dedicated to a used research methodology and solved research objectives. The chapter is divided into several subparts. The part Paper's objectives defines the research questions solved in the paper. The part Research methods explains the measures used for the verification of models' accuracy. The part Selected area of industrial activity shows the economic sector which is in the centre of the verification and it poses its importance and specificity as well as papers connected with the special issue. At the end, attention is paid to the data sample and defines the analyzed companies.

3.1. Paper's objectives

The paper verifies the accuracy of models predicting financial distress in the specific sector of economy. The previous chapter defined the models which had higher accuracy in the area of manufacturing and construction. The research should provide an answer if these models are also suitable for the area of logistics or if there is a need of special predicting tools. This is the first research question. The second one is to detect the model/s with the highest possible accuracy. The models with the best reliability should be recommended for a use in practise and contrary the use of the models with low explanatory power should be restricted. It could especially reduce the universality for subsidiary programs financed and co-financed by the European Union and national or local governments.

3.2. Research methods

The models' reliability and accuracy can be expressed by several metrics such as Cumulative Accuracy Profiles (CAPs); Accuracy Ratios (ARs); Conditional Information Entropy Ratio (CIER); Mutual Information Entropy (MIE) described by Sobehart et al. (2000). These tools seem to be too complicated in connection with the published models predicting financial distress which are popular and widely used because of their simplicity and user-friendliness. It must be noted that models are generally only a simplification of the reality and therefore they work on probabilistic roots (eg. Altman, 1968 or Farooq ae al., 2018) and not all companies can be classified correctly. At the beginning, creation and verification in almost all papers are based on measures such as Type I Error and Type II Error. These measures show an incorrect classification of the tested companies. Type I Error is connected with the incorrect classification in case of the defaulted companies and Type II Error is for the group of the non-defaulted companies. The following table offers a better explanation by showing the division according to classified categories.

Table 1. Type I Error and Type II Error

		Estimated	
		Non-default	Default
Observed	Non-default	True	False Alarm (Type II Error)
	Default	Miss (Type I Error)	True

Source: Fernandes (2005)

If numbers of Type I Error and Type II Error are summed up for an analysed sample, one obtains the absolute value of both kinds of errors. Higher value means lower accuracy because the tested model does not provide relevant answers for further decision making. The gained absolute values are highly dependent on a sample size and therefore it is more convenient to use the relative values instead of the absolute ones. Type I Error as a ratio is constructed as all incorrect classified defaulted companies divided by all defaulted companies. Type II Error as a ratio is constructed analogically for the non-defaulted companies. On one hand it is required to keep the error rate as low as possible and on the other hand to keep the reliability as high as possible. The reliability can be expressed as a ratio as well which has in a numerator the number of all correctly classified (non-)defaulted companies and in a denominator the number of all (non-)defaulted companies. In many cases there is not valid that error ratio plus reliability ratio are equal to 1. It is caused by the model construction itself. Many models do not work only with two groups: healthy and unhealthy but they also use a grey zone which is situated between the two aforementioned extremes. Another reason is that the used model is not able to evaluate the corporate financial situation because of the data whose selected items are equal to zero. This will be discussed in more detail in a chapter dedicated to results. The used research methods have to work with the error rates as well as with the reliability rates. For a user it is crucial to get the lowest wrong classification and the highest correct one.

It is difficult to define the sufficient level of the models' reliability. It is certain that the reliability should exceed 50% probability (otherwise the coin flipping provides the same result) and the error rate should be lower than 50%. The model is generally accepted if its error rate does not exceed 20%. Data samples should be evaluated separately. It means that the results for the defaulted entities should be first evaluated without the non-defaulted entities. Some models can be too strict and others too moderate. The best suitable models for defaulted and non-defaulted entities are compared in the following step. The most accurate models are those, whose tools provide reliable results for the defaulted as non-defaulted companies.

3.3. Selected area of industrial activity

Models predicting financial distress are usually verified on one or more entrepreneurial sectors. It has to be taken into account that there are differences among sectors in the performance, indebtedness, used property etc. The verification is usually performed on the companies belonging to manufacturing because they have a common goal to produce products for customers and many other common features. They created the backbone of the economy although the centre has shifted to services. It can be applied to the manufacturing industry as a whole group as in the case of Karas & Režňáková (2013) or Machek (2014) or on individual industry sectors belonging to manufacturing as Klečka & Scholleová (2010) or Čámská (2015 or 2016). Other sectors than manufacturing are analysed rarely because the most of models predicting financial distress were mainly constructed for the verification of the companies operating in manufacturing. The last global economic crisis introduced a need of the verification also in other entrepreneurial sectors. One example can be presented by logistics including transport and storage which are typical cycle-sensitive industries (Maripuu & Maennasoo, 2014). Due to cyclical sensitivity the economic crisis affects this sector extremely quickly and it spreads further. There can be found papers verifying accuracy of the models predicting financial distress in the area of logistics. Typically it is focused on specific countries whose economy is heavily dependent on transport and connected activities. Let's mention Lithuanian papers Kanapickiene & Spicas (2016) or Marcinkevicius & Kanapickiene (2014), Polish papers Juszczyk (2010) or Brozyna et al. (2016) focused on Poland and Slovakia. There are not such specific papers for the Czech Republic which verify the accuracy of models predicting financial distress in the area of logistics. There can be found papers focusing generally on the financial situations of the companies belonging to logistics in the Czech Republic as Hyršlová et al. (2018) or Telecký (2015).

3.4. Data sample

Models' verification significantly depends on a used data sample and therefore it has to be explained which business entities have been included in a data sample. The data sample consists of two groups. First group has to be represented by unhealthy companies and second group has to contain healthy companies for fulfilling the purpose of the models predicting financial distress. The definition of the healthy and unhealthy companies is too general and it has to be specified for a companies' selection.

The situation is simpler in the case of the unhealthy companies because these companies have to be ailing with serious consequences on their long-term existence. There is not a uniform definition of unhealthy or defaulted companies according to the literature review. Depending on publicly available data it can be used the definition provided by Act No. 186/2006 Coll., Bankruptcy and Settlement (the Insolvency Act) in the Czech Republic. This paper considers the defaulted companies to be insolvent. A declared insolvency proposal is a start of an insolvency proceeding. From the corporate database Albertina there have been extracted the companies with the insolvency proposals declared in the time period 2014-2018 plus first months of the year 2019. It is the post-crisis period of stable conditions in the Czech economy (Volejníková & Řezníček, 2016). It has an advantage that the results are not affected by exceptional economic conditions.

The second limitation is availability of financial statements which are crucial for the verification of the models predicting financial distress. It is widely accepted that financial problems have been already occurring for several years before bankruptcy. For this statement it can be noted Beaver (1966), Altman (1968) and many others. The data sample works with the financial statements constructed one or two years before the insolvency proposal. The chosen time of the financial data is important because older data did not have to contain any signs of coming problems yet. On the other hand the financial statements drawn up after the insolvency proposal are too much affected by the corporate crisis and they cannot be used for the prediction any more. The final data sample consists of 30 companies operating in CZ-NACE H whose financial statements constructed one or two years before the insolvency proposal are publicly available. The data sample does not seem wide but it is exhaustive according to the number of insolvency proceedings at the analysed time and the unavailability of financial statements. Although publishing of financial statements is required by the law in the Czech Republic it is not very much respected and especially in the case of the ailing companies (Bokšová & Randáková, 2013).

It can be assumed that the group of healthy companies is willing to publish their financial statements more in comparison with the insolvent ones. On the other hand there does not exist any guideline how to select companies which are supposed to be classified as healthy. The right verification should not be based on the general sample containing all companies registered and operating in the given industry but it should be based on the sample containing really healthy entities. One solution leads through a positive economic value added which were already used in papers Čámská (2015 or 2016). The positive economic value added can be identified as an increase of invested capital which is considered to be the most important enterprise goal (Synek & Kislingerová, 2010 or Tirole, 2006). The healthy group is defined as the companies creating the positive value added in the year 2017 for the purpose of this paper. Although it is the year 2019 there have not been published financial statements for the year 2018 in the case of most companies. The year 2017 represents the last possible one for which almost all willing companies published already their financial statements. The positive value added is determined as ROE (net income divided by equity) exceeding the minimal profitability requirement for owners published by Czech Ministry of Industry and Trade (MPO, 2018). It works with a disadvantage that the value added is based on the accounting data instead of the market data (Jordan at al., 2011). It must be noted that the market data are rarely available in the Czech Republic because of the ineffective capital market and therefore this indicator seems as the best one for measuring the main corporate goal and for solving a choice of the healthy companies.

The extraction of the data sample was performed in several steps as shown in the following table. First there were detected the companies operating in CZ-NACE H whose financial statements are available for the year 2017 and whose entrepreneurial activity is not connected with any insolvency proposal (it is crucial for the unhealthy companies). After first extraction there were 2352 statistical units with different level of the financial health and performance. The second step follows the positive economic value added but this step is divided in two sub-parts because of the paradox ROE (Strouhal et al., 2018). The positive value of the indicator ROE can be even gained for the negative net income in the case of negative equity (caused by cumulated losses in the previous periods). If net income is negative the company does not create the positive economic value added at all. The first sub-part searches the companies with the positive value of the indicator ROA (based on the ratio income to assets which have to be positive) and there were detected 1697 statistical items. The last sub-part follows ROE exceeding the minimal profitability requirement for owners. The Ministry of Industry and Trade (MPO, 2018) published the minimal profitability requirement for owners equal to 8.07%. It means that 1163 companies operating in CZ-NACE H had higher ROE than 8.07% in 2017 and they were creating the positive economic value added for their owners. These companies represent the healthy group for this research and further verification.

Table 2. Sample selection

	Healthy companies
Total availability for 2017	2352
Positive ROA	1697
ROE exceeding minimal requirement	1163

Source: author

4. RESULTS

Results for all models predicting financial distress introduced in chapter 2 have been computed. The gained evaluation of individual companies contained in data sample explained above will be shown in this chapter. The interpretation will follow the division of the sample to the defaulted and non-defaulted companies. Most models can be interpreted together because they use for the classification two or three zones – unhealthy, grey and healthy group. Exceptions are Grünwald model, Bonita and R model, which will be evaluated separately. The reason is that these models were created with more than three classification zones. The results will be displayed in tables containing absolute numbers of the classified companies belonging to each model zone and relative indicators as reliability and error rate. Reliability shows the percentage of the companies that was evaluated perfectly and error rate represents the percentage of the companies that were evaluated totally imperfectly. The definition of these indicators was explained in the part Research methods.

Table 3. Explaining power in the case of defaulted companies

Model	Unhealthy	Healthy	Grey Zone	Not evaluated	Reliability	Type I Error
Altman	21	7	2	0	70.00%	23.33%
IN01	21	6	3	0	70.00%	20.00%
IN05	21	7	2	0	70.00%	23.33%
Doucha	11	8	1	10	36.67%	26.67%
Kralicek	18	1	5	6	60.00%	3.33%
Prusak 1	18	5	1	6	60.00%	16.67%
Prusak 2	0	0	30	0	0.00%	0.00%
PAN-E	15	5	0	10	50.00%	16.67%
PAN-F	23	7	0	0	76.67%	23.33%
PAN-G	23	7	0	0	76.67%	23.33%
D2	23	6	0	1	76.67%	20.00%
D3	20	4	0	6	66.67%	13.33%
Hajdu and Virag	5	25	0	0	16.67%	83.33%
Šorins/Voronova	26	4	0	0	86.67%	13.33%
Merkevicius	25	5	0	0	83.33%	16.67%
Taffler	25	4	0	1	83.33%	13.33%

Source: author

The table monitoring the defaulted companies proves that there are significant differences among the used models predicting financial distress. It must be noted that these models have already demonstrated a high explanatory power on other samples. This cannot be confirmed for the sample used here. Some models maintain their high explanatory power, some have a moderate one and there are also several models with poor results. Setting reliability and error rate aside for a while, we will focus on the number of unevaluated companies. Models Doucha and PAN-E are not able to evaluate 10 companies which represent one third of the data sample. Also models such as Kralicek, Prusak 1 and D3 have a higher proportion of the companies whose financial data cannot be evaluated. Such a result does not mean that the model provides incorrect answers for the decision making but it notifies the user that the model cannot work properly because of financial items equal to zero. On the other hand such a result does convey anything to the reader. Focusing on Type I Error, the worst results are connected with the model of authors Hajdu and Virag whose error rate exceeds 80%. No results are provided by Prusak 2 because all companies belong to the grey zone although in reality there was the insolvency proposal in each case. Quite a high error rate and low reliability rate are valid for the Doucha approach which has been already mentioned because of the high proportion of unevaluated companies. Extremely good results are connected with the models of Šorins/Voronova, Merkevicus and Taffler whose reliability rate exceeds 80%. Almost the same results have been achieved by the models PAN-F, PAN-G and D2 (reliability rate 76.67%). Unmentioned models as Altman, IN01, IN05, Kralicek, Prusak 1 and D3 have the reliability rate higher than 50% but not reaching 80% because of wrong classification, usage of grey zone or impossibility of evaluation. The group containing the defaulted companies is only one part of the sample and therefore the model has to have also high reliability rate for the non-defaulted companies.

The table containing the final evaluation for non-defaulted companies will prove or disprove the results gained previously for defaulted entities. Higher proportion of impossible evaluation is repeated in the case of the models Doucha and PAN-E. Both models reach a very high reliability rate. The model created by Hajdu and Virag has one of the highest reliability rates but we have to take in mind that this model reaches the highest error rate in the case of the defaulted companies. It can be concluded that this model is too soft and classifies the majority of companies as healthy without respecting their real financial situation.

No model has a reliability rate below 50% but some models are very close (IN01, Prusak 1 and Prusak 2). The models created by Prusak also have quite a high error rate in comparison with the other used prediction approaches. The reliability rate exceeding 90% can be observed in the case of the models PAN-E, PAN-F, PAN-G, D2, Hajdu and Virag. It must be noted that the models PAN-E and Hajdu and Virag do not provide relevant answers for the defaulted entities and therefore they will not be a part of the final recommendation. The previous sample adored the approaches of Šorins/Voronova, Merkevicus and Taffler. The results for Merkevicius dropped significantly but Šorins/Voronova and Taffler reach almost 80% reliability rate but their error rate shows dissatisfaction.

The tables dedicated to the defaulted and non-defaulted companies do not contain the results for the models Grünwald, Bonita and R. These models differ in the classification zones and therefore each will have their individual evaluation tables. The weakness of Grünwald model is the high proportion of the companies which cannot be evaluated. It is mainly caused by the indicator interest coverage defined as EBIT/interest. When the company does not use any debts connected with the interest than the item interest is equal to zero and the ratio cannot be computed. The model itself does not have a high error rate for both samples but it is not useful because it does not provide an answer in many observed cases.

Table 4. Explaining power in the case of non-defaulted companies

Model	Unhealthy	Healthy	Grey Zone	Not evaluated	Reliability	Type I Error
Altman	58	795	309	1	68.36%	4.99%
IN01	24	636	494	9	54.69%	2.06%
IN05	52	769	333	9	66.12%	4.47%
Doucha	9	898	168	88	77.21%	0.77%
Kralicek	106	783	265	9	67.33%	9.11%
Prusak 1	196	692	258	17	59.50%	16.85%
Prusak 2	216	598	340	9	51.42%	18.57%
PAN-E	28	1047	0	88	90.03%	2.41%
PAN-F	36	1118	0	9	96.13%	3.10%
PAN-G	84	1070	0	9	92.00%	7.22%
D2	17	1137	0	9	97.76%	1.46%
D3	187	967	0	9	83.15%	16.08%
Hajdu and Virag	17	1137	0	9	97.76%	1.46%
Šorins/Voronova	237	925	0	1	79.54%	20.38%
Merkevicius	418	744	0	1	63.97%	35.94%
Taffler	231	923	0	9	79.36%	19.86%

Source: author

Table 5. Explaining power of Grünwald model

	Defaulted companies	Non-defaulted companies
Unhealthy	6	43
Weaker	0	9
Good	0	22
Extremely good	0	323
Not evaluated	24	766
Reliability	20.00%	27.77%
Error	0.00%	3.70%

Source: author

Grünwald model uses four evaluation zones and Bonita model uses originally even eight evaluation zones. The problem is not that some cases should not be evaluated, there is a much more serious issue. In the case of the defaulted companies the model classified a sample incorrectly because the error rate reaches 50%. It can be interpreted that the user will gain the results in a worse fashion than coin flipping. Bonita model does not have a high accuracy rate for fulfilling the forecasting purpose.

Table 6. Explaining power of R model

	Defaulted companies	Non-defaulted companies
Low danger	6	935
Slight danger	2	17
Medium danger	1	23
High danger	0	12
Extremely high danger	20	175
Not evaluated	1	1
Reliability	66.67%	81.86%
Error	26.67%	16.08%

Source: author

The last atypical model is R model using five evaluation zones. This model does not have any serious weakness. Only one defaulted and one non-defaulted company cannot be evaluated. The error rate is not extremely high for neither of the two samples. Especially the results for the group of the non-defaulted companies are quite good because the reliability rate is higher than 80%. This cannot be confirmed for the second sample. The reliability rate for the defaulted companies is lower and it reaches almost 67%. The models whose results have been introduced above have better accuracy and therefore R model will not be a part of the final recommendation.

Table 7. Explaining power of Bonita model

	Defaulted companies	Non-defaulted companies
Extremely good	12	384
Very good	2	185
Good	1	241
Moderately good	0	196
Poor	0	148
Slight threaten	1	4
Threaten	2	1
Extremely threaten	11	1
Not evaluated	1	3
Reliability	46.67%	69.65%
Error	50.00%	0.52%

Source: author

This paragraph will sum up conclusions gained for the defaulted and non-defaulted companies. It is necessary to find the models predicting financial distress which have a high explanatory power for both types of companies. When forecasting is done the user does not know which companies are defaulted and which are non-defaulted. This answer should be provided by the forecasting itself. For practical use, the following models should be recommended – PAN-F, PAN-G, D2, Šorins/Voronova and Taffler. The weaknesses of other models have already been discussed.

5. CONCLUSION

This paper used the models predicting financial distress for forecasting corporate financial health. Selected models proved their accuracy in the past but it was for other kinds of data samples. The specificity of this research lies in the sector of economic activity. The analysed companies belong to the group CZ-NACE H which contains companies operating in transportation and storage. Many tested models have not reached enough accuracy and therefore cannot be recommended for further use. On the other hand, a group of models predicting financial distress have been detected, which have enough accuracy for companies belonging to the transportation and storage. PAN-F, PAN-G, D2, Šorins/Voronova and Taffler are the models which had a high explanatory power for the analysed data samples.

While we found models which can be recommended for practical use, this research also illustrates the specificity of the economic sector Transportation and storage. Many models with good results for the manufacturing or construction failed. It proves that there is a need for further research in this area and introduces a possibility for the model constructed especially for this economic sector in the Czech Republic.

This paper proves that a model's universality is a problem. This statement has broader implications for the general evaluation of the financial situation. Governmental bodies should not use one universal model in case when the applicants of the subsidies are evaluated. Managers from corporate sector should also reflect their company's specifics as is the belonging to the industry branch in this case.

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COST CALCULATION IN ROAD FREIGHT TRANSPORT

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Abstract

Cost management is important for every transport company. Increasing competition in road freight transport forces companies to cost-effectiveness, so they need to know their costs of carrying out the transport service. The article aims to illustrate the structure of costs in road freight transport and analyze the changes in fixed and variable costs for different annual kilometers traveled. Traditional accounting was used to calculate the total and average costs. In the research, we determined the changes in total and average costs for different annual kilometers, which are expected and comparable with other countries. From the transport company's point of view, the structure of costs is also important, and the finding that the highest of the costs are fuel, labor and toll costs. The research enables transport companies to understand the cost structure and provide opportunities for increasing competitiveness based on cost control. Further research is aimed at determining the cost structure of different types of transport vehicles and the changes of fixed and variable costs in the case of different mileage with using ABC costing methods.

Keywords: road freight transport, transport cost, total costs, average costs

1. INTRODUCTION

Road freight transport is an important factor in the economy of each country. Transport possibilities are one of major factors deemed to be of importance to multinational corporations in the decision-making processes followed when determining where to locate a logistics centre (Gajšek & Rosi, 2015). The production structure of GDP generates traffic and storage activity of more than 6% of added value, of which more than 50% is land transport, where road freight transport accounts for more than 80% (SORS, 2019).

Theoretically, we divide the costs of the company on fixed and variable (eg. Rodrigue, 2017). The transport company usually incurs fixed costs even if the carrier does not carry out the transport work (Topolšek, Čižman, & Lipičnik, 2010). Fixed costs represent costs associated with the vehicle (depreciation, registration), and partly the costs associated with the driver. In addition, a fixed period is fixed also indirect costs of the company (for example, the costs of the company's management, financial services, commercials...) (e.g. Bokor & Markovits-Somogyi, 2015). From the point of view of efficiency, fixed costs force us to ensure that transport companies carry out as much as possible productive work (as many ton-kilometers performed) as the increase in fixed-unit fixed costs increases.

However, it is important to emphasize that we are limited in this way with the capacities of production sources and legislation.

Variable costs with costs associated with increasing mileage. In the structure of variable costs, the most important are fuel costs, toll costs and labor costs (eg daily allowance, mileage surcharge). Fuel costs depend on the type of vehicle and the price of a liter of fuel. The cost of tolls differs between EU countries since various factors influence the setting of the price of tolls. For example, the toll in Germany includes the costs of air pollution, noise and infrastructure costs. The toll is also differentiated according to the emission classes of the engine and the permissible weight by vehicle classes.

Table 1. Toll classes in Germany from 1.1.2019

1		+ 2	+ 3		= 4
Emission class	Proportion of toll rate * for external costs Air pollution	Proportion of toll rate * for external costs Noise pollution	Axle and weight class	Proportion of toll rate * for infrastructure	Toll rate *
Euro 6	1,1	0,2	7,5–11,99 t	8,0	9,3
			12–18 t	11,5	12,8
			>18t to 3 axles	16,0	17,3
			>18t from 4 axles	17,4	18,7
Euro 5, EEV 1	2,2	0,2	7,5–11,99 t	8,0	10,4
			12–18 t	11,5	13,9
			>18t to 3 axles	16,0	18,4
			>18t from 4 axles	17,4	19,8
Euro 4, Euro 3 + PRC 2**	3,2	0,2	7,5–11,99 t	8,0	11,4
			12–18 t	11,5	14,9
			>18t to 3 axles	16,0	19,4
			>18t from 4 axles	17,4	20,8
Euro 3, Euro 2 + PRC 1**	6,4	0,2	7,5–11,99 t	8,0	14,6
			12–18 t	11,5	18,1
			>18t to 3 axles	16,0	22,6
			>18t from 4 axles	17,4	24.0
Euro 2	7,4	0,2	7,5–11,99 t	8,0	15,6
			12–18 t	11,5	19,1
			>18t to 3 axles	16,0	23,6
			>18t from 4 axles	17,4	25,0
Euro 1, Euro 0	8,5	0,2	7,5–11,99 t	8,0	16,7
			12–18 t	11,5	20,2
			>18t to 3 axles	16,0	24,7
			>18t from 4 axles	17,4	26,1

Source: Toll Collect

Total costs represent the sum of fixed and variable costs. Total costs increase with mileage, and the increase depends on the characteristics of variable costs, which can be rising, proportionate or decreasing (Rebernik & Širec, 2016).

From the point of view of business, the average cost of the completed kilometer is important, as they show the dependence of the total costs on the volume of operations. The average cost decreases with the volume of operations, which requires companies to maximize the utilization of the fleet. Cost control is not possible without knowing the full costs of the company (Sternad, 2018). For efficient operations, the company needs cost accounting that represents that part of the entire accounting system that monitors the costs for management decision-making and financial accounting (Hočevar, 2008). The incurrence of costs is always related to some purpose or cost driver (Bokor, 2009).

Cost allocation requires cost breakdowns at direct and indirect costs (Jacyna & Wasiak, 2015). The basic criterion for the breakdown of costs to direct and indirect (general) is whether these costs are in direct or indirect connection with the cost driver and are determined in accordance with the economy of operations.

Direct costs are those types of costs that can already be allocated to the cost driver at the time of their creation or the cost driver caused them (Reiche, 2017). Mostly, these costs are linked to carrying out transport activities and driving a freight vehicle. Indirect costs are those types of costs caused by two or more cost drivers. For indirect costs, it is primarily characteristic that they can not be directly allocated to an individual cost driver (Hočevar, 2008).

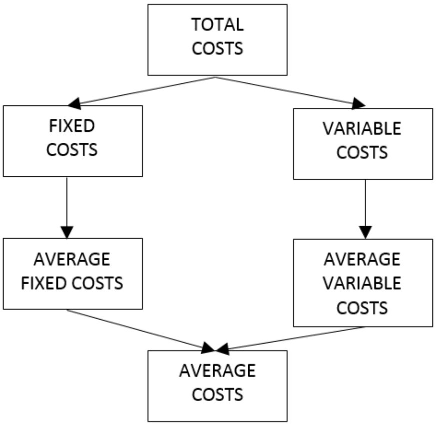
In addition to basic transportation, several transport companies perform other activities (storage, vehicle repair...). Therefore, it is necessary to determine the share of transport activity in the company. Also, transport companies have different fleets (by type of transport and capacity). If we determine the costs for a particular group of vehicles, indirect costs must be correctly allocated to individual vehicle groups (eg. Nurminen et al., 2009). The possible criteria for the division are the number of vehicles of each group or the annual kilometers performed if there are major differences between the vehicle groups.

In research, we focused on the analysis and structure of transport costs for trucks with a capacity of 24 tons. We simulated the change in the share of fixed and variable costs at various annual kilometers traveled.

2. METHODOLOGY

In the survey, we used the traditional cost estimation in Slovenia in accordance with the Slovenian Accounting Standards (hereinafter SAS, 2016). The research was conducted in 4 steps. Figure 1 shows the research model.

Figure 1. Research model



In the first step, we needed data on the vehicle (load capacity, average monthly transported mileage) and the number of vehicles in the company for the preparation of road freight transport calculations. Based on SORS data (2019) and relevant studies (Hočevar, 2008; Kot, 2015), we estimated the average monthly kilometers of 10.000 km. Different mileage scenarios were assumed for the analysis of cost changes: 8.000 km, 9.000 km, 10.000 km, 11.000 km and 12.000 km per month. We also assumed that the company has 10 identical vehicles with a capacity of 24 tons.

Costs in the calculation model are divided into direct costs related to the provision of transport services and indirect costs (e.g. Kovacs, 2017). Total vehicle costs over a period of one year are calculated using the equation:

$$TC = c_{dep} + c_{fuel} + c_{main} + c_{ins} + c_{reg} + c_{toll} + c_{sal} + c_{ind},$$

where are

c_{dep} – annual depreciation costs,
c_{fuel} – annual fuel costs,
c_{main} – annual maintenance costs,
c_{ins} – annual insurance costs,
c_{reg} – annual registration costs,
c_{toll} – annual toll costs,
c_{sal} – annual driver's labor costs,
c_{ind} – annual indirect costs.

Direct costs are divided into three categories of costs: costs associated with the vehicle, the transport route, and the driver.

Costs related to the vehicle are the cost of depreciation, fuel cost, maintenance cost, insurance cost, and registration fee.

The cost of depreciation represents the replacement value of the underlying asset. Fixed assets are vehicles and trailers. In accordance with the SAS (2016), the depreciation method, annual depreciation rate, and amortization basis are determined at the beginning of amortization. In the research, the method of straight-line depreciation was chosen. Annual depreciation rates were determined on the basis of the depreciation period. In the calculation of our own transport price, we assumed a depreciation period of 7 years for vehicles and 7 years for trailers. The depreciation basis of vehicles and trailers is the purchase value of fixed assets. In the research, we used an average vehicle purchase value of 80.000 EUR and an average trailer purchase value of 25.000 EUR. When calculating the depreciation basis, we took into account that the vehicle has a further 20% of the value after the expiry of the amortization period. The depreciation cost is calculated using the equation:

$$DB_v = PV_v - RV_v,$$
$$DB_t = PV_t - RV_t,$$
$$c_{dep} = \frac{DB_v}{DP_v} + \frac{DB_t}{DP_t},$$

where are
DB_v – depreciation basis for vehicles,
DB_t – depreciation basis for trailers,
PV_v – vehicle purchase value,
PV_t – trailer purchase value,
RV_v – vehicle rest value,
RV_t – trailer rest value,
c_{dep} – annual depreciation,
DP_v – vehicles depreciation period,
DP_t – trailer depreciation period.

Fuel cost is a product of fuel consumption per kilometer and the price of fuel. We assumed that the average fuel consumption is 30 l / 100 km. The price of fuel on 25.4.2019 is EUR 1.04836 excluding VAT. We separately evaluated the average fuel consumption of AdBlue, which is 4 l / 1000 km. The average fuel price of AdBlue is 0.6 EUR excluding VAT.

$$c_{fuel} = \frac{FC}{100} \cdot P_{fuel} \cdot K,$$

where are
c_{fuel} – annual fuel cost,
FC – fuel consumption,
P_{fuel} – fuel price,
K – annual kilometers.

Maintenance costs (c_{main}) include the cost of routine maintenance, repairs, cleaning and other costs associated with maintaining the fleet. The cost of maintenance was also included the cost of the tires. The cost of maintenance is increasing with mileage, which is why the study took into account the proportional increase in maintenance costs with kilometers traveled, therefore, the study suggested that the average maintenance cost for a transported monthly distance of 8.000 km amounts to 5.000 EUR and for a transported monthly distance of 12.000 km it is7.000 EUR.

The cost of insurance (c_{ins}) includes the cost of basic insurance, casco insurance, carrier liability insurance and other costs associated with insurance of rolling stock. In the research, we took into account that the average value of the insurance was 3.500 EUR.

The registration fee (c_{reg}) for a vehicle includes the cost of the technical inspection, the annual levy, the renewal of registration and other costs associated with the registration of the rolling stock identified by the undertakings. The average registration fee is 800 EUR.

Costs related to the transport route are the cost of tolls, tunnels, parking and other costs arising on the transport route. The cost of tolls (c_{toll}) is increasing with the distance traveled, so we suggested in the research that the average annual cost for road vehicles at a monthly distance of 8.000 km is 22.000 EUR, and for a transported monthly distance of 12.000 km it is 30.000 EUR. The remaining costs in this group due to the minimal impact on the cost structure were not captured.

Driver-related costs include driver's gross salary, daily allowance, recourse, travel expenses, food and other costs (education, licenses, medical examinations ...). The labor cost (c_{sal}) was also divided into a fixed part, which is related to the existing legislation and the variable part, which is related to the kilometers traveled. The value of the fixed part of the salary is 12000 EUR, and the variable part is 0,125 EUR / km.

Indirect costs (c_{ind}) are costs incurred at the level of the whole enterprise. When an enterprise has only a transportation activity, all costs are directly related to the performance of the transport activity. We assumed that a company with 10 vehicles has an average of 150.000 EUR of indirect costs.

In the second step, we divided the costs into fixed and variables. On the basis of the relevant studies (Bokor & Markovits-Somogyi, 2015) and our own experience, we included depreciation, insurance, registration, part of labor costs and indirect costs among fixed costs. Among the variable costs, we included the costs of fuel, maintenance, tolls and part of labor costs, depending on the mileage.

In the third step we calculated the average fixed and average variable costs by means of the equations:

$$AFC = \frac{FC}{K},$$
$$AVC = \frac{VC}{K},$$
$$TC = FC + VC,$$

where are
AFC – average fix costs,
FC – fix costs,
AVC – average variable costs,
VC – variable costs,
TC – total costs,
K – annual kilometers.

In the fourth step, we calculated the average cost per kilometer using the equation:

$$AC = AFC + AVC,$$

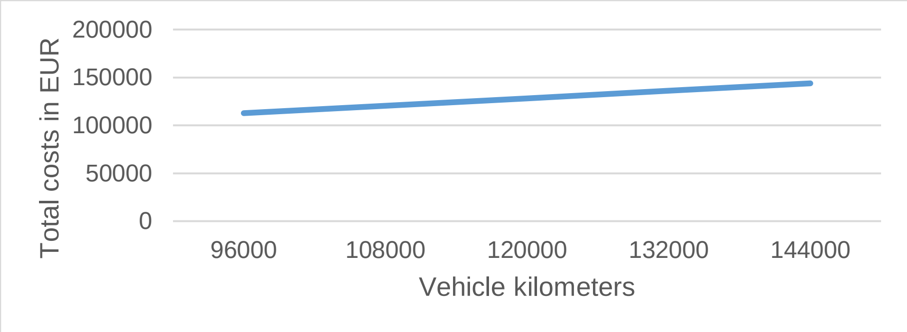
where is
AC – average costs.

In the research, we also observed and graphically depicted the changes in costs in the case of different kilometers.

3. RESULTS

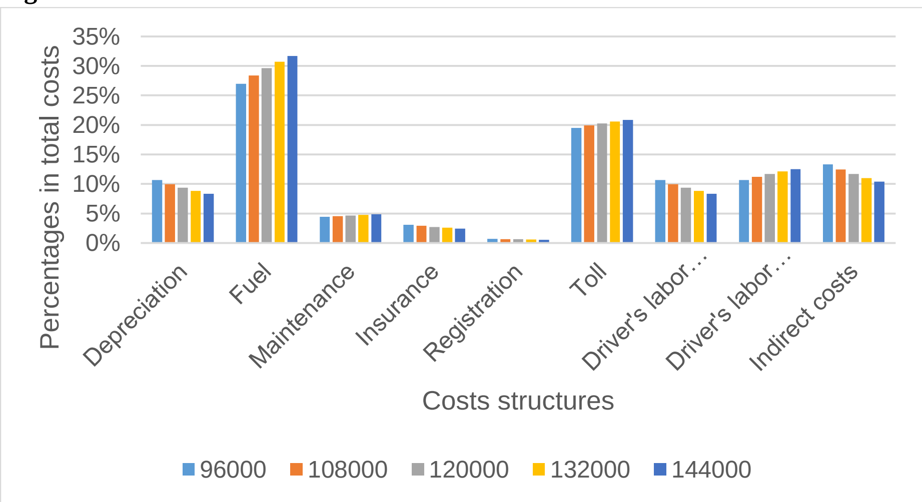
The total cost of freight transport increases with increasing distance. In the research, we assumed that costs were increasing evenly, but in practice, due to additional unforeseen costs, the costs may increase exponentially. Figure 2 shows an increase in total costs.

Figure 2. Total costs



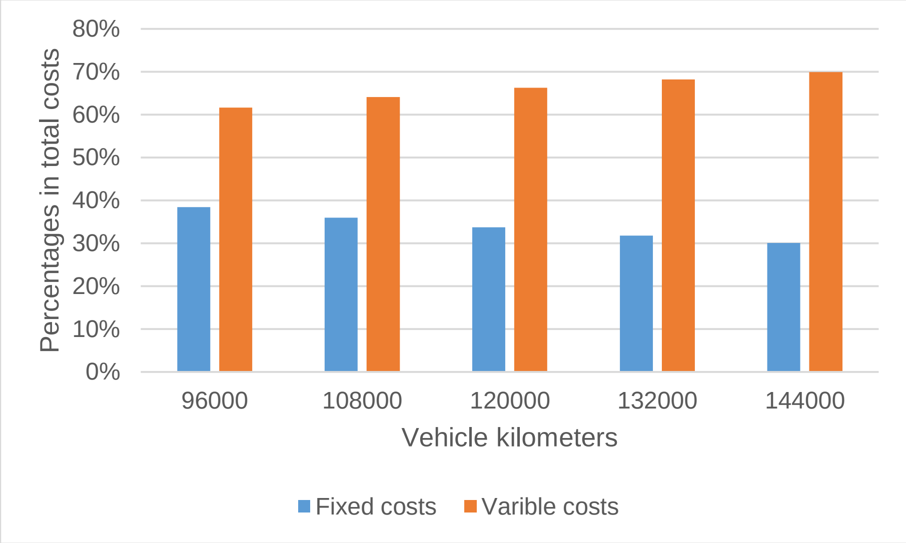
The largest share in the cost structure present fuel costs. With an annual mileage of 9.000 km, the fuel cost is 27% in total costs, and for the kilometers of 144.000 km, it is already 32%. The other highest cost is the cost of work divided into a fixed and variable part. With an annual mileage of 96.000 km, the total labor cost is 22% and for 144.000 km it is 21%, as the fixed part of the wage is falling faster than the variable increases. An important share in the cost structure represents a cost of tolls of around 20%. The lowest cost (1%) represents the cost of the registration fee. Figure 3 shows the changes in shares in the cost structure.

Figure 3. Cost structure



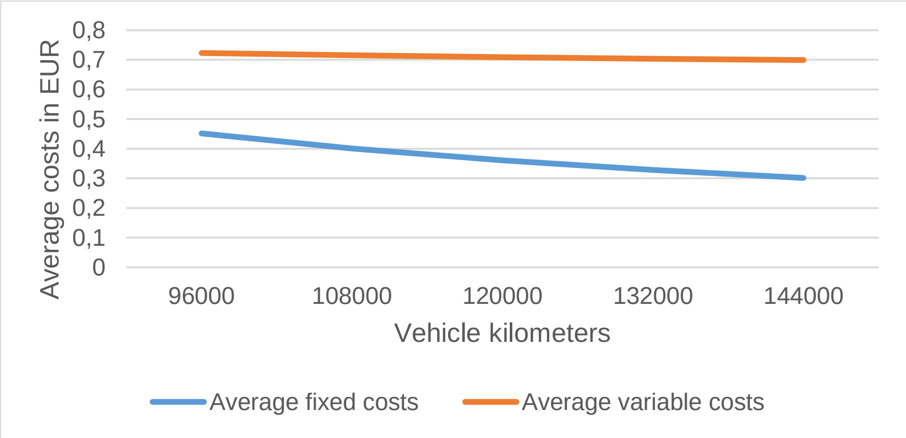
At 120.000 km, the share of the fixed costs is 34% and the variable is 66%. With less mileage, the share of fixed costs is increasing (at 96.000 km is a share of 38%), with higher mileage, the share of fixed costs is reduced to 30% at 144.000 km. Figure 4 shows the shares of fixed and variable costs in total costs.

Figure 4. Shares of fixed and variable costs



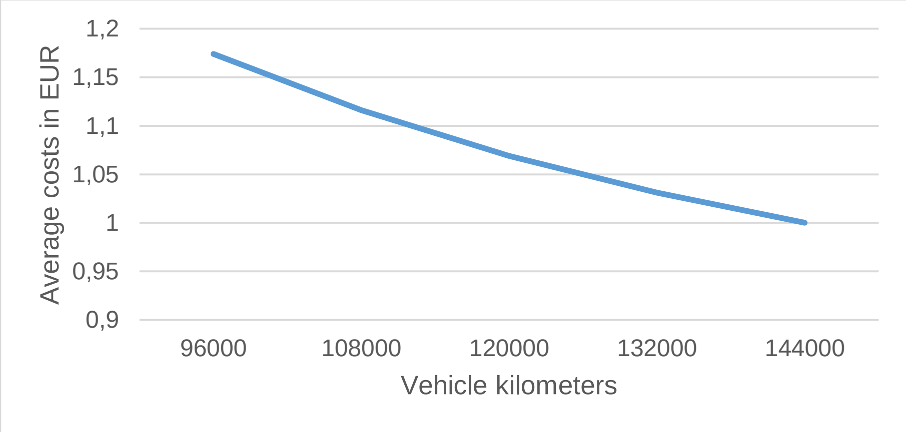
Since we assumed a proportionate increase in total costs, the average variable cost is around 0,70 EUR / km for different annual kilometers traveled. The average fixed costs are reduced from 0,40 EUR / km at 96.000 km to 0,30 EUR / km at 144.000 km. Graphically, the average fixed and variable costs are shown in Figure 5.

Figure 5. Average fixed and variable costs



From the perspective of a transport company, knowledge of average costs (cost per kilometer) is needed. The average cost is the basis for determining the sales price of the transport service. The average cost excluding the calculated profit margin varies from 1.15 EUR / km at 96.000 km, to 1 EUR / km at 144.000 km. Graph of average costs is shown in Figure 6.

Figure 6. Average costs



4. CONCLUSION

Cost management is becoming very important for all transport companies, and rational organization of freight transportation on time from point A to B must be at minimal cost (Topolšek, Čižiūnienė, & Cvahte Ojsteršek, 2018). Competition primarily from the eastern countries is growing, and therefore knowledge of the own price of the transport service represents the competitiveness in the market and the direction to the markets, where we can get the highest added value with our costs.

Costs consist of fixed and variable costs. Fixed costs do not change with the kilometers traveled, and the achievement of lower average costs requires an annual score of as many kilometers as possible. Fixed costs range from 30 to 38%. Variable costs increase with mileage and represent up to 70% of total costs.

In the research, we determined the changes in total and average costs for different annual kilometers traveled, which are expected and comparable with other countries. From the transport company's point of view, the structure of costs is also important, and the finding that the bulk of the costs are fuel, labor and toll costs. Reducing fuel costs can be achieved by optimizing the truck's run and purchasing newer trucks that, in addition to saving on fuel costs, also allow for cost savings for tolls related to the type of engine (eg EURO 6). Due to the quality of transport services, savings in labor costs are almost impossible, but in practice (in Slovenia) drivers from other countries have significantly lower average wages than in Slovenia.

Further research is aimed at determining the cost structure of different types of transport vehicles and the changes of fixed and variable costs in the case of different transported annual kilometers and using another accounting method (eg ABC costing).

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TOWARDS INCREASED LOGISTICS EFFICIENCY BY MEANS OF KNOWLEDGE MANAGEMENT

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Abstract

While in the industrial age the competitiveness of a business entity was typically correlated with its productivity, in the information age, also known as the knowledge age, it is correlated with the efficiency with which information and knowledge are used. In this context, information represents a dynamic interpretation and understanding of the relationship between time-dependent datasets, while knowledge comprises relatively timeless data or information, i.e. data that enables one to understand specific situations. Due to the significance of information and knowledge in the modern era, it is important for a business entity to manage not only its material resources, but also information and knowledge. One of the business processes where information and knowledge management is an essential factor in achieving efficiency is logistics. Today, the collection and use of information is in the domain of relatively high-quality information systems that enable the efficient management of logistics chains. Thus, it may be said that the efficiency of logistics chain management is proportional to the quality of the information system that manages information relating to logistical processes. On the other hand, if the efficiency of logistics in a business entity is proportional not only to the efficiency of information management, but also to the efficiency of knowledge management, the question arises as to which systems are used for knowledge management in the age of information and knowledge. While information management systems are highly developed and widely used, knowledge management systems are still in their infancy. It is a fact that, to an extent, information systems are used for knowledge management; however, they represent only one segment of knowledge management. Thus, when it comes to logistics it is essential to consider and develop, in the form of an application model, a portfolio of programme-type tools that need to be interpolated and used in a modern business entity with the aim of increasing the efficiency of logistics by means of knowledge management.

Keywords: logistics, knowledge, information systems, knowledge management systems, knowledge management.

1. INTRODUCTION

Knowledge management is normally construed as a relatively homogeneous concept that focuses on knowledge, i.e. its management. However, it is a relatively new and very broad concept that encompasses a variety of technologies, techniques and tools, and focuses on the organisation of knowledge for the purpose of reusing it and thereby increasing the efficiency of its use, as well as on capturing, documenting and distributing it. A modern society that relies on information and communication technologies uses digital repositories of knowledge. Therefore, in addition to focusing on tacit knowledge, i.e. knowledge stored in human minds, knowledge management focuses on the methods of knowledge externalisation and digitisation. Knowledge management is used in many areas of human activity. In addition to being a cornerstone of information science, it lies at the heart of philosophy, psychology, sociology, economics, etc. For instance, contemporary information science, in particular library science, is based on knowledge management.

Knowledge management is of particular importance for economic sciences because, conditionally speaking, it originated in economic research. In 1961, Kenneth J. Arrow noticed that learning increases the productivity of a business system (Arrow, 1961). Drucker has introduced the concept of knowledge workers and explored their productivity (Drucker, 1999). Numerous authors have considered the impact of knowledge on the efficiency of a business organisation. However, knowledge is essentially a phenomenon from information science, and, similar to wisdom, is viewed as a derivative of data or information. (Hoppe at al., n.d.) In particular, during a business process, the transformations of material and energy occur under the influence of information and knowledge while, at the same time, producing information and knowledge themselves. The management subsystem of a business system manages a business process by transmitting information and knowledge and receives information and knowledge through a feedback system. Knowledge is a key factor in the decision-making process in the domain of management processes that take place in a subsystem that manages a business system, but at the same time, it is a key factor in ensuring and increasing the productivity of a subsystem responsible for business operations. Therefore, especially in the contemporary business environment where information and knowledge are key resources in ensuring the competitiveness of business systems, it may be concluded that knowledge is a critical factor in the survival of business systems and in increasing their efficiency. Similarly, knowledge is a key factor in achieving logistics efficiency. It is therefore essential to determine how knowledge management functions, which technologies, techniques and tools it utilises, and how they can be used to improve logistics efficiency. Given the fact that logistics is essentially a material and information process, but also a knowledge-based process, the work at hand focuses on defining a model that will exploit the potential of knowledge management to boost logistics efficiency in the modern business environment.

2. RESEARCH METHODOLOGY

Logistics can be viewed as critical support for efficient business process implementation. It is common knowledge that Napoleon's victories, in particular the one at Austerlitz, were won due to good planning, mobility and efficiency of the logistics that successfully followed and supplied Napoleon's troops (Toole, 2011). Similarly, business entities today depend greatly on logistics efficiency. As logistics essentially involves tangible and intangible activities, its intangible component encompasses information and knowledge used both in the decision-making phase and in the implementation phase. Thus, it may be concluded that logistics efficiency is correlated with the efficiency of organising information and knowledge. The research at hand has been carried out in an effort to help business entities optimally use information, and in particular knowledge. The main goals of the research are to:

1. consider the concepts of knowledge management and knowledge, and explore how they affect logistics efficiency;
2. consider the technologies, techniques and tools used in knowledge management that can help organise knowledge with an aim of increasing logistics efficiency.

In order to achieve the research goals, a vast variety of scientific methods was used, among which the following should be mentioned: deduction, abstraction, classification, generalisation, specialisation, aggregation, combination, systematic analysis and synthesis, causal conclusion, analogy, descriptive and symbolic modelling, as well as other scientific methods.

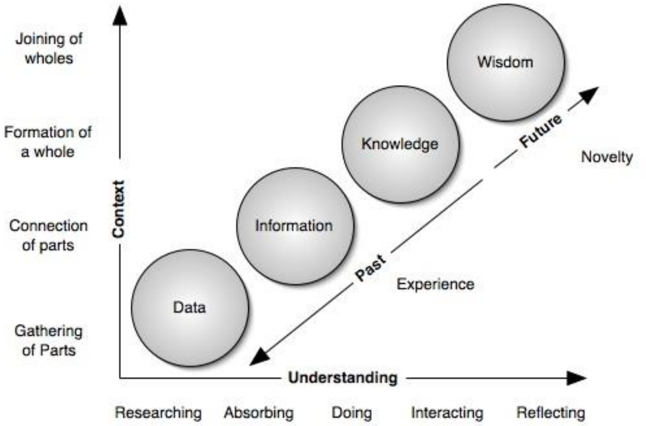
3. RESEARCH RESULTS

One of the theories of human society distinguishes between two major technological revolutions that have dramatically changed the world. The first great revolution took place about 4,000 years BC when human society learned how to grow grains, which led to a sedentary lifestyle and the establishment of a social organisation that still exists in the form of class societies commonly referred to as states. The first technological revolution owes its name to the fact that human society had to discover and adopt a number of technologies, such as production and processing of metal, calendar, script, cartography and the like, in order to increase the efficiency of grain production. The impact on the evolution of the human society of the second technological revolution, which started during the Second World War, was as profound as that of the first revolution, if not more so. The research undertaken for military purposes has led to the development of two major technologies that are essential for the modern era: rocket technology, which has enabled the exploration and conquest of space, and information-communication technology, which has brought about revolutionary changes in the principles of functioning of the contemporary human society. While rocket technology, also known as space technology, is still in its infancy, information and communication technology has had a massive impact on the development of human society and has changed our modes of functioning to such an extent that the modern society can rightfully be considered the new era in the evolution of human society.

Unlike in the agrarian and the industrial era, the focus of the society in the new era is no longer on the management of material goods, but rather on the management of data as the basic raw material for generating information, knowledge and wisdom. Virtually everything that can be digitised will be digitised. Given the industrial potential of the society and the ubiquitous globalisation enabled by the development of transportation, and, in particular, the development of telecommunications, since the mid-20th century there has been a marked increase in competition among producers. As a result, the focus in the contemporary business environment has been shifted from solving technological problems in the field of production and minimisation of production costs to solving issues relating to market positioning and business operations optimisation, an integral part of which is the optimisation of logistics processes as it is a vital success factor for contemporary business entities. Given that artificial intelligence-driven machines are increasingly used to automate business processes, the proportion of manual labour has been decreasing as the proportion of intellectual work has been increasing. In contemporary society, competitive advantage is gained through information and knowledge superiority as a key factor in the successful functioning of the business rather than the ubiquitous information and communication technology. Regarding this, Carr states: “Behind the change in thinking lies a simple assumption: that as IT’s potency and ubiquity have increased, so too has its strategic value. It’s a reasonable assumption, even an intuitive one. But it’s mistaken. What makes a resource truly strategic—what gives it the capacity to be the basis for a sustained competitive advantage—is not ubiquity but scarcity. You only gain an edge over rivals by having or doing something that they can’t have or do. By now, the core functions of IT – data storage, data processing, and data transport – have become available and affordable to all. Their very power and presence have begun to transform them from potentially strategic resources into commodity factors of production. They are becoming costs of doing business that must be paid by all but provide distinction to none.” (Carr, 2003).

Given the significance of information and knowledge to contemporary business systems in gaining a competitive advantage, it is necessary to make a distinction between these two concepts and recognise their role and potential in building competitiveness in the current market environment. In the field of information sciences, information and knowledge are commonly viewed as a derivative of data as indicated in the DIKW model. Figure 1 shows the relationship between information and knowledge in the DIKW model.

Figure 1. DIKW model



Sources: Fogarty, T.: The Learnings Typhoon, 2006, http://knowledgetyphoon.blogspot.com/2006/, according to: Clark, D, Continuum of understanding, 2004, http://www.nwlink.com/~donclark/performance/understanding.html (14.12.2016)

Based on the relationship between information and knowledge, two scientific approaches have been developed. Information management focuses primarily on information, while knowledge management focuses on knowledge. The differences between these two approaches are shown in Table 1.

Table 1. Differences between Knowledge Management and Information Management

S/N	KNOWLEDGE MANAGEMENT (KM)	INFORMATION MANAGEMENT (IM)
1	The KM process includes "Knowledge creation" as part of the KM framework. Knowledge is created through interactions amongst different individuals and different types of knowledge	IM process does not include knowledge creation. It is limited to capturing, processing preserving, storage and distribution of information.
2	KM is more concerned with managing experiences, know-how, skills to create a learning cycle. The knowledge gained can be used to make predictions	IM is focused on managing of information about a particular context, and storage of information in repositories for easy retrieval and distribution.
3	KM involves managing information (inform explicit knowledge), managing process and managing people, creation of innovation and managing of intellectual assets	Information management involves managing information only (this includes all processes from capturing to dissemination of information)

Source: Edosio, U.: Knowledge Management Concept, Research gate, 2014, https://www.researchgate.net/publication/264129318_Knowledge_Management_Concept , p. 5, [1.3.2018]

Information and knowledge form the basis of a business entity's market superiority. Hence, information primarily facilitates the following:

1. market positioning and identification of consumer needs;
2. awareness of the situation and changes at the social, economic, technical, technological and legislative level;
3. economical business decision-making at all levels of decision making;
4. the implementation of business activities in a business entity by means of management information and the flow of information through the feedback system;
5. monitoring of business events and sustaining the business using the information collected and processed by the accounting information system;
6. informing consumers about the business entity and product range through activities in the framework of communication with the market;
7. sale and distribution of products to consumers;
8. informing the relevant bodies about business results as well as other organisations that an entity wishes to inform out of business interest;
9. economical procurement of raw and other materials based on information collected in the supply market and by sourcing the appropriate workforce in the labour market;
10. management of production processes and logistical support;
11. management of payment transactions within and outside the business system;
12. functioning of the value chain, i.e. functioning of a business system by means of formal communication of the business process actors in the form of written or oral work orders and oral and written reports on successful performance of tasks;
13. fostering of good working relationships among co-workers in an organisation through formal and informal communication, i.e. creating a team spirit that defines the perception and organisational culture of a business organisation;
14. fostering of good working relationships between people in the organisation and those outside the organisation through formal and informal communication, i.e. creating partnership and friendly relations, which enables market and social positioning of an organisation and defines the public perception of the organisational culture of a business organisation.

On the other hand, knowledge primarily allows the following:

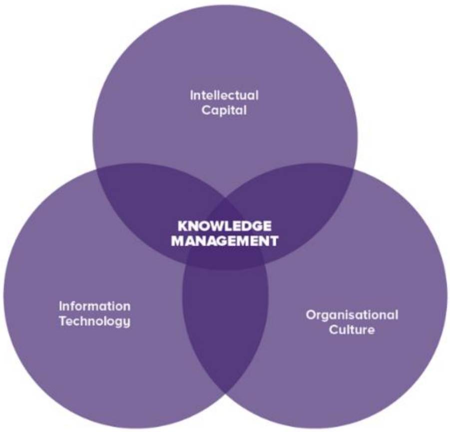
1. understanding and use of information to create new insights and knowledge concerning the functioning of the social, economic and legal environment of a business system;
2. defining of a mission and vision, and creating of a superior business strategy through business planning, by means of knowledge combination and wisdom;
3. establishing and building of a business system by defining technical and technological processes and technical and technological transformation (evolution) of the business system, thereby organizing the business system and establishing organisational culture;

4. establishing of the organisational structure of a business system and the hierarchical relationships between the management (subsystem responsible for managing) and the subsystem responsible for implementation;
5. creating of legal, economic and other content in the form of various business documents;
6. human resources activities in all segments of the value chain that defines the business process;
7. allocation and development of human resources in terms of their technical and technological (professional) competence and adoption of and adherence to organisational culture;
8. increase in the value of human capital through human resources training, and as a result an increase in the value of the business system;
9. increase in reproductive labour productivity;
10. increase in the value of the manufacturing programme of the existing products and/or the development of new products through creativity and innovation of human resources;
11. understanding of consumer needs and behaviour, and the finding of optimal ways to meet these needs, based on market information;
12. communicating and solving of tasks put before the business system by the environment (social, economic and legislative segments of the system);
13. processing of internal and external information for the purpose of decision-making at all levels by using the knowledge of decision-making techniques and models, i.e. sound decision-making by using decision models containing knowledge and information as input values for the variables of the decision-making model;
14. operation and valorisation of the results of the accounting information system (understanding and use of accounting information);
15. proactive and reactive action of management through the transformation of information collected from the system (feedback information) and the environment into management decisions (information);
16. avoidance and resolution of crisis situations;
17. prudential management of finances (in particular investment policy) and optimal functioning of the payment system
18. optimal conduct in the business, i.e. production process and in logistics activities as support;
19. reaction of each individual to the received information in an effort to maintain the value chain, adhering to the code of conduct and organisational culture;
20. reorganisation of business processes (e.g. transformation from mass production to production based on customer knowledge, i.e. small-batch production and one-off production).

As evident from the above, information and knowledge are intertwined in the business process. Hence, it may be concluded that information without knowledge is almost worthless and vice versa. Unlike data, both information and knowledge are products of the human mind, i.e. they do not exist beyond the human mind. As a rule, knowledge allows one to understand and use information. While information tells the recipient “who”, “what”, “where”, and “when”, knowledge answers the question “how”. However, both information and knowledge are focused on the past, i.e. tell about past events, while wisdom that answers the question “why” enables one to understand the problem and use that to envisage future events (Bellinger, n.d.).

Fotache notes the following concerning knowledge management and how it relates to information management: “So KM is not an entirely new discipline and has a positive impact on management theory and at the same time on the management information (MI). KM represents a shift from emphasis on information to focus on individuals who create and own knowledge. The challenge is the development of coherent, comprehensive, systemic and systematic KM, which takes into account the constant interaction between organisational strategy, values, human capital and information infrastructure. Finally, it must be pointed out that supporting knowledge creation and dissemination processes are not new concepts. However, after comparing IM and KM, it is important to note that the KM practice was deeply influenced by improving the ability to process information and communicate, synchronous and asynchronous, using new devices and technologies. In the new economy, knowledge productivity is the determining factor of the competitive position of a company, of an industry, of a nation, totally democratic, in the sense that any country, any industry or any company does not have a ‘natural’ advantage or disadvantage. The only advantage you can have 70is the ability to exploit knowledge that is everywhere, because the value is now created by ‘competitiveness’ and ‘innovation’, both of which are applications of knowledge.” (Fotache, 2013). Figure 2 shows the elements of knowledge management.

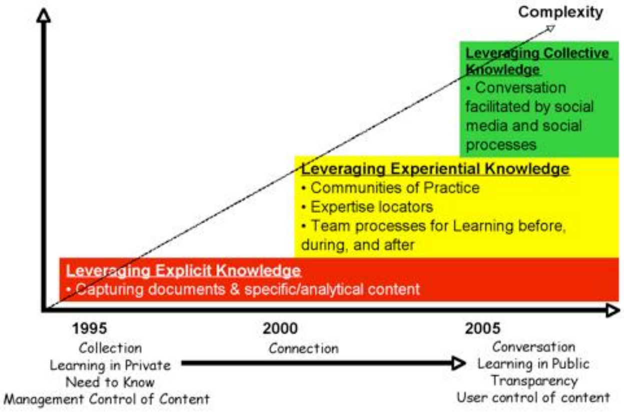
Figure 2. Elements of knowledge management



Source: Knowledge Management, KB manage,
https://www.kbmanage.com/concept/knowledge-management (10.6.2018)

Although knowledge management is not an entirely new concept, it is constantly evolving which means that knowledge management paradigms have changed over time. Figure 3 shows knowledge management evolution.

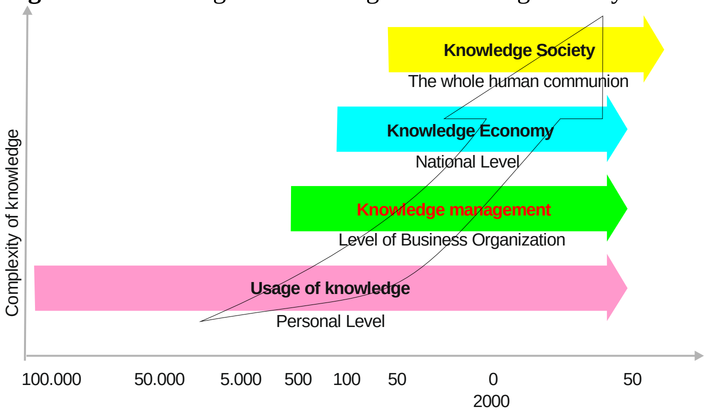
Figure 3. Knowledge management evolution



Source: Dixon, M.: Welcome to Conversation Matters, Blog, 2009, http://www.nancydixonblog.com/2009/03/welcome-to-conversation-matters.html [23.5.2016]

Human society has been using knowledge since its beginnings. Knowledge management focuses on the use of knowledge at the level of a business organisation. As can be seen from Figure 4, the multiplicative effect of the use of knowledge at the business level leads to the creation of a knowledge economy, and the generalisation of this process will ultimately result in a knowledge society whose origins are visible today. This is why, perhaps ostentatiously, the contemporary society is called a knowledge society, although, admittedly, it is headed in that direction.

Figure 4. From usage of knowledge to knowledge society



It should be noted that knowledge management is aimed at:

1. Optimising the use of human resources to enhance organisational efficiency
2. Defining models for knowledge externalisation especially in digital repositories, mainly for the purpose of:

a. reducing the impact of human factors on the efficiency of access to and use of knowledge;
b. increasing the efficiency of decision-making;
c. enabling knowledge to grow in an organisation by means of knowledge internalisation;
d. group problem solving.

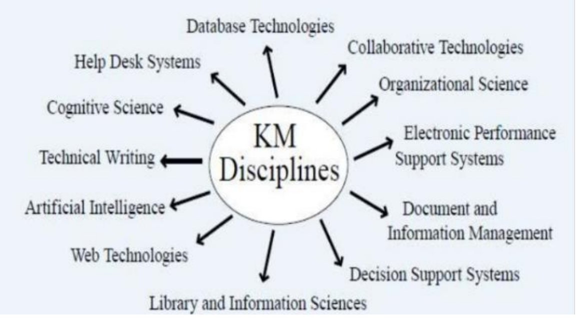
Knowledge management is essentially the management of intangible assets of a business entity, as shown in Figure 5.

Figure 5. Management of tangible and intangible assets of a business entity

Source: Tangible vs. Intangible Strategies Playmaker, https://www.playmakersystems.com/wp-content/uploads/2018/02/Tangible-vs-Intangible-Strategies.jpg

Knowledge management is a complex interdisciplinary approach and thus cannot be considered one-dimensional, or viewed as a single programme tool or a single target group of tools. It is a broad, complex, and multi-layered concept. The interdisciplinary nature of knowledge management is illustrated in Figure 6.

Figure 6. Interdisciplinary nature of knowledge management



Source: Marisennayya, S.: Knowledge Management Theories, https://www.slideshare.net/M.Senapathy/akm-ppt-c2-km-theories [12.5.2018]

To achieve the goals of knowledge management, especially those relating to knowledge externalisation in digital repositories for its reuse, various techniques, tools and technologies are used. Table 2 provides an overview of the major knowledge management techniques, tools and technologies.

Table 2. Major knowledge management techniques, tools, and technologies

Knowledge Creation and Capture Phase	Knowledge Sharing and Dissemination Phase	Knowledge Acquisition and Application Phase
Content creation ▪ Authoring tools ▪ Templates ▪ Annotations ▪ Data mining ▪ Expertise profiling ▪ Blogs	Communication and collaboration technologies ▪ Telephone ▪ Fax ▪ Videoconferencing ▪ Chat rooms ▪ Instant messaging ▪ Internet telephony ▪ E-mail ▪ Discussion forums ▪ Groupware ▪ Wikis ▪ Workflow management	E-learning technologies ▪ CBT ▪ WBT ▪ EPSS
Content management ▪ Metadata tagging ▪ Classification ▪ Archiving ▪ Personal KM	Networking technologies ▪ Intranets ▪ Extranets ▪ Web servers, browsers ▪ Knowledge repository ▪ Portal	Artificial intelligence technologies ▪ Expert systems ▪ DSS ▪ Customization–personalization ▪ Push/pull technologies ▪ Recommender systems ▪ Visualization ▪ Knowledge maps ▪ Intelligent Agents ▪ Automated taxonomy systems ▪ Text analysis—summarization

Source, Knowledge Management, blog, 2011, http://knowledge-management-hendy-1101080113.blogspot.com/2011/05/rangkuman-kedelapan-km-tools-culture.html

A comprehensive overview of KM tools and techniques is provided in Table 3.

Table 3. Comprehensive overview of KM tools and techniques

Category	**Specific Tool or Technique**
Creation	Creativity Techniques - not just brainstorming but 50+ ways to stimulate creativity Creative abrasion - generating discussion through challenge and opposing views Research / Analysis - new knowledge from experimentation and data analysis Simulation / Modelling - modelling systems to gain better insights Skilful dialogue - a structured way of generating knowledge through discourse
Discovery	Concept mapping - visually linking to concepts to identify their relationships Content Analysis - analysis of key words in documents to reveal issues and trends

	Data Mining - using AI tools to discern patterns and relationships hidden in Text Mining - similar to above but working with text; often uses statistical analysis
Identification	Expertise profiling - know-who: identifying subject matter experts Knowledge audit - using a combination of methods to identify knowledge assets Needs analysis - identifying core knowledge needed for people to do their job 'Yellow pages' - a directory of people organised by their skills, not name
Capture (tacit knowledge)	Knowledge harvesting - eliciting and capturing knowledge from an expert Entry interview - structured interview to capture knowledge from a new hire Ethnography - a systematic study of people at work Exit interview - capturing knowledge before an employee leaves or retires Observation - recording (e.g. by video) how a set of tasks is carried out
Acquisition (existing knowledge)	Alerting - using emails or 'pop ups' to alert users to new or changed information Browsing - browsing online or offline content in a semi-purposeful way Filtering - using key words or terms to discard less relevant information Searching - purposefully seeking out information on a specific topic
Organizing	Card sorting - using labelled cards to sort topics into categories Classifying - categorizing content according to its various attributes Mapping - showing relationships between items of information Metadata - defining descriptors (title, topic, keywords etc.) for content Tagging - adding descriptors (metadata) to items of online content Taxonomy - developing a hierarchy of subject categories Thesaurus - a controlled vocabulary, a list of preferred terms for keywords
Sharing (techniques)	Away days - networking events away from the office Communities of Practice - informal knowledge networks focussed around a specific topic Co-location - locating people from different departments together, typically for a project Cross-functional team - bringing together people with different perspectives Facilitated workshops - sessions which bring a variety of perspectives to specific issues Knowledge centre - an enhanced corporate library: a repository of knowledge and know-who OpenSpace - a form of meeting in which participant set the agenda Share Fair - corporate 'trade shows' that show outputs from across the organisation Sharing best practices - replicating good practices throughout the organisation Storytelling - using narrative to disseminate knowledge in a memorable way Wallcharting - different ways of posting words /pictures on a wall in response to question Workspace design - using office layout to create 'caves and commons'
Sharing (tools)	Blog - personal diary of knowledge experts that allow user comments Audio conferencing - conversation (by phone or online voice) in a group in multiple locations

	Email - the most widespread form of online knowledge exchange, but often badly misused Discussion group (message board, forum) - an online focal point for knowledge conversations Instant messaging (chat) - a real-time dialogue using typed words Intranet (portal) - corporate network holding structured easy-to-find information LinkedIn - an online professional networking tool, giving access to contacts, discussion groups etc. Videoconferencing - online conversation where participants can see each other (e.g. Skype) Wiki - an evolving body of knowledge into which anyone can contribute
Learning	After Action Review (AAR) - a structured post-event review to learn lessons Benchlearning - an extension of benchmarking to take learning into day-to-day work Corporate university - a learning centre that mixes traditional teaching, e-learning and on-the-job training Decision Diary - recording the assumptions and feelings after a decision has been made Lessons Learned - a database of situational lessons, often the synthesis of AARs Learning Networks - knowledge networks specifically focussed to review and learn from events Log Books - routine recording of activity and outcomes, so that later review can enhance learning Post project Review - a formal review of the process and outcomes of a project; could be an AAR Structured Dialogue - a meeting where conversation is structured to a learning outcome
Using/ Applying	Combining - assembling disparate information and knowledge to create new insights Personal Knowledge Management (PKM) - individual methods based on tasks and preferences Sense-making - assimilating knowledge into individual mental models
Exploiting	Commercializing - the end-to-end process of converting knowledge into products and services Licensing - licensing proprietary knowledge to others, including competitors Packaging - restructuring information and knowledge into saleable products Productizing - turning a service or set of competences into a more tangible 'product' Trading - selling knowledge in various forms on knowledge markets
Protecting/ Preserving	Archiving - using different media / locations to preserving knowledge not currently actively used Intellectual Asset Management - pro-active use of intellectual property - trademarks, patents, copyrights etc. Records Management - managing business records in a systematic way for current and future use

Evaluating/ Measuring	Benchmarking - comparing performance across different organisations and learning from the results Benefits tree - assessing outputs and outcomes in a hierarchy of benefits Intellectual Capital Measurement - measuring various factors in an IC model KM assessment - assessment of the quality and effectiveness of KM initiatives Knowledge audit - identifying sources and uses of knowledge
Governance	KM Accreditation - certifying individuals as competent KM practitioners Knowledge Ethics - applying ethical standards to the way that knowledge is shared and used KM Governance - the overall framework for effective oversight of KM within an organisation KM Leadership - senior individual or champions that promulgate good KM practices KM Role and Skills - creating career structures and job descriptions for KM practitioners KM Standards - best practice guidelines endorsed by national / international standards bodies KM Strategy - developing an overall approach that delivers business benefits through KM KM Structures - the way that KM and KM roles are organised within an organization Knowledge audit - identifying sources and uses of knowledge Recognition and Rewards - ways of rewarding individuals, teams and networks for good KM

Source: Skyrme, D. J.: KM Tools and Techniques, https://www.skyrme.com/kmpractices/techniques.htm [12.5.2018]

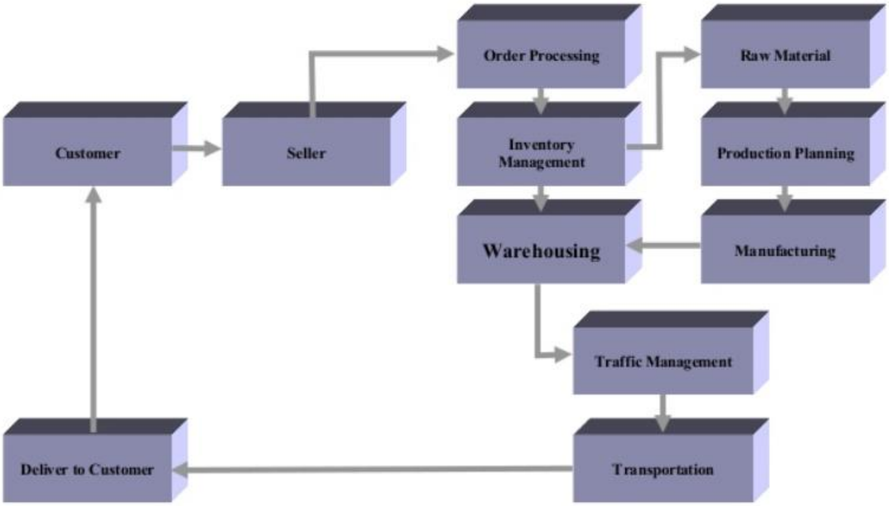
There are many definitions of the term logistics. One of them defines logistics as “an engineering science that deals with the flows of resources between their point of origin and the point of consumption in order to meet some requirements. The resource can be anything. It can be a physical item, such as food, materials, equipment, staff or liquids. It can also be an abstract item, such as time, information, particles or energy. All of those items need to be delivered from their point of origin to the point of consumption as fast as possible, and with a minimum of resources used for their delivery.”(What is Logistic?, n.d.) The same source distinguishes the following types of logistics (What is Logistic, n.d.):

- Procurement logistics – consists of activities such as market research, requirements planning, make-or-buy decisions, supplier management, ordering, and order controlling. The targets in procurement logistics might be contradictory: maximizing efficiency by concentrating on core competences, outsourcing while maintaining the autonomy of the company, or minimizing procurement costs while maximizing security within the supply process.
- Production logistics – connects procurement to distribution logistics. Its main function is to use available production capacities to produce the products needed in distribution logistics. Production logistics activities are related to organisational concepts, layout planning, production planning, and control.

- Distribution logistics – has, as main tasks, the delivery of the finished products to the customer. It consists of order processing, warehousing, and transportation. Distribution logistics is necessary because the time, place, and quantity of production differ with the time, place, and quantity of consumption.
- After-sales logistics – the main task of after-sales logistics of customer satisfaction, consisting of exchange logistics, which covers the warranty issues; return logistics, which covers the delivery of returning the products to the factory, for example, and service parts logistics, which covers the service network, so the repairmen can have the parts they need right on time.
- Disposal logistics – whose main function is to reduce logistics cost(s) and enhance service(s) related to the disposal of waste produced during the operation of a business.
- Reverse logistics - denotes all those operations related to the reuse of products and materials. The reverse logistics process includes the management and sale of surpluses, as well as products being returned to vendors from buyers. Reverse logistics stands for all operations related to the reuse of products and materials. It is "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. More precisely, reverse logistics is the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal. The opposite of reverse logistics is forward logistics."
- Green logistics – describes all attempts to measure and minimise the ecological impact of logistics activities. This includes all activities of the forward and reverse flows. This can be achieved through intermodal freight transport, path optimisation, vehicle saturation and city logistics.
- Global logistics – can be defined as the challenges and opportunities presented to various organisations worldwide to achieve global excellence. It allows for competition and growth.
- Domestics logistics – can be defined as the challenges and opportunities presented to various organisations domestically to achieve domestic excellence. It allows for competition and growth.
- Concierge Services are offered to those who need assistance whether it be for pleasure or out of necessity. From hotel guests who want a specific meal not listed on the menu to senior citizens who need companionship, concierge services are available to take care of your needs.
- RAM logistics – combines both business logistics and military logistics since it is concerned with highly complicated technological systems for which Reliability, Availability and Maintainability are essential, e.g. telecommunication systems and military supercomputers.

As already mentioned earlier in this paper, logistics, similar to other business processes, integrates the transfer and transformation of matter, energy and information. Logistics is managed by means of information and knowledge. The logistics process comprises a series of events that produce information, i.e. records that enable the documenting and monitoring of the logistics process. Knowledge is an intangible component of the logistics process that allows the overall functioning of logistics on the one hand and the management of the logistics process on the other. The elements of the logistics process are shown in Figure 7.

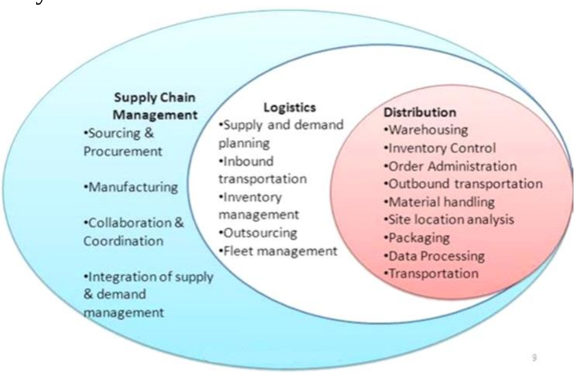
Figure 7. The logistics process



Source: Tanel, T.: International Logistics & Warehouse Management, https://www.slideshare.net/Tanel/international-logistics-warehouse-management [14.5.2018]

Logistics may be defined as the vital support to a business process, i.e. to a business value chain. Thus, logistics represents the application-oriented part of the supply chain. Figure 8 shows the main differences between logistics and the supply chain.

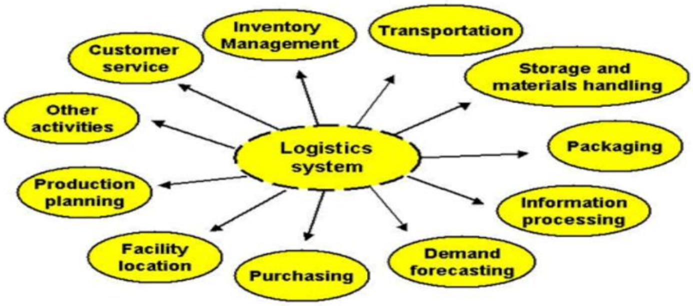
Figure 8. Logistics as an element of the supply chain management of a business entity



Source: Kumar, A.: Logistics Vs Supply Chain Management, http://www.authorstream.com/Presentation/anupamkr-1968947-logistics-vs-supply-chain-management/ [27.3.2018]

Logistics management encompasses a number of components as depicted in Figure 9.

Figure 9. Components of Logistics Management



Source: Logistics and Supply Chain Management, https://shasuncollege.edu.in/wp-content/uploads/2017/11/Logistics-and-supply-chain-managemnet_03_2017-18.pdf [11.6.2018]

The organisation and operation of logistics in a business entity depend on a number of factors. We differentiate between the following approaches to the organisation of logistics services (Chetak Logistics, n.d.):

- 1PL - A first-party logistics provider is a firm or an individual that needs to have cargo, freight, goods, produce or merchandise transported from a point A to a point B. The term first-party logistics provider stands both for the cargo sender and for the cargo receiver.
- 2PL - A second-party logistics provider is an asset-based carrier, which actually owns the means of transportation. Typical 2PLs would be shipping lines which own, lease or charter their ships; airlines which own, lease or charter their planes and truck companies which own or lease their trucks.
- 3PL - A third-party logistics provider provides outsourced or 'third party' logistics services to companies for part or sometimes all of their supply chain management functions.
- 4PL - A fourth-party logistics provider is an independent, singularly accountable, non-asset based integrator who will assemble the resources, capabilities and technology of its own organisation and other organisations, including 3PLs, to design, build and run comprehensive supply chain solutions for clients.
- 5PL - A fifth party logistics provider will aggregate the demands of the 3PL and others into bulk volume for negotiating more favourable rates with airlines and shipping companies. Non asset based, it will work seamlessly across all disciplines.

The central ethos of 5PL is its commitment to collaboration and to obtaining a higher degree of resource utilisation in order to achieve savings and open up opportunities to secure the best possible solution at minimum cost/carbon etc.

The aforementioned information about logistics, its position, functioning, management components, and approaches to organizing it indicate that it is a complex concept involving a large number of components. Similar to knowledge management, it is an interdisciplinary concept because in addition to economic components it includes the technical component, transport, ecology, legal dimension, cultural component, etc. Efficient operation of logistics requires a wide range of differentiated knowledge. This sets high standards, in terms of the breadth and depth of knowledge, for logistics professionals, especially those involved in logistics management who have adopted a holistic approach to logistics. Thus, it is difficult to keep such a complex and demanding process functional and economical without using all available resources that facilitate the efficient creation, capture, documentation, processing and distribution of knowledge. Hence, a logical conclusion would be that knowledge management may and rightfully should play a key role in ensuring logistics efficiency. It may also be concluded that knowledge management has the potential to increase logistics efficiency primarily in terms of:

1. sourcing and recruiting of the highest-quality candidates for logistics positions;
2. increasing employee skills for performing day-to-day tasks through e-learning;
3. encouraging employees to be creative and innovative in their job;
4. using the existing experience and best practices in solving situations that occur repeatedly;
5. defining the decision-making model with the aim of facilitating optimal decision-making related to logistics issues;
6. use of KM techniques, tools and technologies with the aim of creating, collecting, documenting, processing and distributing knowledge;
7. building performance- and business-focussed organisational culture in the logistics subsystem of a business system;
8. learning and adopting cultural values and customs of suppliers, consumers, i.e. markets where interactions with other cultures and customs are taking place;
9. developing awareness of, adopting and complying with legislative requirements and other frameworks set by different areas and frameworks in which logistics operates;
10. creating team spirit for the purpose of facilitating the exchange of experience among logistics staff through conversation and socializing.

Logistics cannot function effectively in the contemporary business environment without knowledge management techniques, tools and technologies. There is probably no logistics system that does not use some of the components of knowledge management. Given that knowledge management is a complex concept comprising a large number of components, an increase in the number of components used, i.e. a wider application of knowledge management in logistics systems will increase the efficiency of knowledge management itself. The abovementioned applications of knowledge management aimed at increasing logistics efficiency represent the minimum on which the model for application of knowledge management in logistics should be built.

4. CONCLUSION

Historically, human society has been changing constantly since the emergence of the earliest civilisations. While in the early years of human civilisation the changes may have seemed small and almost indiscernible to a person witnessing them, the pace of societal changes taking place today is extremely fast due to a significant increase in the general level of knowledge that is reflected in the development of a number of technologies that have changed the way the human society functions. One of the major drivers of current changes is the modern information and communication technology that has fundamentally changed the way knowledge is created, captured, stored, processed, and distributed. Vast amounts of knowledge and information and issues relating to their organisation and optimal use have prompted the development of two new scientific concepts - information management and knowledge management. While information management has become, more or less, a comprehensive concept in the corporate sphere owing to integral business-information systems and databases, in particular after the emergence and development of Enterprise Resource Planning Systems, knowledge management integrates a multitude of techniques, tools, technologies and approaches and can therefore not be observed as a one-dimensional concept. However, regardless of its breadth and complexity, knowledge management is the key to knowledge superiority, as one of the key competitive factors in the contemporary business environment.

Knowledge, be it in the form of higher-quality workforce or decision-making models, technologically superior products, or greater knowledge of consumer habits and needs, has become one of the key success factors for contemporary business entities. It increases the efficiency of business processes and thereby the efficiency of logistics. The work at hand has identified KM techniques, tools, and technologies that can be used in contemporary logistics, as well as areas where they can be used to enhance logistics efficiency. The research results provide the basis for further research into the application of knowledge management in logistics. In addition to identifying the optimal tools for each of the potential areas of KM application in logistics, further research needs to consider and define a knowledge management model for logistics as a separate scientific field that will provide a systematic approach to the harmonisation of knowledge about logistics processes.

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III. TRANSPORTATION

EVALUATION AND FORECAST OF THE FUNCTIONAL REGION OF THE NORTHERN ADRIATIC AIR TRAFFIC

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Abstract

The aim of this paper is to evaluate demand for air passenger traffic of the functional region of the Northern Adriatic and to define future measures (infrastructure, work and organization) in the air traffic sector of the functional region. The purpose of the paper is to prove the hypothesis that air traffic of the functional region of the Northern Adriatic is dependent on tourism, that existing airports meet the needs of the functional region and that it's not necessary to plan and build new airports. Research results rest on secondary information sources and scientific methods of descriptive and inferential statistics. The key finding of this paper indicates the growth of demand for air traffic, necessity of technical, technological and safety improvements and the need for expanding and upgrading new areas so that air traffic of the functional region of the Northern Adriatic may function more efficiently.

Key words: functional region of the Northern Adriatic, air traffic, demand, infrastructure, tourism

1. INTRODUCTION

Functional regions are areas with high-frequent intraregional interaction. The concept of functional regions is applied worldwide with the aim of understanding and defining functionally connected areas for the purpose of managing traffic system across administrative boundaries, however they cannot be considered constant in terms of space, so they have to be followed and adjusted continually. The most common approach to defining functional regions is based on analysis of information on population commuting to work and school as daily migrations may serve as a quality basis for identifying the degree of other interaction forms. The functional region of the Northern Adriatic as one of six Croatian functional regions covers the area of the Istria county, Primorje and Gorski Kotar county and Lika and Senj county.

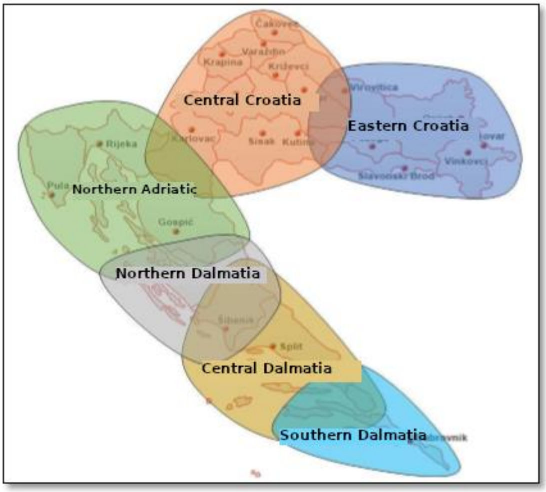
Air traffic and air traffic infrastructure represent a major factor of economy development and particularly of tourism in the area of the functional region of the Northern Adriatic. Consequently, this paper researches the correlation between the number of tourist arrivals and air traffic demand of the functional region of the Northern Adriatic in order to get an answer whether the existing air traffic infrastructure can meet current and future needs of the functional region and whether it is necessary to invest in building the new air traffic infrastructure. In order to find answers to these questions i.e. to prove the constructed hypothesis that existing airports meet the needs of the functional region – current and future demand for air passenger traffic and that no planning and building of new airports is required, in various combinations numerous scientific methods have been employed from which the methods of descriptive and inferential statistics stand out.

2. CURRENT AIR TRAFFIC SITUATION OF THE FUNCTIONAL REGION OF THE NORTHERN ADRIATIC

Development of traffic system in the Republic of Croatia is considered highly important for both economic and social growth as well as international connectivity. Traffic system that consists of traffic infrastructure and its organization/management is an instrument of local development that fosters exchange of goods and better accessibility to all economic, health, tourist and other occurrences. Consequently, the Traffic Development Strategy of the Republic of Croatia for the period from the year 2017 to the year 2030 was drawn up, adopted and passed by the government of the Republic of Croatia in the session held on 24th August 2017 (National Gazette 84/17). The aforementioned strategy divided Croatia into six functional regions characterized by high level of traffic interaction within their respective areas as follows: 1) central Croatia, 2) eastern Croatia, 3) northern Adriatic, 4) northern Dalmatia, 5) central Dalmatia and 6) southern Dalmatia (Figure1).

In the area of the functional region of the Northern Adriatic there are three internationally certified airports that were awarded certificates in accordance with: 1) European Commission Regulation (EU) no. 139/2014: a) Pula Airport – permanently; b) Rijeka Airport – permanently. 2) Air Traffic Act (National Gazette no. 69/09, 84/11, 54/13, 127/13 and 92/14), Article 75, Mali Lošinj Airport – permanently.

Figure 1. Zones for functional and regional analysis



Source: Traffic Development Strategy of the Republic of Croatia for the period from the year 2017 to the year 2030

Pula, Rijeka and Mali Lošinj Airports serve regular international and domestic air traffic (network, charter and low-budget airlines) as well as irregular air traffic particularly in the tourist season (summer, a part of spring and autumn). There are regular flights to bigger neighbouring airports and international hubs such as Paris, Frankfurt, Vienna, Munich and London. Pula and Rijeka Airports are dominantly ports of international and Mali Lošinj of local character. Pula Airport has direct flights to 17, and Rijeka Airport to 10 European countries. These flights, besides Croatia Airlines, are maintained by several international airlines a part of which are low-budget such as Eurowings, Ryanair, easyJet and other.

Pula Airport has a capacity of 1.000.000 passengers per year and 1.200 tonnes of goods per year and due to favourable meteorological, technical and technological conditions it is able to ground handle also bigger aircrafts whereby it represents a possible alternative port for the area of Croatia as well as for airports of countries closer to Croatia. Today Rijeka Airport has a capacity of a passenger building and an apron at the current traffic level. Passenger building capacity is only 100.000 – 150.000 passengers per year for aircrafts that are 120- up to 140-seats big, which with regard to the ground handling of bigger planes with 200 and more seats in international traffic, doesn't qualify in terms of quality when it comes to ground handling. Mali Lošinj Airport in terms of capacity mostly meets the requirements of the current traffic level which represents app. ten thousand passengers per year, however the issue here is about increased safety since the existing USS is non-instrumental and the airport area is unenclosed.

Apart from these, there are airports that have approvals for use in accordance with Article 74 of the Air Traffic Act and particularly:

1) County of Istria: a) Vrsar Airport; b) Campanož Airport – Medulin; c) Pula Airport – on water within the port open for public traffic.

2) County of Primorje and Gorski Kotar: a) Grobnik Airport; b) Rijeka Airport -Port Rijeka (on water); c) Mali Lošinj Airport (on water); d) Rab Airport (on water);
3) County of Lika and Senj: a) Otočac Airport

Overview of airport and operator features is shown in the following Table.

Table 1. Overview of airport and operator features of the functional region of the Northern Adriatic

ICAO Code	*Airport Name*	*Airport Operator*	*ARP Coordinates*
LDPL	Pula Airport	Zračna luka Pula d.o.o.	445336.72N 0135519.89E
LDRI	Rijeka Airport	Zračna luka Rijeka d.o.o.	451.300.80N 0143412.96E
LDLO	Mali Lošinj Airport	Zračno pristanište Mali Lošinj d.o.o.	44357.26N 0142335.48E
LDR O	Otočac	Aeroklub Krila Gacke	445049.40N 0151713.56E
LDR G	Grobničko polje	Zrakoplovno društvo Krila Kvarnera	452246.41N 0143012.58E
LDRR	Rab (airport on water)	Europski obalni avioprijevoznik d.o.o.	444405.69N 0144551.74E
LDPP	Pula (airport on water)	Europski obalni avioprijevoznik d.o.o.	445257.27N 0135025.07E
LDL M	Mali Lošinj (airport on water)	Europski obalni avioprijevoznik d.o.o.	443315.34N 0142625.18E

Source: Prepared by the authors according to Croatian Civil Aviation Agency

In the future the local network of air lines will not change more significantly particularly when it comes to domestic needs, however the air lines network can be changed if capacity or other factors require to do so especially at the regional level.

3. LITERATURE REVIEW

Croatia is small European country between the Mediterranean Sea and Central Europe. Potential traffic for domestic air transportation is limited because Croatia has a small number of population and modern highways constructed for all main directions. This study aims to find out the determining factors turning potential demand into air travel passengers. Population, gross domestic product per capita and distance are considered as the leading geo-economics dynamics behind air travel demand (Sivrikaya & Tunc, 2013) as depicted in Table 2.

Table 2. Commonality in Types of Variables

Variable's Name*	Number of Repeat	Reference Articles
Population	11	Abed, S.Y., Ba-Fail, A. O., Jasimuddin, S. M. (2001); Alam, J.B., Karim, D. M. (1998); Asri, D.U., Sugie, Y. (2003); Ba-Fail, A. O., Abed, S. Y. (2000); Bhadra, D. (2003); Grosche, T., Rothlauf, F, Heinzl, A. (2007); Ippolito, R. A.(1981); Kim, K.W., Seo, H. Y., Kim, Y. (2003); Kopsch, F (2012); Wirasinghe, S.C., Kumarage, S. (1998); Wu, C., Han, J., Hayashi, Y. (2011).
GDP	9	Abed, S.Y., Ba-Fail, A. O., Jasimuddin, S. M. (2001); Alam, J.B., Karim, D. M. (1998); Asri, D.U., Sugie, Y. (2003); Ba-Fail, A. O., Abed, S. Y. (2000); Grosche, T., Rothlauf, F, Heinzl, A. (2007); Ippolito, R. A.(1981); Kopsch, F (2012); Wei, W., Hansen, M. (2006).
Distance	5	Aderamo, A.J. (2010); Grosche, T., Rothlauf, F, Heinzl, A. (2007); Ippolito, R. A.(1981); Kopsch, F (2012); Wei, W., Hansen, M. (2006).
Travel Time	5	Abed, S.Y., Ba-Fail, A. O., Jasimuddin, S. M. (2001); Kim, K.W., Seo, H. Y., Kim, Y. (2003); Wirasinghe, S.C., Kumarage, S. (1998); Wu, C., Han, J., Hayashi, Y. (2011).
GDP per capita	4	Abed, S.Y., Ba-Fail, A. O., Jasimuddin, S. M. (2001); Ba-Fail, A. O. (2004); Ba-Fail, A. O., Abed, S. Y. (2000); Dargay, J., Hanly, M. (2001)
Price	5	Dargay, J., Hanly, M. (2001); Grosche, T., Rothlauf, F, Heinzl, A. (2007); Kopsch, F (2012); Wirasinghe, S.C., Kumarage, S. (1998); Wu, C., Han, J., Hayashi, Y. (2011).
Service Frequency	4	Alam, J.B., Karim, D. M. (1998); Asri, D.U., Sugie, Y. (2003); Ippolito, R. A.(1981); Wei, W., Hansen, M. (2006).
CPI	3	Abed, S.Y., Ba-Fail, A. O., Jasimuddin, S. M. (2001); Ba-Fail, A. O. (2004); Ba-Fail, A. O., Abed, S. Y. (2000).
Import Volume	3	Abed, S.Y., Ba-Fail, A. O., Jasimuddin, S. M. (2001); Ba-Fail, A. O. (2004); Ba-Fail, A. O., Abed, S. Y. (2000).
Employment	2	Alam, J.B., Karim, D. M. (1998); Carson, R. T., Cenesizolu, T., Parker, R. (2011).
Exchange Rate	2	Ba-Fail, A. O. (2004); Ba-Fail, A. O., Abed, S. Y. (2000).
Cost	2	Asri, D.U., Sugie, Y. (2003); Wirasinghe, S.C., Kumarage, S. (1998).

Expenditures	2	Ba-Fail, A. O. (2004); Ba-Fail, A. O., Abed, S. Y. (2000).
Fuel Price	1	Carson, R. T., Cenesizolu, T., Parker, R. (2011).

*The most common variables are listed out of a sample of 15 different relevant articles

It is established that transport is closely related to the economic activity, (ECMT, 2001). Both passenger and freight transport follow generally the rate of economic development. Passenger transport is directly influenced by increased income and quality of life. One of key impacts on traffic demand is attributed to GDP, because it typically generates an increase in travel (Pupavac, 2009).

Croatian economy is peculiar because tourism is one of the most important economic sectors, so further on, the number of tourist arrivals will be considered as a potential variable of an econometric model. Before the 90s of the past century, 60-65% of air transport was contributed to tourist travel. The number of tourists using air transport before the 90s was at a steady 20% of the total number of tourists. The latest survey conducted by the Institute for Tourism provides the following indicators: 91% of tourists arriving to destinations in Croatia use road transport, air transport is used by 8%, maritime transport by 0,7% and rail transport by 0,3%. This indicates that tourists have preferences for road and air transport on arrival in Croatian tourist destinations, while the use of maritime and rail transport lags far behind. This means that air transport dominantly depends on the movement of tourist demand (Pupavac, et al, 2014). According to data obtained by the World Tourism Organization in 2010, 51% of international tourists used air travel for arrival to desired destinations (UNWTO, 2011).

4. DATA AND METHODOLOGY

Traffic demand represents the entirety of requirements for transport services or transfer of various entities (people, goods, packages, information) by different types of traffic with a defined price within a certain timeframe (Pupavac, 2017). The starting point of passenger traffic demand is found in advantages passengers want to gain at a certain destination (Čavrak, 1999). Physical indicators of passenger traffic demand are the number of transported passengers, passenger kilometres, number of vehicles and alike. In order to estimate traffic demand, the correlation between the growth of gross domestic product and passenger traffic is most often the subject of analyses in research (Pupavac, 2009). As the Republic of Croatia is an explicitly tourist country, which almost one fifth of its GDP earnes from tourism, it seems appropriate to research the role of tourism as a generator of demand for passenger air traffic. Accordingly, a model to estimate air passenger demand in the functional region of the Northern Adriatic can be written as a function:

$$PA = f\,(BDP, TA) \qquad (1)$$

where: PA – air passenger demand, GDP – gross domestic product, TA – tourist arrivals. Variable PA is a dependent variable, while GDP and TA are independent or explanatory variables. Supposing that the number of passengers in air transport depends on the GDP and the number of tourist arrivals, its linear form would be as following:

$$Y = b_0 + b_1 BDP + b_2 TA \quad (2)$$

Data required for analysis are shown in Table 3.

Table 3. Passenger traffic in airports of the functional region of the Northern Adriatic, tourist arrivals and GDP fluctuation

Year	Passengers_ Rijeka Airport	Passengers_ Pula Airport	GDP in 000 HRK	TA (000)
2000.	14230	66772	234589,7	7137
2001.	32799	102985	243586	7880
2002.	50366	140431	256841,8	8320
2003.	46587	136207	269575	8878
2004.	57024	155566	281031	9412
2005.	122493	209412	292859,8	9995
2006.	169250	295342	306739,8	10385
2007.	162740	384487	323522,8	11162
2008.	111863	397363	331155,4	11261
2009.	113563	318838	308305,7	10935
2010.	61883	332399	301214,7	10604
2011.	84713	355920	301214,7	11456
2012.	77082	367455	295190,4	12434
2013.	142975	351196	292238,5	13128
2014.	106235	382992	291946,2	12914
2015.	139718	359426	298661	14343
2016.	145297	436121	309114,1	15594
2017.	142111	595812	317769,3	17431
2018.	183606	718187	326031,3	18667

Source: Prepared by the authors according to: Statistics of Pula Airport and Rijeka Airport, Statistical Annual of the Republic of Croatia and Tourism in Numbers 2018

This study applied desk research scientific methods: methods of analysis and synthesis, comparative method, methods of descriptive and inferential statistics. Numeric calculations are performed using the MS-Excel.

5. RESEARCH RESULTS AND DISCUSSION

Based on the data from Table 4 it is evident that the functional region of the Northern Adriatic carries out slightly less than a half of the total tourist arrivals to the Republic of Croatia.

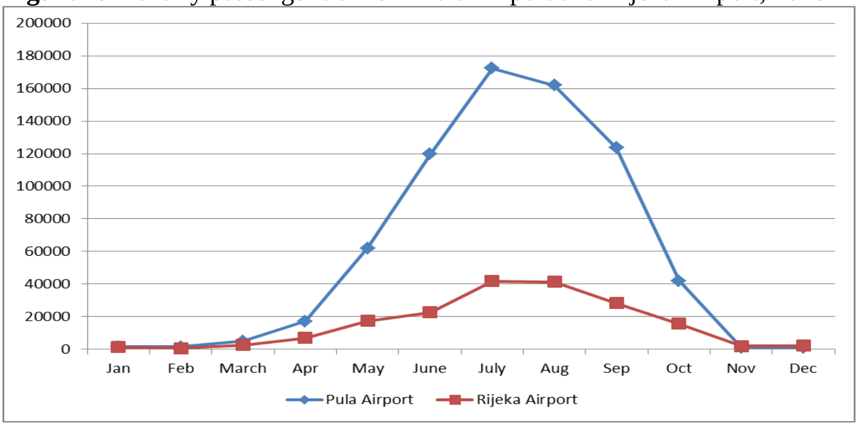
Table 4. Tourist arrivals to the Republic of Croatia and counties of the functional region of the Northern Adriatic (in 000)

County	2016	2017	Growth rate 2017/2016
Istria	3763	4104	9,06%
Primorje and Gorski Kotar	2598	2789	7,35%
Lika and Senj	621	736	18,51%
Total:	6982	7629	9,26%
Total Republic of Croatia	15594	17431	11,78%
% share of the Northern Adriatic region	44,77%	43,76%	

Source: Tourism in numbers 2017, p.31 and our own calculations

It's interesting that only 11% of tourists come to Croatia by air traffic. There are several reasons for this – vicinity to large emissive markets, good development of road traffic and weaker development of other traffic forms (Pupavac, 2018). Nevertheless, huge dependence of air traffic of the functional region of the Northern Adriatic on the number of tourist arrivals is evident. This is also confirmed by huge seasonality of air passenger traffic (cf. Figure 2).

Figure 2. Monthly passenger traffic in Pula Airport and Rijeka Airport, 2018



Source: Prepared by the authors according to statistical data of Pula Airport and Rijeka Airport

The seasonality issue i.e. dependence on the number of tourist arrivals is particularly emphasized at Pula Airport, which throughout summer months carries out traffic 154 times bigger than in off season. In order to get a deeper insight into passenger traffic in these two airports based on the data from Table 2, a short descriptive analysis is made showing the number of transported passengers in Rijeka Airport and Pula Airport for the period from the year 2000 until the year 2018 (cf. Table 5).

Table 5. Descriptive statistics of traffic in Rijeka Airport and Pula Airport

	Rijeka Airport	**Pula Airport**
Mean	103396,5789	321416,3684
Standard Error	11454,12602	37678,56941
Median	111863	351196
Standard Deviation	49927,37781	164237,0764
Sample Variance	2492743055	26973817262
Kurtosis	-1,114798034	0,729992297
Skewness	-0,16390497	0,568694333
Range	169376	651415
Minimum	14230	66772
Maximum	183606	718187
Sum	1964535	6106911
Count	19	19
Largest (1)	183606	718187
Smallest (1)	14230	66772
Confidence Level (95,0%)	24064,22577	79159,73679

In the observed period 1,96 million passengers passed through Rijeka Airport. The annual mean amounts to only 103 396 passengers (SD =49 927). The largest annual traffic volume of 183 606 passengers was realized in the year 2018. The smallest traffic volume of 14 230 passengers was realized in the year 2000. The median value amounts to 111 863 which means that in one half of the years of the observed period the bigger value of median is recorded. In the same period 6,1 million passengers passed through Pula Airport. The annual mean amounts to 321 416 passengers (SD =164 237). The largest annual traffic volume of 718 187 passengers was realized in the year 2018. The smallest traffic volume of 66 772 passengers was realized in the year u 2000. The median value amounts to 351 196 meaning that in 50% of the years in the observed period the bigger value of median is recorded.

Further on in this research, discussion based on the data from Table 2, interdependence among passenger traffic in airports of the functional region of the Northern Adriatic, the gross domestic product and the number of tourist arrivals is researched. (cf. Table 6).

Table 6. Correlation analysis of the number of transported passengers in Rijeka and Pula airports, GDP and the number of tourist arrivals

Correlations (ZLRKA) Marked correlations are significant at p < ,05000 N=19 (Casewise deletion of missing data)						
	Means	**Std.Dev.**	**PAP**	**PAR**	**GDP**	**TA**
PAP	321416,4	164237,1	1,000000	0,773153	0,829015	0,943313
PAR	103396,6	49927,4	0,773153	1,000000	0,818009	0,746820
GDP	293767,7	26656,3	0,829015	0,818009	1,000000	0,700400
TA	11680,8	3114,3	0,943313	0,746820	0,700400	1,000000

The carried-out correlation analysis confirmed the existence of strong and positive dependence of the number of transported passengers on the number of tourist arrivals and gross domestic product in both airports. With regard to Pula Airport (PAP) air traffic shows somewhat greater dependence on the number of tourist arrivals (r=0,94), whereas the traffic volume of Rijeka Airport (PAR) shows somewhat greater dependence on the fluctuation of gross domestic product (r=0,81). Consequently, a regression analysis was carried out (cf. Table 7 & Table 8) in order to form a separate model to estimate the number of transported passengers in Rijeka Airport and a separate model to estimate the number of transported passengers in Pula Airport.

Table 7. Results of regression analysis for Rijeka Airport (PAR)

Regression Summary for Dependent Variable: PAR R= ,85351674 R^2= ,72849082 Adjusted R^2= ,69455217 F(2,16)=21,465 p						
	b*	**Std.Err. - of b***	**b**	**Std.Err. - of b**	**t(16)**	**p-value**
Intercept			-279073	80529,45	-3,46547	0,003188
GDP	0,578941	0,182510	1	0,34	3,17211	0,005914
TA	0,341329	0,182510	5	2,93	1,87020	0,079865

Table 8. Results of regression analysis for Pula Airport (PAP)

Regression Summary for Dependent Variable: PAP R= ,97234350 R^2= ,94545188 Adjusted R^2= ,93863336 F(2,16)=138,66 p						
	b*	**Std.Err. - of b***	**b**	**Std.Err. - of b**	**t(16)**	**p-value**
Intercept			-715140	118736,7	-6,02291	0,000018
GDP	0,330399	0,081806	2	0,5	4,03882	0,000951
TA	0,711902	0,081806	38	4,3	8,70235	0,000000

Based on the conducted regression analysis (cf. Table 7 & Table 8) regression models can be recorded with the aim of estimating traffic volume in Rijeka Airport (PAR) and Pula Airport (PAP) until the year 2025.

PAR = -279073 + GDP + 5TA (3)

PAP=-715140+2,GDP+38TA (4)

Model (3) is not conclusive (cf. Table 7). The regression analysis without tourist arrivals as variable in model shows the better result (cf. Table 9).

Table 9. Results of regression analysis for Rijeka Airport (PAR)

Regression Summary for Dependent Variable: PAR R= ,81800869 R^2= ,66913821 Adjusted R^2= ,64967576 F(1,17)=34,381 p						
	b*	**Std.Err. - of b***	**b**	**Std.Err. - of b**	**t(17)**	**p-value**
Intercept			-346696	77060,14	-4,49903	0,000316
GDP	0,818009	0,139508	2	0,26	5,86353	0,000019

Because we want to keep importance of tourist arrivals as variable we made decision to use model (3) for estimating traffic volume in Rijeka Airport which is the main limitation of this research. The mean GDP growth rate of the Republic of Croatia standing at 3% per year and the mean annual growth rate of the number of tourist arrivals standing at 4% will be taken as starting assumptions for traffic predictions in two aforementioned airports until the year 2025. Validity of the aforementioned assumptions is based on the fact that the Tourism Strategy predicts the growth of the number of tourist arrivals at the mean rate of 4% until the year 2025 and that the Croatian economy will get out of crisis as well as on positive economic growth rates. If the aforementioned assumptions are realized, then the traffic volume through the airports of the functional region of the Northern Adriatic would look as shown in Table 10.

Table 10. Traffic volume prediction in airports of the functional region of the Northern Adriatic until the year 2025

Year	PAR	PAP
2020.	206477	746985
2021.	222148	798429
2022.	238333	851719
2023.	255051	906923
2024.	272317	964112
2025.	290151	1023357

Based on the made prediction it is evident that both Airports in the future will indicate a trend in increasing the number of passengers. In the year 2025 Pula Airport could qualify among Croatian airports that realize passenger traffic volume larger than a million of passengers (Zagreb, Dubrovnik, Split) and thus reach the full level of its capacity. Also, Rijeka Airport could reach the full level of its capacity until the year 2025.

6. CONCLUSION

One of the main aims of the Traffic Development Strategy of the Republic of Croatia and Master Plan of the Functional Region of the Northern Adriatic is to provide highest safety standards for air traffic on international, national and regional level in order to efficiently decrease dangers in air traffic, reduce accidents possibility and limit negative consequences of such accidents. Infrastructure of airports and aircrafts have to meet international safety standards. Pula Airport is important for accessibility of this region from distant locations. Traffic volume in the airport indicates a seasonality trend which might cause bottlenecks considering the limited infrastructure. It is necessary to observe two operative aspects that include: 1) service quality, primarily because of competitiveness with neighbouring international airports and 2) balance between safety and operative capacities. These aspects, inter alia, emphasize the need for increasing capacities of this airport by upgrading certain elements: access light signalling system, take-off and landing runways, aprons, terminals and accesses. The Master Plan of the airport defines validity of proposed measures and identifies priorities having in mind environmental requirements and real needs and capability according to expected demand. Rijeka Airport shows growth of passenger traffic and has additional capability to increase passenger traffic. The Master Plan of Rijeka Airport has to lay down scope and dynamics of activities in airport development by taking into account environmental requirements. Development of Mali Lošinj Airport is planned with the aim of better connectivity between Mali Lošinj and parts of the functional region in accordance with various safety requirements and traffic demand. Analyses show a prospective need for expanding the take-off and landing runway, apron and terminal. The Master Plan of Mali Lošinj Airport will lay down validity of these measures and order them by priorities having in mind environmental requirements and real needs and capability according to expected demand. Pula, Rijeka and Mali Lošinj Airports meet the needs of the functional region and neither planning nor building new airports is required but technical, technological and safety improvements, expansions and upgrading of new areas. The fact that the number of tourist arrivals depends mostly on the gross domestic product of emission countries is pointed out as the major deficiency of this paper and accordingly, future researches should include gross domestic product fluctuations in these countries as variables in the model for predicting the number of passengers in the airports of the functional region of the Northern Adriatic.

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REGRESSION MODEL IN ROAD TRANSPORT SERVICES

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Abstract

The success of a company depends on a number of factors. One of them is the ability to meet customer expectations and match the market needs. Mathematical methods and tools are helpful in assessing demand. The forecasts made should take into account all the factors shaping the demand for goods and services, however, they are often difficult to define, not only because of their large number, but also because of the impact of individual variables which is difficult to determine. In many cases, the number of orders placed is strongly dependent on the time at which they are placed. Needs may vary depending on the time of day, week or year. Then we are dealing with the so-called seasonality, which is a very important matter that needs be taken into account in a company which allows to better adapt the company's activities to customer requirements.

This article describes the seasonality of demand in a company providing domestic road transport services using heavy-duty vehicles. The legitimacy of conducting such analyses and potential benefits were indicated.

Key words: demand forecasting, seasonality, road transport, multiple regression

1. INTRODUCTION

The transport of cargo and people are one of the main needs of today's world. The dynamic growth of industrial production and trade results in the constant growth of the demand for transport services. The transport industry plays a very important role in the market economy, ensuring efficient and effective functioning of all of its elements. Complexity and volatility of transport demand poses a challenge for companies providing such services (Borucka, 2018). The problem lies mainly in the multiplicity of factors influencing demand. These factors shape the demand for transport services (Dittmann, 2000; Mitkow et al., 2018) and affect quality thereof, which translates directly into customer relations (Borucka, 2018). Transport demand determinants are often subject to cyclical, repetitive changes, making it possible not only to predict them, but also to prepare for them. Mathematical tools and methods come in handy in this respect. The application of the selected one shall be presented in this article.

The method of demand analysis was presented basing on transport data provided by the transport company. Multiple regression, which allows to take into account many exogenous variables, was used for this purpose. The forecast was made on the basis of observations of the demand for transport services made in the last 39 months. The aim of the analysis was to present the effectiveness of the use of mathematical tools that are already successfully used in modeling the vehicle flow (Mitkow et al., 2018), their readiness (Borucka, 2018) or in assessing the impact of selected factors on their efficiency and effectiveness (Świderski et al., 2018).

2. RESEARCH METHOD

Describing the variability of occurring phenomena and processes is possible due to the use of stochastic process models. If time is the domain of the stochastic process, then we are dealing with a time series, i.e. a sequence of information ordered in time. Individual observations are recorded with a precise time step. Then the measurements are a set of observations describing the implementation of the analyzed phenomenon and the changes occurring in it. Full identification of the process requires decomposition of the time series, i.e. extraction of all elements present in it. They can be systematic components such as trends, periodic or cyclical fluctuations as well as random components. A mathematical model is selected on the basis of the dependencies between the diagnosed observations (Bielińska, 2007; Dittmann, 2000). In the presented case, it will be a multiple regression.

Regression models are widely used in many fields of science (Chiou et al., 2015; Pupavac, 2018), including transport. They deal with a number of issues related to it, particularly with regard to the sustainable development of transport services. Examples of this include assessment and forecasting of noise pollution (Gulliver et al., 2015; Dintrans & Préndez, 2013), carbon dioxide emissions (Xu & Lin, 2015; Asumadu-Sarkodie & Owusu 2017; Xie et al., 2017), or the level of energy consumption in transport (Hu et al. 2010; Chai et al., 2016). The literature also contains research on driver behavior (Singh et al., 2019), the use of public transport (Chiou et al., 2015), public transport buses arrival time (Singh et al., 2019; Yu et al., 2017, Bai et al., 2015), etc. In Huang et al. (2017) and Aguero-Valverde et al. (2016) for example, multidimensional spatial models for analyzing the occurrence of road accidents were proposed. Regression models work well in all cases where we are dealing with factors that significantly affect the analyzed phenomenon. The review of literature and empirical data gathered determined the decision to use this model in the present article.

Regression belongs to the group of analytical models that require finding mathematical functional dependencies that reflect the implementation of the process. Its main purpose is to forecast, i.e. to extend the analysis to arguments outside the scope of collected empirical data, and to determine how the studied phenomenon will develop in the future (Statsoft, 2006; Sokołowski, 2016). The estimation of parameters consists in finding the appropriate trend function, and then describing and extracting seasonal and cyclical fluctuations (if there are any). The simplest form of a trend is the linear function (1), describing the implementation of the process of development of the analyzed phenomenon by means of an exogenous variable, in this case – time t , and a directional coefficient β, which determines the constant growth of the predicted variable in the unit of time (1).

$$f_t = \beta_0 + \beta_1 t \tag{1}$$

Depending on the structure of the studied phenomenon, a trend can also be estimated using other functions, for example exponential, quadratic or power functions. If there are fluctuations in the process, the trend function shall not be sufficient enough (Maciag at al., 2013; Mitkow at al., 2018).

Fluctuations may occur due to a number of factors. They are determined by the repetitive rhythm of the phenomena: daily, weekly, monthly, etc. thus these are seasonal fluctuations, or they shape long-term, rhythmic fluctuations of the value of the series around the developmental trend, i.e. cyclical fluctuations. To estimate the parameters of such a model the classical least squares method or the maximum likelihood estimate can be used.

Regression enables assigning the value of a variable dependent to specific values of independent variables in an analytical way. Depending on the need, it can take different forms. Its simplest type is simple linear regression, describing the dependencies between variables using a straight line (2).

$$\hat{y} = \beta_0 + \beta_1 x + \varepsilon \tag{2}$$

where:
β_1 – directional coefficient,
β_0 – absolute term (point of intersection with the axis of ordinates),
x – independent variable,
y – dependent variable (endogenous, predicted),
ε – random error.

If there are more exogenous variables, the multiple regression model may be used, which takes the form (3):

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + \varepsilon \tag{3}$$

where:
β_0 – absolute term,
β_i – model parameters – regression coefficients
x – independent variable,
y – dependent variable (endogenous, predicted),
ε – random error.

Regression factors describe how, on average, the value of the dependent variable y will change if the value of the independent variable x, to which they refer, will change by a unit, assuming a fixed level of the other independent variables (Mitkow et al., 2018; Sokołowski, 2016).

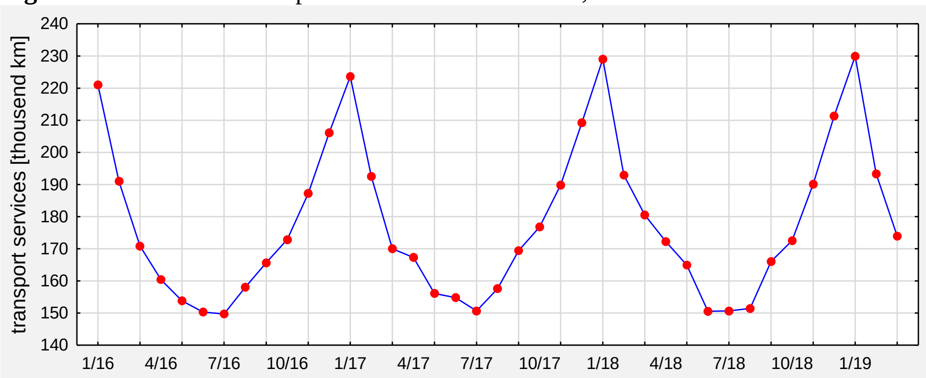
The situation is quite simple if the independent variables are of a quantitative nature. However, often in the analysis of economic phenomena it is not the case, and variables – as in the analyzed example – are of a qualitative nature. Then their number is limited and they cannot be treated in the way accepted for continuous variables in regression, as they have no economic sense, and the calculated model coefficients have no economic interpretation. In order to create a regression model, it is necessary to re-code them. Such a qualitative or discrete variable, having several or more categories, is coded to the appropriate q number of binary (zero-one) variables, which are used in the regression equation. However, in order to be able to apply the least squares method to model estimation it is necessary to use q-1 of artificial variables, because the introduction of q number of variables, i.e. in the number equal to exogenous variables, will provoke a linear dependence between the regressors, and the *X'X* matrix will be singular (Mitkow et al., 2018). This is due to the fact that binary variables sum up to unit. Such a phenomenon is described in econometric literature as a *dummy variable trap* related to binary variables (Bielińska, 2000; Mitkow et al., 2018). Such a model is not estimable and therefore the number of artificial variables must always be one unit less than the q number of categories (levels) identified for a given attribute (feature). Only then is the estimated model correct and consists of an absolute term β_0, the sum of the products of the structural parameters and the binary variables Dk number k=1;;q, representing seasonality, and a random component (4).

$$y = \beta_0 + \beta_1 t + \delta_1 D_1 + \cdots + \delta_k D_k + \varepsilon \tag{4}$$

3. TEST SUBJECT

The subject of the analysis was the company's transport operations over the last 39 months. The company owns 23 semi-trucks. The course of the transport operations is shown in Fig. 1.

Figure 4. Demand for transport services in 2016-2019, in thousands of kilometers



Source: own study

The chart clearly shows a high seasonality of transport operations. This is confirmed by the calculated, selected measures of descriptive statistics presented in the table below (tab. 1).

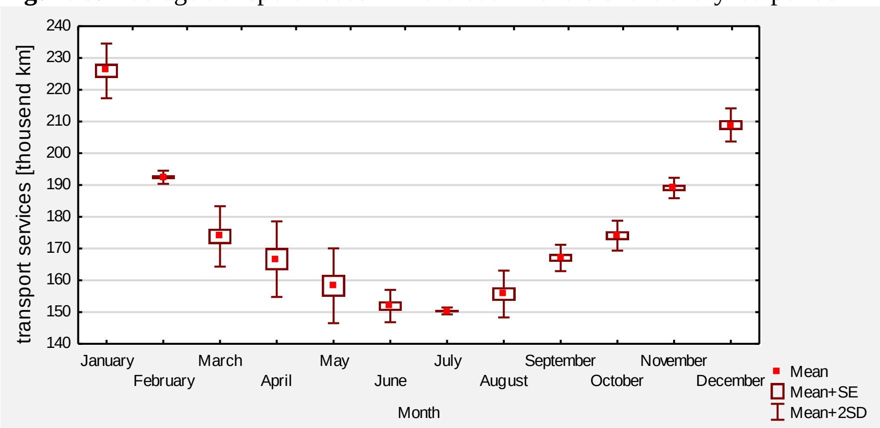
Table 1. Basic measures of descriptive statistics in individual months

Month	Mean [Thousands of km.]	Median [Thousands of km.]	Minimum [Thousands of km.]	Maximum [Thousands of km.]	Standard deviation [Thousands of km.]	Coefficient of variation [%].
January	225.9	226.3	221.0	230.0	4.3	1.9
February	192.5	192.7	191.0	193.3	1.0	0.5
March	173.8	172.4	170.0	180.5	4.8	2.7
April	166.7	167.3	160.4	172.2	6.0	3.6
May	158.3	156.1	153.8	165.0	5.9	3.7
June	151.9	150.6	150.3	154.8	2.6	1.7
July	150.4	150.7	149.7	150.7	0.6	0.4
August	155.7	157.6	151.4	158.0	3.7	2.4
September	167.1	166.1	165.7	169.4	2.1	1.2
October	174.1	172.9	172.5	176.8	2.4	1.4
November	189.1	189.8	187.2	190.1	1.6	0.9
December	208.9	209.2	206.2	211.3	2.6	1.3

Source: own study

The specificity of the company's activity causes that the greatest transport needs occur in the winter months, from November to March. The lowest results were recorded in the warm months, i.e. in the period from May to August. Clear differences between individual months are well illustrated by the frame graph in figure 2.

Figure 5. Average transport needs in individual months of the analyzed period



Source: own study

The strong dependence between the services provided and the calendar date should be taken into account in the mathematical model of demand. The graph of transport needs in the studied period (Fig. 1) also suggests the occurrence of a development trend, however, seasonal fluctuations make it somewhat difficult to distinguish it visually. In order to confirm the occurrence of a trend, a mechanical method of determining the trend using moving averages was used. Simple moving averages (3-period, 6-period and 12-period) were determined, the graphs of which are shown in Fig. 3, 4 and 5.

Figure 6. 3-period moving averages

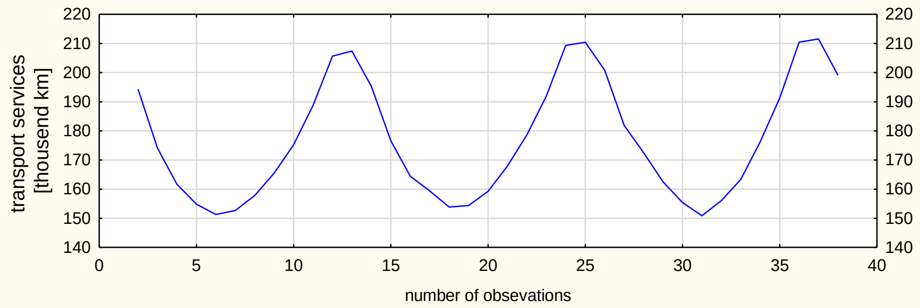


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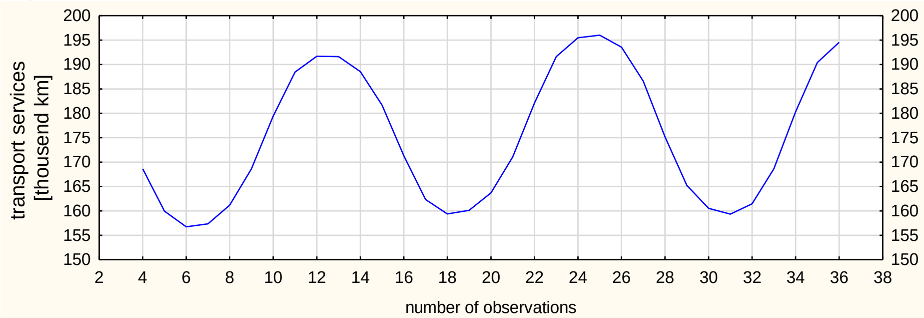
Figure 7. 6-period moving averages

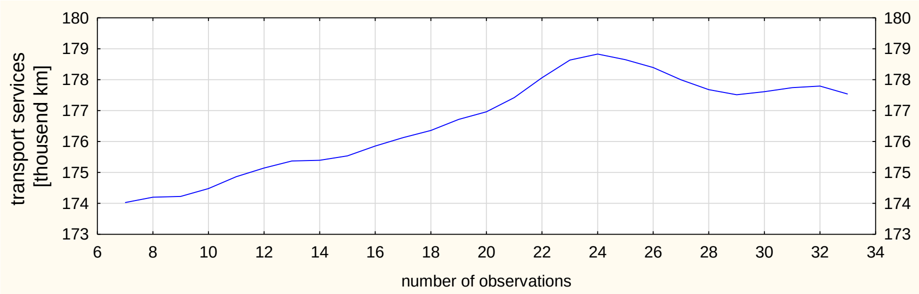


Source: own study

The graph of 6-period moving averages shows the existence of a trend and its increasing character, which is confirmed by the graph of 12-period moving averages. This means that the mathematical model should include long-term trend and short-term seasonality for individual months, expressed in binary variables in a number of one less than the number of months. Thus, the model will consist of the absolute term, the trend, and the sum of eleven products of structural parameters and binary variables D_k for $k \epsilon \{1, 11\}$ seasonality, as presented in formula (5).

$$y = a_0 + a_1 t + b_1 D_1 + \cdots + b_k D_k \quad (5)$$

Figure 8. 12-period moving averages



Source: own study

The literature proposes the estimation of the model reduced by the variable with the lowest or highest indication. Then the remaining variables refer to the maximum or minimum level of the studied phenomenon. In the analyzed case, the highest value recorded in January was selected. This means that the seasonal parameter estimates will refer to the "January" level. Therefore, all parameter values for the individual months will be negative, as each parameter will be lower than the value for January. The results of estimation of parameters of multiple regression function and errors in estimation are presented in Table 2.

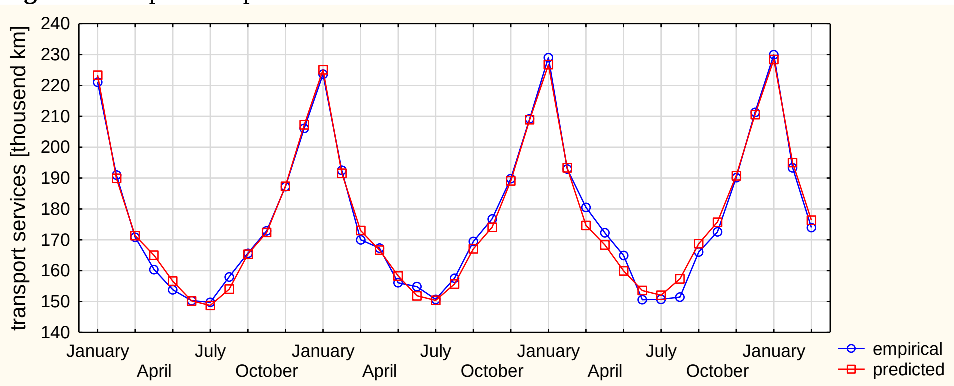
Table 2. Results of the estimation of the multiple regression model

	R= 0.99, R^2= 0.98 Adjusted R2= 0.98 F(12,26)=182,08, p<0,0000 SE: 3.11			
	b	Std. error of b	t(26)	p
Absolute term	223.25	1.78	125.53	0.00
t	0.14	0.05	3.10	0.00
February	-33.60	2.20	-15.25	0.00
March	-52.35	2.20	-23.75	0.00
April	-58.84	2.38	-24.69	0.00
May	-67.36	2.38	-28.29	0.00
June	-73.88	2.38	-31.05	0.00
July	-75.53	2.38	-31.75	0.00
August	-70.38	2.38	-29.58	0.00
September	-59.14	2.38	-24.84	0.00
October	-52.27	2.38	-21.93	0.00
November	-37.42	2.39	-15.68	0.00
December	-17.71	2.39	-7.41	0.00

Source: own study

The adjusted coefficient of determination, which determines what percentage of the variation of the dependent variable (Y - endogenous) is explained by the independent variable (X - exogenous) is satisfactory and amounts to 98%, errors in parameter estimation are low and do not exceed 3%. Moreover, the quality of the model is evidenced by the fact that all estimated parameters are statistically significant, which is also satisfactory due to the substantive interpretation of the model and the lack of need to remove insignificant exogenous variables. The graph of empirical and forecast values is presented in Fig. 6.

Figure 9. Graph of empirical and forecast values



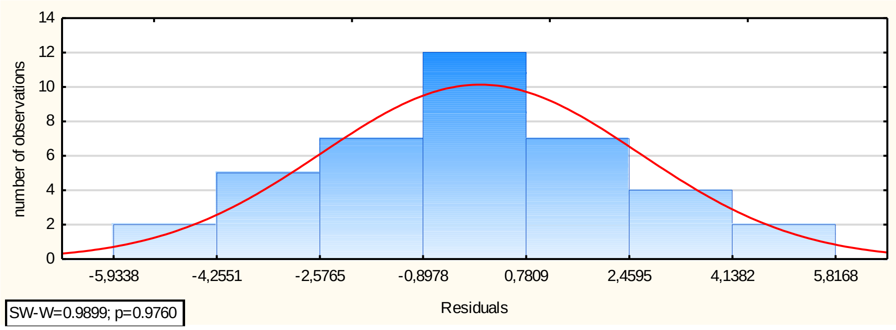
Source: own study

4. MODEL DIAGNOSTICS

The basis for assessing the accuracy of matching the theoretical function to the empirical data is the analysis of the differences between the empirical and theoretical values known as the residuals of the model. Confirmation of the correctness of the regression model therefore requires verifying the basic assumptions concerning the residuals, which include the checking the normality of their distribution and the existence of significant dependencies of the autocorrelation function.

Figure 7 shows the histogram of the distribution of residuals which indicates that the distribution is close to normal, as confirmed by the calculated statistics of the Shapiro-Wilk test, the calculated value of which is 0.9899 and the test probability is p=0.976, which means that there are no grounds to reject the H0 hypothesis at the level of significance alpha=0.05, indicating that the distribution of the variable is close to normal.

Figure 10. Histogram of the residuals of the model

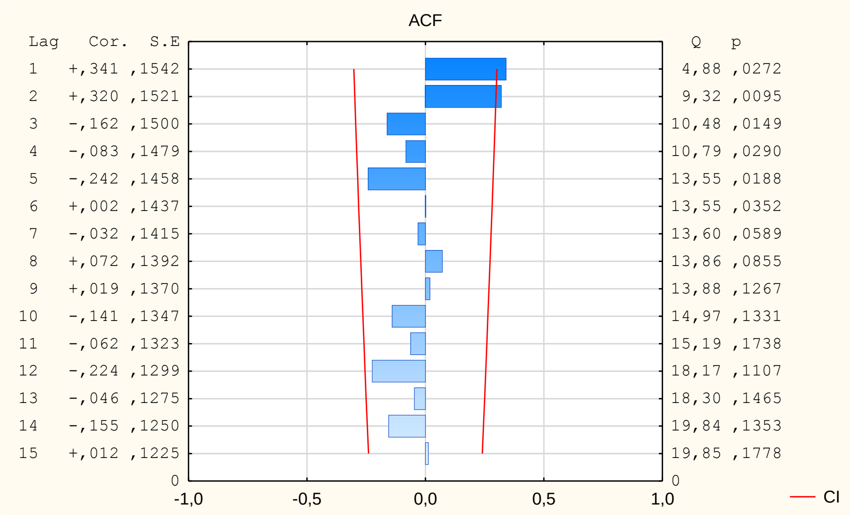


Source: own study

Another factor determining the correctness of the model is the lack of correlation between all the residuals' values, i.e. the confirmation that there are dependencies which were unexplained by the model. For this purpose, the graphs of autocorrelation and partial autocorrelation function, presented in Fig. 8 and Fig. 9 were analyzed.

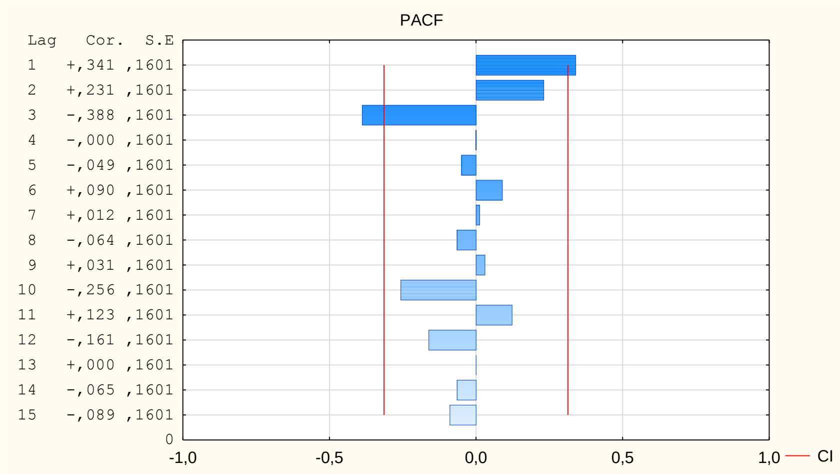
It turns out that all values of functions are statistically insignificant, which confirms the correctness of the model's construction.

Figure 11. Autocorrelation function of the regression model residuals



Source: own study

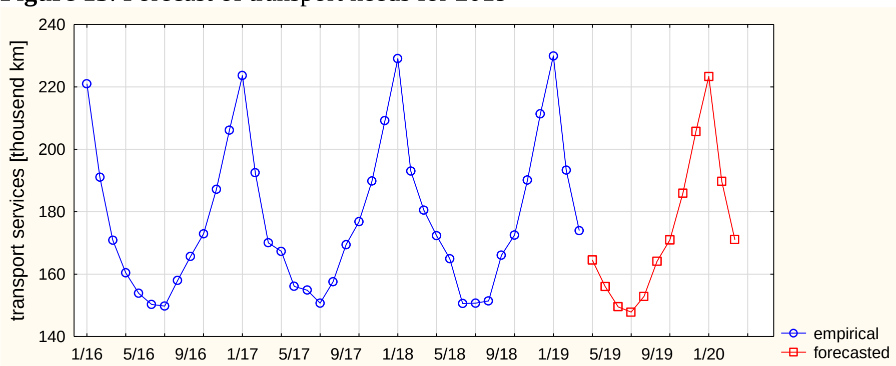
Figure 12. Partial autocorrelation function of the regression model residuals



Source: own study

On the basis of the results obtained, a forecast of transport needs for 2019 was also proposed (fig. 10).

Figure 13. Forecast of transport needs for 2019



Source: own study

After analyzing of the graph in Fig. 10 it seems that the forecast for January is underestimated. However, it should be stressed that each forecast requires monitoring, verification and continuous adjustment to the dynamically changing market. In addition, the forecast plays only an advisory function, allowing to indicate the main directions of change and provides excellent support for management processes. However, it does not provide ready-made decisions.

5. CONCLUSIONS

The analysis showed the possibility of forecasting the transport demand in a company providing transport services. The proposed model revealed not only a clear seasonality of the process, but also the existing upward trend. This information is very important, especially for a company, which, similarly to the studied one, operates its own transport. Firstly, it indicates that there are months in which the transport potential may not be fully utilized. On the other hand, it warns that steadily growing demand may in the near future be the cause of a shortage of vehicles and a failure to fully meet transport needs, especially in the months when these are the highest. This means that it is necessary to review the transport strategy of the company and propose directions that on the one hand, minimize the degree of underutilization of vehicles and on the other hand, protect the interests of the company in the event of demand greater than the transport capacity.

The analysis was limited to the assessment and forecasting of the impact of the calendar month on transport demand. Despite the fact that it provided interesting conclusions concerning the company's operations, which strongly emphasizes its utilitarian character, the demand is influenced by many other factors, which were not included in this study. Therefore, other factors influencing demand, such as market competition, the level of prices and quality of transport services, size and structure of demand for transport of a given type of cargo, impact of the economic situation, should also be analyzed in future studies. This would increase the scale and adaptability of the company's offer to market demand by adjusting transport capacity and planning (if necessary) investment measures, the need for which has already been partially articulated in the study presented.

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FORECASTING DEMAND FOR TRANSPORT SERVICES ON THE EXAMPLE OF PASSENGER TRANSPORT

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Abstract

Success on the market is fostered not only by the quality of provided services, but also by the precise satisfaction of purchasers' needs. Therefore, demand forecasting is an important element of any company function, including transport. It also allows for appropriate shaping of the level and structure of inventories. It facilitates proper organization of processes and better management of resources. This is particularly important in the transport services industry, where vehicle readiness determines possibility of performing the task. Demand is influenced by a multitude of factors, which are often difficult to define and describe, therefore this article proposes the ARIMA model, in which the conducted study was based on the assumption that the dependent variable is affected only by its own value, lagged over time. The study was supplemented by the ARIMAX model, which additionally takes into account exogenous variables resulting from the diagnosed seasonality of the process.

The analysis was presented on the example of a Polish company (based in Warsaw) offering passenger transport services, for which the number of passengers was forecast. Such information allows not only for a more efficient use of the available human and technical resources, but also for an increase in the company's profit.

Key words: transport services, ARIMA model, ARIMAX model, demand, forecasting

1. INTRODUCTION

Passenger transport in literature is most frequently approached from the legislative perspective (Abramovic et al., 2017, Gładysz et al., 2016; Stimac & Vistica, 2018; Wesołowski, 2016), which results from the fact that passenger transport is a very complex issue, conditioned by a number of regulations. Many articles discuss the quality (Klopott & Miklińska, 2017; Świderski, 2018) and customer preferences (Kozłowska & Cygan, 2018; Mikulska & Starowicz, 2016; Naletina et al., 2018) as they constitute the driving force behind the entire industry. Mathematical modeling of transport is less popular in literature, both in terms of theoretical methods and their practical application (Sikora & Borowski, 2011; Żurkowski, 2009). Estimating demand for transport services is a particularly interesting issue in this area, therefore the aim of this article is to indicate selected, possible to apply methods of mathematical forecasting of this phenomenon.

The transport demand in cities is influenced by a multitude of factors, often difficult to predict. Some of them are life rhythm-based and can be modeled using variables, such as time of day or hour, others such as preferences or needs of potential customers are more difficult to identify. Therefore, companies offering passenger transport services need to adapt their strategy to the high dynamics of demand as well as plan drivers' work and vehicle availability in a way ensuring that as many of them as possible are available in a situation of high demand for services, and unjustified idleness at times of lower demand is avoided. Any unnecessary downtime generates costs, and lack of transport capability when there is a demand for it means a profit lost.

Mathematical tools and methods are helpful in identifying potential demand. A number of them (such as regression models) require information on factors affecting a given phenomenon, which are often difficult to identify or measure, in order to obtain reliable forecasts. Therefore, time series models are a good solution, which, in order to build a forecast, require information only about the value of the dependent variable lagged in time. Such models include, among others, autoregressive or moving average models, as well as combinations thereof, such as ARMA, ARIMA or SARIMA. The application and comparison of the selected model shall be presented in this article.

The author's intention was to show that it is possible to offer reliable forecasts of demand for transport services even in a situation of limited access to information, and thus to better plan the use of resources and adapt them to customer needs. Furthermore, the aim was to emphasize the utilitarian nature of such analyses when applied to create the company's strategy.

2. TIME SERIES FORECASTING MODELS

Analysis methods of sequences of chronologically ordered information, showing a certain dependence between individual observations, are called the time series analyses. Mathematical description of this dependence makes it possible, not only to determine the nature of the studied phenomenon, but also to forecast, i.e. to predict the future values of the time series. The so-called stationary models, which assume that the analyzed process is in balance with the constant average level, occupy a special place among the models used for describing real stochastic processes. However, since many economic phenomena are of non-stationary nature, such analysis methods have also been developed, the ARIMA processes in particular (Stimac & Vistica, 2018).

ARIMA (*Autoregressive integrated moving average model*) is a model created by integration of the autoregressive model – AR and the moving average model – MA. The AR model is based on the assumption that there is an autocorrelation between the current values of the forecast variable and its values lagged in time. The current value of the process is expressed as a finite linear combination of the previous values of the process (1) (Box & Jenkins, 1983; Devon, 2016):

$$y_t = \theta_0 + \theta_1 y_{t-1} + \theta_2 y_{t-2} + \dots + \theta_p y_{t-p} + \varepsilon_t \quad (1)$$

where:

$y_t, y_{t-1}, y_{t-2}, y_{t-p}$ - the value of the forecast variable at the time or in the period $t, t-1, t-2, \dots, t-p$;

$\theta_0, \theta_1, \theta_2, \theta_p$- model parameters;

ε_t - model error (residual) for the moment or period t;

p- lag length.

Whereas in the MA (*moving average*) process, the values of the endogenous variable are expressed as a function of the lagged values of the stationary random component [Chaoqing et al., 2016; Chen et al., 2016]. The parameter q of this process, i.e. the order of the MA process, indicates the level of lags adopted for the model. The form of the MA model is as follows (2):

$$y_t = \phi_0 + \varepsilon_t - \phi_1 \varepsilon_{t-1} - \phi_2 \varepsilon_{t-2} - \dots - \phi_q \varepsilon_{t-q} \quad (2)$$

where:

$y_t, y_{t-1}, y_{t-2}, y_{t-q}$ - the value of the forecast variable at the time or in the period $t, t-1, t-q$;

$\varepsilon_t, \varepsilon_{t-1}, \varepsilon_{t-2}, \varepsilon_{t-q}$ - errors, residuals of the model in the periods $t, t-1, t-2, \dots, t-q$;

$\phi_0, \phi_1, \phi_2, \phi_q$- model parameters;

q- lag length.

Mixed autoregressive–moving average models allow for greater flexibility in fitting the model to the real time series [Xin, 2017]. The form of the ARIMA model is as follows (3):

$$y_t = \theta_0 + \theta_1 y_{t-1} + \theta_2 y_{t-2} + \dots + \theta_p y_{t-p} + \phi_0 + \varepsilon_t - \phi_1 \varepsilon_{t-1} - \phi_2 \varepsilon_{t-2} - \dots - \phi_q \varepsilon_{t-q} \quad (3)$$

If there are clear seasonal variations in the process, the SARIMA (*Seasonal* ARIMA) model can be used. It is constructed by supplementing the ARIMA model with a seasonal component. This requires the determination of three additional parameters including such a component, i.e. P – the order of seasonal lags of the AR type, Q – the order of seasonal lags of the MA type, D – the seasonal differentiation parameter. ARIMA models can also be combined with classic regression models. The result of which is the ARIMAX (*Autoregressive integrated moving average with exogenous* variables) model, in which an additional exogenous variable is included in order to improve forecasting efficiency. Therefore, the form of the ARIMAX model is the ARIMA model supplemented by a set of exogenous regressors (4) [Box & Jenkins, 1983]:

$$y_t = c + \beta x_t + \theta_0 + \theta_1 y_{t-1} + \theta_2 y_{t-2} + \dots + \theta_p y_{t-p} + \phi_0 + \varepsilon_t - \phi_1 \varepsilon_{t-1} - \phi_2 \varepsilon_{t-2} - \dots - \phi_q \varepsilon_{t-q} \quad (4)$$

where:

β- coefficient of variation

x_t- additional exogenous variable

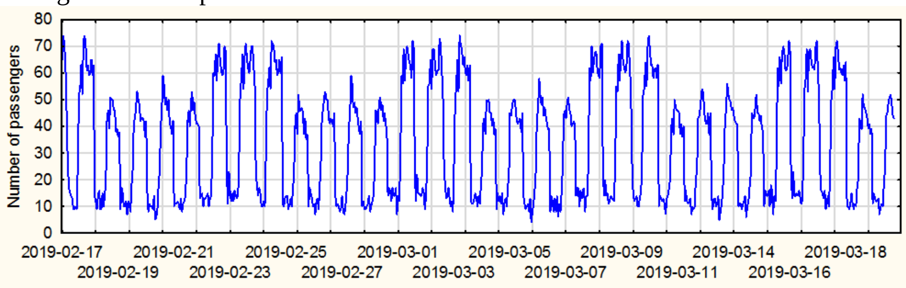
The procedure for estimating the parameters of the above models was developed by George Box and Gwilym Jenkins in the 1970s. The proposed algorithm consists of the following stages of time series analysis: identification, estimation, verification, forecast determination, according to which this analysis was conducted.

3. MODELING METHOD

3.1. Arima Model

According to the methodology of statistical research (Bielińska, 2007; Taylor & Karlin, 1998), the first stage is the visual evaluation of the time series, presented in Fig. 11. The analyzed phenomenon is characterized by a clearly visible seasonality of the process, as a result of which the series is not stationary.

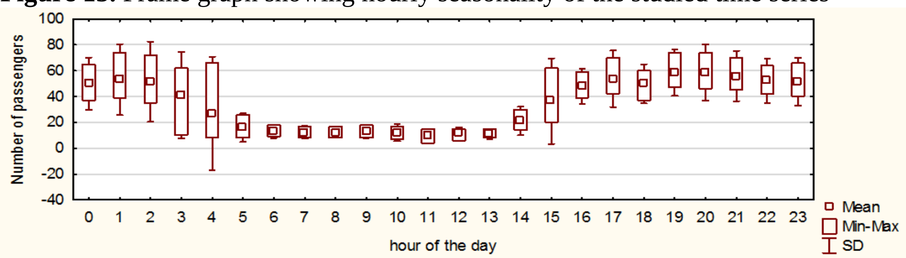
Figure 14. Graph presenting the number of passengers using transport services during the studied period



Source: own study

A detailed analysis revealed that this seasonality is primarily determined by the time of provision of the service. It turns out that at different times of day the demand for transport is different, which is shown in the frame graph in Fig. 12 on which the analysis of the examined variable was made depending on the time of its execution.

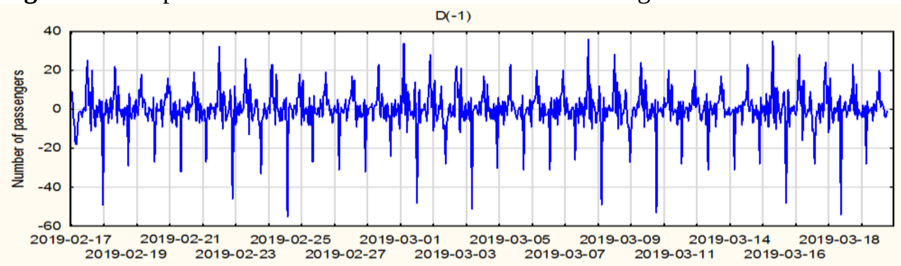
Figure 15. Frame graph showing hourly seasonality of the studied time series



Source: own study

The variation in the number of people using the company's services changes over the course of the day, making the process non-stationary. Since ARIMA methods can only be used for stationary series or reduced to stationary series, it is necessary to achieve at least stationarity in a broader sense (unchangeability during the first and second moment) (Box & Jenkins, 1983). Therefore, in order to smoothen the expected value and variance, a differentiation of the time series was applied. The graph of the variable after differentiation is shown in Fig. 13.

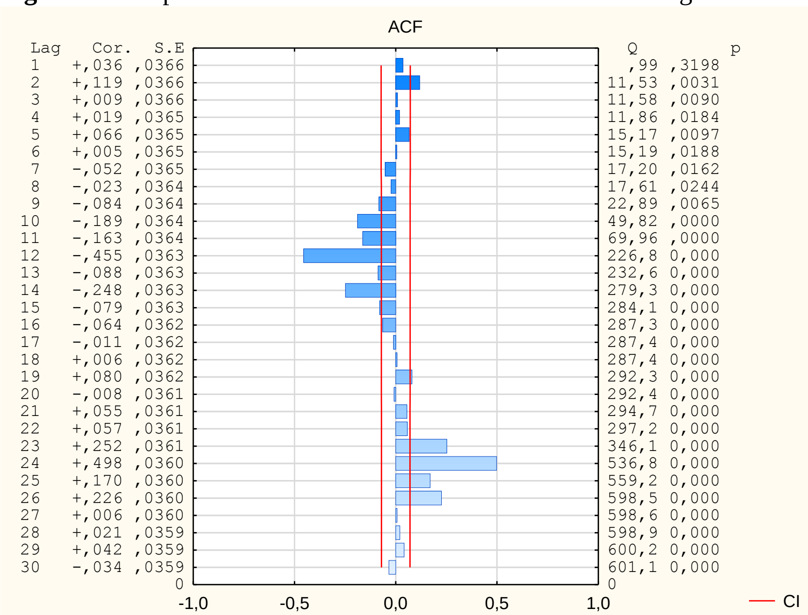
Figure 16. Graph of the series after differentiation with a lag d=1



Source: own study

The next step is to identify the appropriate subclass of ARIMA models by determining the initial values of their parameters. The basic tools in this respect are graphs of an autocorrelation function (ACF) and a partial autocorrelation function (PACF). The ACF values shown in the Fig. 14 disappear quickly for the initial lags and the significant value for lag 2 suggests that the value of the moving average parameter will be q=2. However, the values for the lag d=12 and its multiplicity are clear, which indicates a strong seasonality of the process, necessary to be included in the model.

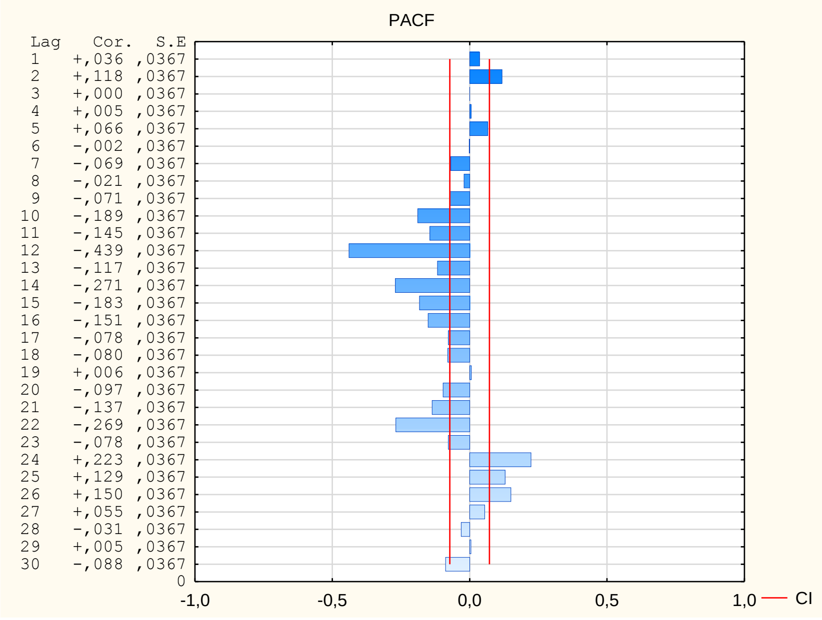
Figure 17. Graph of autocorrelation function with off-season lag d=1



Source: own study

The PACF graph (Fig. 15) leads to identical conclusions in terms of seasonality, also showing high indications for lag d=12. In addition, it suggests the value of the autoregressive element p=2.

Figure 18. Graph of partial autocorrelation function with nonseasonal lag d=1



Source: own study

Finally, it was decided to estimate the parameters of the ARIMA model using the *testing down* method, assuming that it is a moving average process with a non-stationary parameter $q = 2$ and a non-stationary autoregressive parameter p=2. Additionally, seasonal parameters were taken into account, which resulted in transformation of the assumed ARIMA model into a seasonal model, i.e. SARIMA. The two best models were selected from all tested models, for which all model parameters were statistically significantly different from zero. The results of the estimation are presented in Table 3.

Table 3. Results of the ARIMA model parameters estimation

Parameter	The ARIMA model (2,1,1)(2,0,0)	The ARIMA model (2,1,2)(2,0,0)
transformations	D(-1)	D(-1)
p(1)	0.56	-0.59
p(2)	0.13	0.35
q(1)	0.94	-0.21
q(2)		0.75

Parameter	The ARIMA model (2,1,1)(2,0,0)	The ARIMA model (2,1,2)(2,0,0)
Ps(1)	-0.31	-0.35
Ps(2)	0.48	0.49
Seasonal lag	12	12
MS	65.8	66.1
MRPE	27.5	28
AIC	5630.94	6699.33

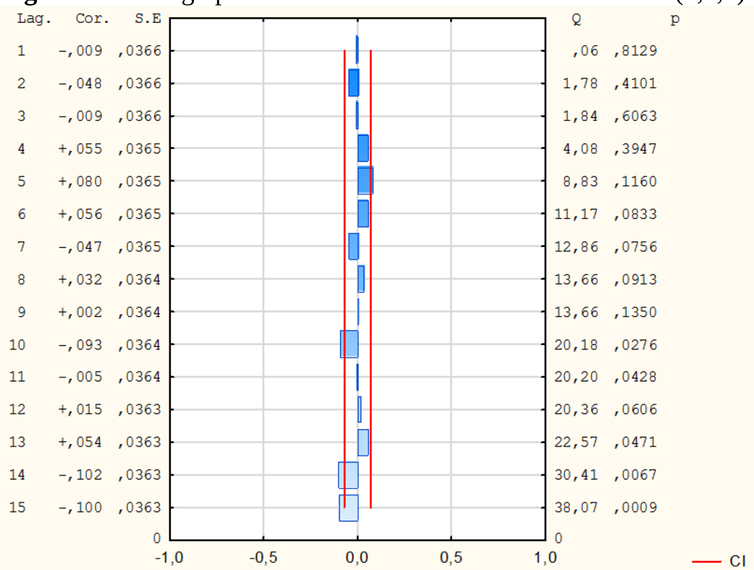
Source: own study

For the proposed models estimation errors and Akaike information criterion were calculated, and on the basis of these criteria (MS-Mean square error, MRPE - Mean relative prediction errors, AIC - Akaike Information Criterion) the best one was selected, which turned out to be the ARIMA model (2.1.1) (2.0.0) in the form (5):

$$y_t = 0.94\, y_{t-1} + \varepsilon_t - 0.56\, \varepsilon_{t-1} - 0.13\, \varepsilon_{t-2} + 0.31\, \varepsilon_{t-12} - 0.48\, \varepsilon_{t-13} \qquad (5)$$

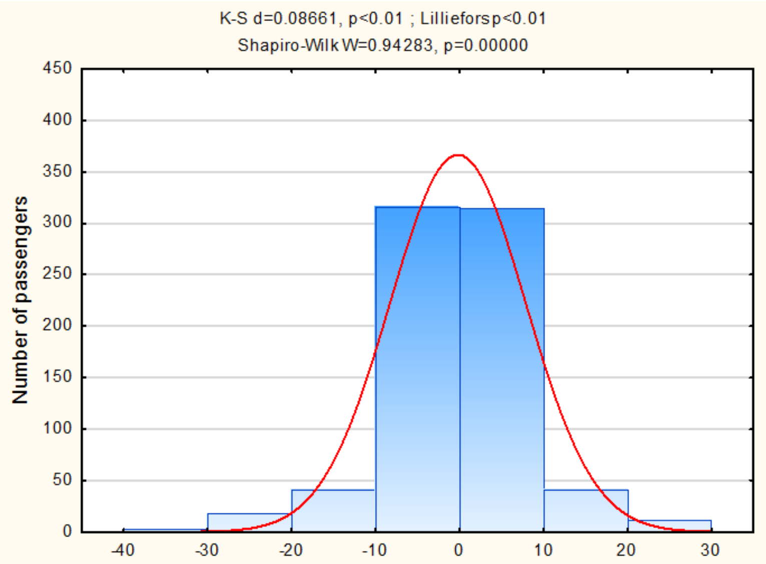
Then it was diagnosed by analyzing the distribution of residuals. In a correctly constructed model, the residuals should be random and symmetrical. In order to examine these features, the autocorelogram (Fig. 16) and the histogram of the distribution of residuals (Fig. 17) were drawn up. The ACF shows few statistically significant indications suggesting that not all dependencies were explained by the proposed model. Compatibility with normal distribution was not confirmed either. The test statistic in the Shapiro-Wilk test was W=0.94283, giving p-value p=0.0000.

Figure 19. ACF graphs for the residuals of the ARIMA model (2,1,1) (2,0,0)



Source: own study

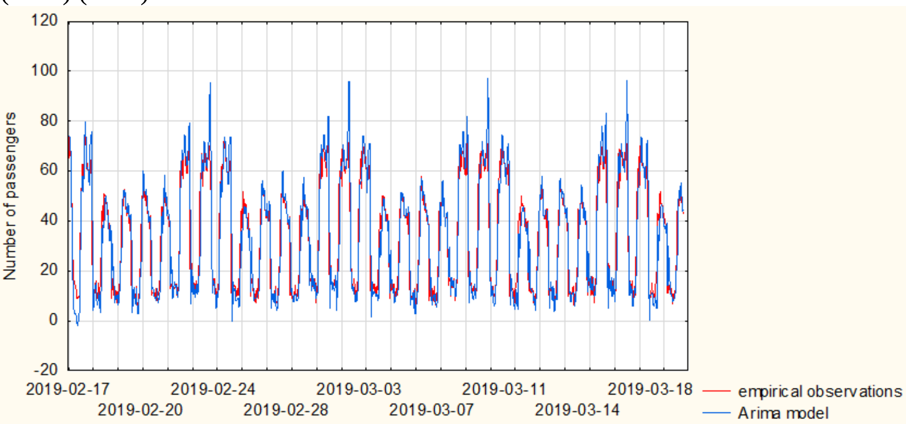
Figure 20. Histogram of the distribution of residuals of the ARIMA model (2,1,1) (2,0,0)



Source: own study

The above results explain why the forecast function differs from empirical observations. The largest errors relate to the maximum observation values achieved for peak transport service demand. The forecast for these hours is definitely overestimated 18.

Figure 21. Graph of the examined series and forecast according to the ARIMA model (2.1.1) (2.0.0)

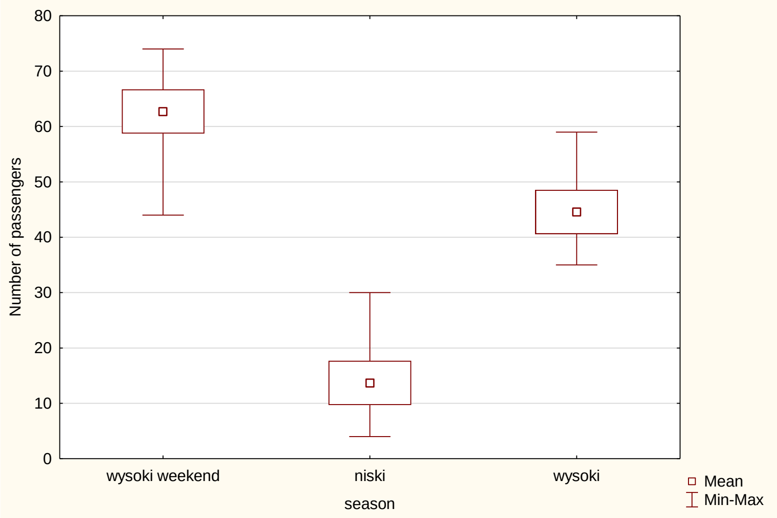


Source: own study

3.2. ARIMAX Model

In order to improve the obtained prognosis [Niematallah & Mototsugu, 2018], a modification of the model, allowing to include additional exogenous variables, has been proposed, i.e. the ARIMAX model [Sutthichaimethee & Ariyasajjakorn, 2017; Wiwik, 2015]. Since the hourly variation shown in Figure 2 is clearly arranged into three separate periods, as confirmed by Fig. 19, it was divided into three levels, resulting from the diverse customer interest. First, low demand is defined as a group of hours during which the number of customers does not exceed 30, followed by a high season on weekdays with a maximum of 49 customers and a high season on weekends starting on Friday afternoons with a maximum of 70 customers.

Figure 22. Frame graph showing the seasonality of the examined transport services



Source: own study

The selected regressors are qualitative variables, thus it was necessary to re-code them into binary variables (zero-one values). The parameters of thusly constructed model were estimated. The results are presented in table 4.

Table 4. Results of the ARIMAX model parameters estimation

Parameter	ARIMAX model
c	-0.03
p(1)	0.22
q(1)	0.21
β_1	53.90
β_2	9.39
β_3	35.99

Parameter	ARIMAX model
MS	30.43
MRPE	17.7
AIC	4553.05

Source: own study

The model obtained this way has the following form

$$y_t = -0.03 + 53.9\, x_1 + 9.39\, x_2 + 35.99\, x_3 + 0.22\, y_{t-1} + \varepsilon_t - 0.21\, \varepsilon_{t-1} \quad (6)$$

where

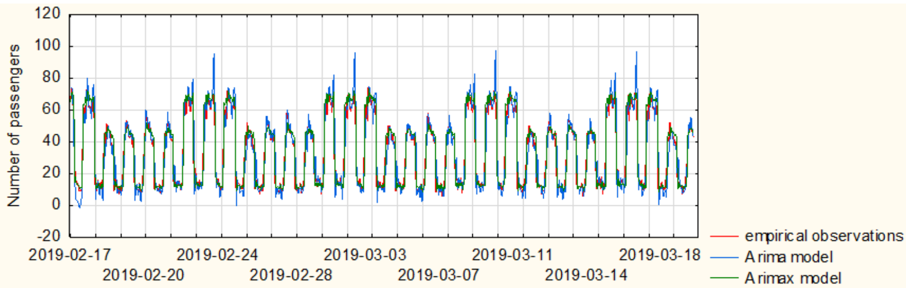
x_1 - the binary variable corresponding to high values at the weekend

x_2 - the binary variable corresponding to the low season on weekdays

x_3 - the binary variable corresponding to the high season on weekdays

According to the criteria adopted for verification (MS error, MRPE, AIC), the ARIMAX model achieved the most satisfactory results out of all the proposed models, as confirmed by Fig. 20, presenting empirical data and forecast functions according to ARIMA and ARIMAX models.

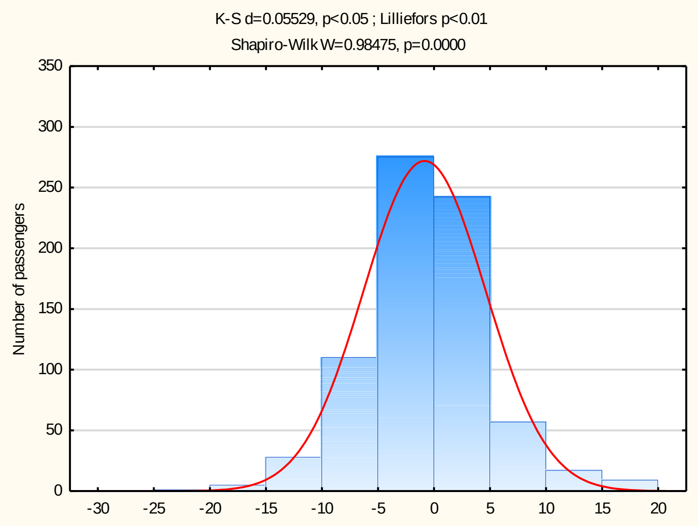
Figure 23. Graph of empirical values and forecast functions according to ARIMA and ARIMAX models



Source: own study

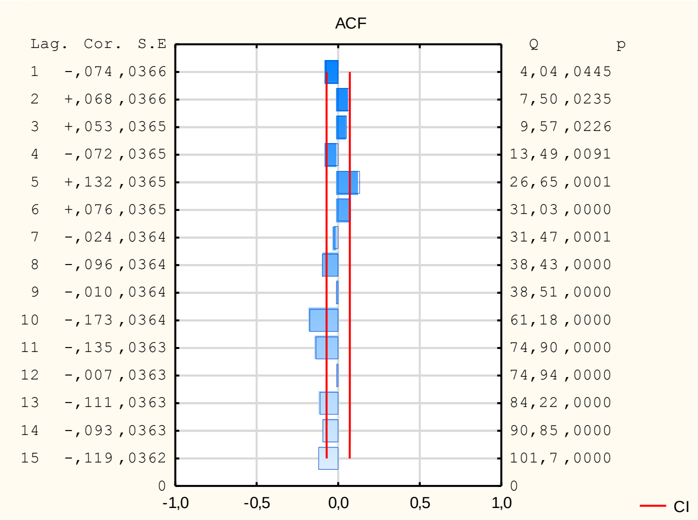
The ARIMAX model is better suited to real observations, but its diagnosis is not satisfactory because the distribution of residuals is still not close to the normal distribution (Fig. 21) and the graph of the autocorrelation function shows significant values of this function (Fig. 22).

Figure 24. Histogram of distribution of the residuals of the ARIMAX model



Source: own study

Figure 25. Graph of the autocorrelation function of the ARIMAX model residuals



Source: own study

3.3. Forecasting According To the ARIMA and ARIMAX Models

In the last stage of the study, the future values of the series were forecast and compared with the retained test observations, which did not participate in the estimation of model parameters. A relative forecast error was also calculated for each predicted value. The obtained results are presented in table 5.

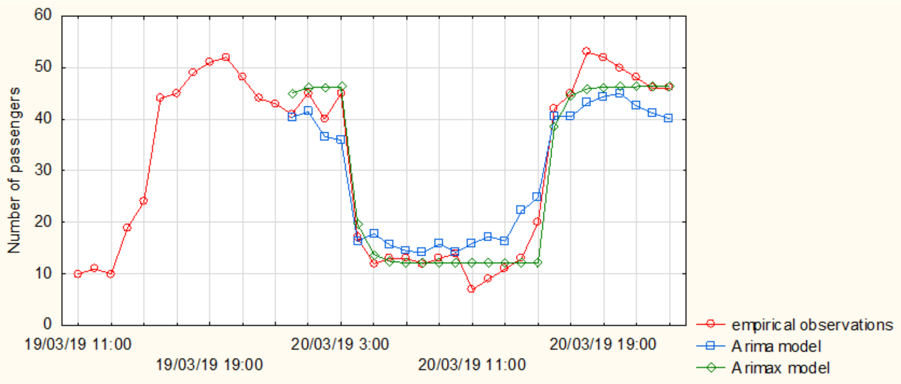
Table 5. Forecasts according to the ARIMA and ARIMAX models

date/time(hour)	empirical observatio	ARIMA forecast	ARIMAX forecast	SE ARIMA	SE ARIMAX
20-03-19 0:00	41	40.3	45.1	1.6%	10.0%
20-03-19 1:00 AM	45	41.5	46.0	7.8%	2.3%
20-03-19 2:00 AM	40	36.6	46.2	8.4%	15.6%
20-03-19 3:00 AM	45	36.0	46.3	20.1%	2.9%
20-03-19 4:00 AM	17	16.3	19.7	4.3%	15.9%
20-03-19 5:00 AM	12	17.8	13.8	48.6%	14.7%
20-03-19 6:00 AM	13	15.6	12.4	19.9%	4.3%
20-03-19 7:00 AM	13	14.5	12.1	11.3%	6.6%
20-03-19 8:00 AM	12	14.1	12.1	17.8%	0.6%
20-03-19 9:00 AM	13	15.8	12.1	21.9%	7.2%
20-03-1910:00 AM	14	14.2	12.1	1.5%	13.9%
20-03-1911:00 AM	7	15.9	12.1	127.7	72.2%
20-03-19 12:00 PM	9	17.2	12.1	91.6%	34.0%
20-03-19 1:00 PM	11	16.4	12.1	49.1%	9.6%
20-03-19 2:00 PM	13	22.2	12.1	70.8%	7.3%
20-03-19 3:00 PM	20	24.8	12.1	24.1%	39.7%
20-03-19 4:00 PM	42	40.5	38.7	3.6%	8.0%
20-03-19 5:00 PM	45	40.5	44.6	10.0%	0.9%
20-03-19 6:00 PM	53	43.1	45.9	18.7%	13.4%
20-03-19 7:00 PM	52	44.4	46.2	14.6%	11.1%
20-03-19 8:00 PM	50	45.0	46.3	10.0%	7.4%
20-03-19 9:00 PM	48	42.5	46.3	11.4%	3.5%
20-03-19 10:00 PM	46	41.1	46.3	10.6%	0.7%
20-03-19 11:00 PM	46	40.1	46.3	12.8%	0.7%

Source: own study

The average forecast error for the ARIMA model was as high as 25.7%, while for the ARIMAX model it was much lower, at 12.6%. The higher effectiveness of the ARIMAX model is presented in Fig 23.

Figure 26. Graph of test observations and forecasts according to the ARIMA and ARIMAX models



Source: own study

4. FINAL THOUGHTS

The presented process is characterized by high complexity, causing difficulties in estimation of parameters of econometric models. However, in companies similar to the examined one, where a limited number of vehicles and drivers providing transport services require the adjustment of their working hours to market demand, even an estimation with a certain error can prove to be very useful. Although the proposed models took into account only the dependence of the examined variable on its value lagged in time (ARIMA model) and additionally, the selected element of seasonality of provided services (ARIMAX model), they are a sufficient guidance to assess the development of demand and may determine the direction of the company's strategy.

The models presented here can be applied in forecasting demand in nearly every company. Depending on the needs, they can be extended with additional variables, increasing the forecast accuracy and reducing estimation errors. However, identifying and measuring all the factors that shape the demand for certain goods or services is not always possible. Often the process of collecting and processing such factors is difficult and sometimes even impossible. Nevertheless, as demonstrated in this article, even a simplified model can provide valuable guidance on the use of available resources (in this case vehicles and personnel) in order to respond more effectively to customer demand. This may translate into an increase in the quality of services provided and customer satisfaction and, as a result, into an increase in the company's profits.

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TRANSPORT LOGISTICS AS A SOURCE OF IMPROVING QUALITY OF LIFE IN A REGIONAL CONTEXT

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Abstract

The article deals with transport logistics as one of the factors for improving the quality of life both in general and in the regional context. The analysis in this case is based on the fact that transport logistics can be seen to have an obvious role here — both directly through investment in transport infrastructure, vehicles, and logistics systems, increasing physical capital; and indirectly through the impact that more efficient transport can have by inducing greater efficiency in the way that other sectors use their own inputs. Beyond the initial effects of transport investment on journey times and costs, labour market, agglomeration and transport network effects also influence the long-term impacts of transport investment on economic growth and urban/regional development. Each of these wider economic impacts has a spatial dimension through their influence on the location and geography of economic and social activity. Objectives, methods, and the particular results of investigations resulted in the definition and characteristics of the transport logistics in terms of the European Union with reference to their application and impact on quality of life in a regional context. The region is perceived as a territorial unit between the state and municipalities, resulting in the need for a specific approach to address the problem, which can then be developed.

Key words: transport logistics, logistics system, investments, quality of life, region

1. INTRODUCTION

Ensuring the desired quality of life for the population, which is in the interest of each country, is influenced by many factors. The aim of this article is to contribute to the broader discussion of this topic in terms of the impact of the transport logistics factor with a regional context. The starting point of our efforts is the fact that the issue is not yet discussed in detail. In our opinion, however, it deserves much more attention.

Regional development is a broad term but can be seen as a general effort to reduce regional disparities by supporting (employment and wealth-generating) economic activities in regions. In the past, regional development policy tended to try to achieve these objectives by means of large-scale infrastructure development and by attracting inward investment.

Logistics, assisting flow of goods, services, and values within the chain from the production spot to the consumption spot and oppositely, from the consumption spot to the production spot; signifies an important point in terms of development of economies. Share of logistics within GDP in most developing countries cannot be denied. Today, when separation of production from consumption, and execution of both activities within limits are in question; logistics management has gained importance and has become one of the important factors determining development levels of various regions within countries. The concept of regional development has been identified, and importance and objectives of regional development have been defined in this time (Cempirek, 2010).

Transport logistics can be seen as one of the key activities of the logistics process, which in financial terms often represents the largest cost item in relation to other logistics activities such as storage, material handling, procurement, inventory management, information systems, customer service etc. The role of transport logistics is to provide the transport process so that the desired benefits are created: the benefit of the site - to move any item where required and the benefit of time - to move the item when it is required. In this way, transport logistics is becoming an important pillar of a logistics system that can be defined as a purpose-built physical and management structure that enables the activation, assurance, evaluation and improvement of the flow of logistics networks (Lambert et al., 2000). In the context of European Union policy, the European Commission in “Freight Transport Logistics in Europe - the key to the development of sustainable mobility”, presents the view that optimization of the European transport system would be possible through the use of a logistics concept.

Quality of life (QOL) is the general well-being of individuals and societies, outlining negative and positive features of life. It observes life satisfaction, including everything from physical health, family, education, employment, wealth, safety, security, freedom, religious beliefs, finance and the environment (Mirică, 2018). As a contributor to economic development, transport infrastructure by its very nature has important spatial impacts, for example on intra-regional and inter-regional transport time and costs, and thus potentially on the location of households and businesses. Transport services are produced and consumed jointly with transport infrastructure, a major component of the fixed capital of the transport sector. A distinguishing feature of the transport sector is that its function is primarily as an input into many other activities. Firms transport products to distribution centres and retail outlets; businesses send their employees to meet with customers, suppliers, regulators and co-workers; people travel to work and for leisure pursuits (Valaskova et al., 2018).

2. RESEARCH METHODOLOGY

The review of literary sources shows relatively limited knowledge about the link of transport logistics as a factor that can increase the quality of life. An exception in this respect is the research of the Tourism Centre of the Department of Forest Resources, University of Minnesota, which in its study examines the impact of transport on quality of life within defined areas (Schneider, 2013). From the research approach point of view, other possibilities of economic benefit of transport based on relevant transport demand and optimal setting of the transport system supply side will be examined in the analysis. Specific attention in the analysis and synthesis of knowledge is devoted to the state and direction of transport development in Slovakia in relation to sustainable development, transport infrastructure with acceptance and utilization of the logistics concept, to which the relevant European Commission documents bind us. The research methodology includes the historical method, desk review, system analyses and field research.

3. TRANSPORT LOGISTICS

The operation of transportation determines the efficiency of moving products. The progress in techniques and management principles improves the moving load, delivery speed, service quality, operation costs, the usage of facilities and energy saving. Transportation takes a crucial part in the manipulation of logistics. Reviewing the current condition, a strong system needs a clear frame of logistics and a proper transport implements and techniques to link the producing procedures (Cempirek, 2010).

The principal role of transport is to provide access between spatially separated locations for the business and household sectors, for both commodity (freight) and person movements. For the business sector, this involves connections between businesses and their input sources, between businesses and other businesses, and between businesses and their markets. For the household sector, it provides people with access to workplaces and education facilities, shops, and social, recreational, community and medical facilities. Given the significance of the sector in economic terms, both the level of transport investment together with the amount of expenditure on transport operations can have wider effects on the economy (as is seen when transport fuel prices increase substantially, resulting in reduced household expenditure on other goods and services) (Ignatyev & NurtdinovIlgiz, 2018).

The direct effects of transport investment are to reduce transport time and costs through reducing travel times, decreasing the operating costs of transport and enhancing access to destinations within the network. Transport investment may also mitigate any economic disbenefits, for example where projects reduce congestion or the risk of injury. These incremental benefits of transport investments may be measured through conventional cost-benefit analysis. Other indirect consequences of transport investments should also be considered when evaluating projects. These include effects on productivity and the spatial pattern of economic development. In the long term, transport investments contribute to economic development by stimulating a variety of inter-connected economy-wide processes, which can yield spatial and regional effects that augment overall productivity (Pernica, 2004).

3.1 Perspectives on the economic contribution of transport

The economic contribution of transport interventions and transport policy can be assessed from various perspectives. These include:

- effects on aggregate economic welfare (that is, the sum of consumer and producer surplus), which is the focus of cost-benefit analysis, as applied to transport policies or projects
- micro-economic, for example, enterprise or household-level productivity effects
- macro-economic, for example, contributions to GDP, investment or employment, and the spatial patterns of economic activity (Ceniga & Šukalová, 2012).

In particular, lower costs and enhanced accessibility, due to better transport links and services, expand markets for individual transport-using businesses and improve their access to supplier inputs. Increased access and connectivity create increased opportunities for trade, competition and specialisation, which can lead to longer-term productivity gains. These changes are analogous to the gains from lowering barriers to trade and the expansion of opportunities that come from doing so. Therefore, knowing the circumstances in which these impacts occur is an important part of understanding the economic benefits that may arise from transport investments (Salaga et al., 2015).

3.2 Demand for transport

The demand for travel by individuals and households is essentially a function of their desire for physical access to workplaces, educational establishments, shops, and social, recreational and community facilities. The extent to which these desires translate into actual travel will be moderated by the time and costs involved in making the desired trip. Travel times and costs will be dependent on:

- the supply of suitable transport services, including speed, quality and convenience factors relating to the services (for example, service frequency, reliability, crowding),
- the financial cost (price) of the services,
- perceptions of any social and environmental costs associated with the trip and the services involved (for example, level of safety and security, adverse environmental effects). Transport demand decisions are complex, as multiple factors are involved, and both longer and shorter term choices need to be addressed. For example, for a company wishing to manufacture and then sell its products in the marketplace, it needs to decide on:
- the sources of its inputs, and how these are to be transported to its manufacturing sites,
- the markets that it is best placed to serve, and how it will transport products to these markets (Kliestik et al., 2015).

This will involve medium-term decisions about whether it provides its own transport (and if so how), or outsources its transport task, and shorter-term choices such as the transport mode to be used, travel times and service quality features as well as price (National strategy, 2016).

Historically, the „generalised costs'(including travel time) of transport have tended to fall as a proportion of the total costs of goods and services, as transport technologies and efficiencies have improved. This reduction in transport costs together with growth in household incomes has resulted in transport becoming relatively cheaper for both businesses and households. This has been a major factor in increasing the demand for transport (per capita) over time. In the household sector, much of this increased demand has manifested through people making longer but faster trips, to take advantage of destinations and opportunities that would previously have been too difficult to access (Gourdin, 2006). The evidence indicates that the time that people spend travelling has varied very little in the modern era (averaging typically 60 to 70 minutes per day), but the distances travelled per person have increased substantially. In the business sector, the declining relative costs of transport have resulted in substantial increases in the transport task involved in manufacturing products and getting them to market, as business processes have been rearranged to minimise total production and distribution costs (Lambert et al., 2000).

3.3 Supply of the transport system

The supply side of the transport system can be altered in a number of ways, including decisions relating to the following (Christopher, 2011):

- investment in, additions to, or improvements in, quality of the infrastructure stock (e.g. new roads or railway lines or rail electrification),
- replacement of existing infrastructure assets (for example, resurfacing a road or renewing railway track),
- reductions in road capacity,
- better management of the asset base (clearing breakdowns faster, better management of traffic flows, new services making fuller use of existing infrastructure),
- changes in money costs (for example, tolls, parking charges, fuel prices),
- changes in regulations relating to the delivery of transport services (for example, changes in competition and regulations affecting entry to public transport and taxi markets) (SACTRA, 2000).

3.4 State and direction of transport in relation to environment in Slovakia

The increase in living standards entails high growth in road transport, especially individual traffic, which requires upgrading and expanding the capacity of the road network. Quality transport infrastructure also determines the development of the economy and is one of the basic criteria when deciding to implement a new investment. More favourable economic conditions for business, flexibility and the ability to respond to the demands of the modern economy have made road transport a decisive market share, with a rise in congestion on major road routes and in cities with a negative impact on the environment and public health. In terms of greening transport it is necessary to introduce and develop the use of renewable sources of transport and to focus on the promotion and development of non-motorized and environmentally friendly modes of transport (Ionescu, 2018):

- There was a decreasing trend in the number of transported passengers and passenger transport performance in addition to individual car traffic, which recorded year-on-year increases in the monitored period of 2000 - 2015. The highest share of passenger transport in passenger transport was represented by individual motoring, followed by public road transport, public transport and rail transport.
- The amount of goods transported by freight had a downward trend with a significant decline after 2008. The freight transport performance in the period 2000 - 2015, despite the volatile nature after 2008, began to grow. The largest share in the amount of goods transported was road freight transport, followed by rail transport and water transport.
- The current state of transport infrastructure is characterized by a dense network of roads, but with a low share of motorways and expressways, also with a relatively dense network of railways, airports of different character, and inland waterways of international importance - the Danube River (Ciszewski & Nowakowski, 2018).
- Only road transport recorded a significant increase in the number of means of transport in the period 2000 - 2015, while in other modes the number of means of transport decreased, with the most significant decrease being recorded in air transport.
- Final energy consumption in the transport sector for the period 2001 - 2015 increased. Road transport accounts for the largest share of fuel consumption and electricity consumption predominates in rail transport.
- Consumption of ecological fuels LPG and CNG recorded an increase in the monitored period 2000 - 2014 despite the fluctuating trend (Koreňová, 2017).

3.5 Transport and Environment Interactions in Slovakia

Currently, there is a tendency in Slovakia to increase road, especially freight and individual car traffic, resulting in a greater burden on the environment, including residential zones, greenhouse gas emissions and basic pollutants, traffic noise, landscape fragmentation and traffic accidents (National strategy, 2016).
Difficulty of transport to resources

- Land use of transport infrastructure represents 0.55% of the total area of the SR. The increase in land area was recorded in road and rail infrastructure. (Land Use Transport Infrastructure Indicator)

Development of transport to the environment

- The development of greenhouse gas emissions is affected by environmentally friendly road transport. In the period 2000 - 2014, CO2 emissions increased, N2O emissions fluctuated around the same level and CH4 emissions decreased.

- Transport is also involved in the production of basic pollutants and heavy metals. Emissions of CO, SO2 and NM VOC decreased in the period under review, despite the fluctuating character, the emissions of TZL and NOx increased. Copper, lead and zinc accounted for the largest share of heavy metal emissions in the transport sector.
- Waste production in 2002 - 2015 was fluctuating with year-on-year increases and decreases. The highest number of old vehicles was processed in 2009, with a fluctuating trend after that.
- In 2011, strategic noise maps and action plans were drawn up for road, rail, air and industrial activities of large-scale noise sources, which are updated every 5 years.
- In the period 2000-2008, traffic accidents were of a volatile nature and since 2009 their number has declined due to legislative changes, and the number of people killed and injured has also decreased. The number of rail accidents has increased slightly since 2010 (Koreňová, 2017).

4. QUALITY OF LIFE

Transportation has emerged as an important, yet still not entirely understood element to Quality of life. Further, rather than a holistic approach to transportation, select transportation areas are typically studied such as public transit and parking, accessibility and mobility, or transportation systems efficiency.
According to Quality of life research within and beyond transportation conducted by the Tourism Centre & Department of Forest Resources University of Minnesota we can described transportation across several major areas (in alphabetical order): access, design, environmental issues, maintenance, mobility, safety and transparency (Schneider, 2013).

- Accessibility refers to access to destinations or people's ability to reach the destinations they must visit to meet their needs and desire to visit to satisfy their wants.
- Design describes the physical layout of the transportation system and includes the multiple components that make up the system (e.g. roads, signs, and lights).
- Environmental issues include air, water, and light.
- Maintenance is a broad category that describes road surfaces, paint indicators, general repair, and seasonal upkeep.
- Mobility is defined as the movement of people from one place to another in the course of everyday life.
- Safety emerged as a primary category in discussing transportation related QOL indicators. Multiple safety elements exist: physical conditions, human behaviour, and the interaction among these factors.
- Transparency included subthemes of communication, finances and planning.

Results of the survey have been specified and defined in the following areas (Schneider, 2013):

- Access: Accessibility refers to access to destinations or people's ability to reach the destinations they must visit in order to meet their needs and desire to visit to satisfy their wants. Much of the existing research measured access in terms of people's ability to reach a destination in a personal automobile. This auto-based conceptualization is limited and measures of access are expanding to reflect the variety of access opportunities people may reach their destinations. As such, subthemes of this category include: public transportation, service transportation, air travel, nonnotarized transportation, trains, and light rail transit.
- Design: The concept of transportation system design is particularly related to access and mobility. Design describes the physical layout of the transportation system and includes the multiple components that make up the system (e.g. roads, signs, and lights). Local neighbourhood streets, regional roads, and interstate connections are all dynamic; as such, design improvement emerged as a subtheme in this category. However, these changes require funding and subsequently, costs emerged as another subtheme. In some cases the physical layout of the transportation system was easy to use and expedited travel, in other cases the layout was poor and confusing to use. Related to this, quality and efficiency were additional subthemes of design.
- Environment: Several characteristics of the environment are shaped and influenced by the transportation system. Respondents noted carbon emissions and air pollution as subthemes for this category. Beyond atmospheric emissions, the transportation system is also responsible for adding considerable sound and light to the environment, and, as such, noise and light pollution are additional subthemes of this category.
- Maintenance: Maintenance is a broad category that describes road surfaces, paint indicators, general repair, and seasonal upkeep. Potholes and other poor road surfaces can negatively influence pavement ride quality and reduce customer satisfaction with state highway maintenance.
- Mobility: Mobility describes movement, the actual process or experience involved with moving from one point or another. Mobility is defined as the movement of people from one place to another in the course of everyday life. While access is required for people to reach desired destinations, mobility refers to the physical movement to get there. This concept of mobility describes movement, such as congestion or free-flowing traffic, travel time, and total hours of delay. Subthemes of this include: traffic flow, commute time, construction, congestion, and travel time within and between communities.
- Safety: Safety emerged as a primary category in discussing transportation related QOL indicators. Multiple safety elements exist: physical conditions, human behaviour, and the interaction among these factors were frequently described as safety concerns. Driver behaviour emerged as an important subtheme related to safety: distracted drivers as well as speeding drivers were mentioned most frequently. Other safety subthemes included troubled intersections or poorly marked streets, railroad crossings, and interactions between vehicles and bikers or pedestrians.
- Transparency: Several subthemes emerged in the focus groups adding depth and breadth to the concept of transparency. Communication in its various forms

appears to be most associated with transparency; specific subthemes include communication about finances and planning (SACTRA, 2000).

4.1 Economic growth

Generally countries can enhance their capabilities and outputs in three main ways, that is, by investment in:

- physical capital
- human capital (through education)
- new knowledge creation and application.

Economic output is a function of the capital and labour inputs used in the economy together with the efficiency with which these inputs are applied. Economic growth therefore depends on increases in these inputs and in total factor productivity (TFP) (BTRE, 2001).

Transport can be seen to have an obvious role here — both directly through investment in transport infrastructure, vehicles, and logistics systems, increasing physical capital; and indirectly through the impact that more efficient transport can have by inducing greater efficiency in the way that other sectors use their own inputs For the transport sector, the key question is whether improvements in transport provision are likely to encourage greater TFP growth by improving incentives for innovative activity. The mainsprings of long-run economic growth are investment and productivity growth. If transport provision is to have an impact it must work through these channels, either directly or indirectly, as a result of its effects on the decisions made by households and firms. One of the main historical impacts of improvements in transport infrastructure has been to make possible and to reduce the costs of long-distance trade and so make markets more integrated. This is perhaps the aspect that makes transport infrastructure special; it may be achieved through better transport networks rather than individual transport schemes. In the presence of imperfect competition in transport-using sectors, it may also lead to important economic effects that are not captured in conventional cost-benefit analysis. Transport and the economy are often said to have a two-way relationship; changes in the supply of transport may affect the level of economic activity and, conversely, the level of economic activity can affect the demand for transport (Olah et al., 2018).

4.2 Transport infrastructure investment

Summary of conditions complementing transport infrastructure investment to contribute to economic growth.

Economic conditions:

- The presence of positive economic externalities (for example, labour market, network or agglomeration economies).
- The potential for economies of scale.
- The potential for specialisation of markets to occur.
- The availability of a good quality, skilled labour force.
- The availability of resources that ―represent entrepreneurial effort that would not have occurred without the infrastructure being in place‖

- The presence of inefficiencies in spatial structure.
- A generally buoyant economy.

Investment conditions:

- The transport mode being invested in.
- The availability of investment funds.
- Network effects (for example. is it a new link in an existing network, a new link connecting two disjointed networks or expansion of a link in an existing network?)
- Scale, timing and location of investment.
- Efficiency in implementation.

Political and institutional conditions – related to the broader policy environment (the „noneconomic" factors) in which the investment takes place:

- Sources and method of finance.
- Presence of complementary or facilitative policies/action (for example, training programmes, structure of tax system, facilitating the entry of competitive and/or innovative firms).
- The organisational and managerial framework of the infrastructure facilities.
- The ―political involvement of the political organs (Gourdin, 2006)

5. TRANSPORT SYSTEM AND REGIONAL DEVELOPMENT

There is used an economic geography perspective to explore the relationships between the transport system and regional development. Its key findings on these relationships included the following (Pernica, 2004):

- The new economic geography and the theory of agglomeration economics emphasises the additional productivity gains made possible through agglomeration in large urban areas.
- Its literature shows that by reducing the cost of transporting goods between locations — which decreases the effective „distance" between two points transport improvements can promote trade, increase competition and variety, and facilitate specialisation in economic activities.
- Infrastructure has an important influence on the location of economic activity and population centres. Infrastructure investment is by its nature spatial, since it involves rival choices about the location of services (including infrastructure) that will serve specific areas. Straub also noted that the new economic geography models help substantiate the claim that infrastructure policy is a form of industrial policy. Indeed, different types of investment have effects on economic activity that work primarily through their impact on business and industrial location and specialisation.
- Infrastructure services are an input to both households and firms consumption and investment decisions. Changes in the availability and quality of infrastructure will crucially influence location decisions, for example migration of households and firms, establishment of new firms and fixed capital investment in different locations.

- Economic geography models consider location patterns to be the result of the interplay between agglomeration and dispersion forces:
  - Agglomeration forces arise as the result of increasing returns that may be either internal or external to firms. Increasing internal returns push firms to locate their activities in regions with bigger markets to be able to serve more consumers or where, through concentration of suppliers, the firm‘s input costs are lower than otherwise. Agglomeration may also arise for reasons external to the firm, such as knowledge spill overs or access to a more highly trained workforce.
  - Acting against these agglomeration forces are dispersion forces affecting both the supply and demand side of relevant markets. For example, agglomeration brings with it increasing costs of land and labour, as well as congestion. And locating in urban concentrations may mean neglecting distant markets.
  - Transport costs are important in determining the balance between agglomeration and dispersion forces, as both forces diminish as transport and trade costs decline.
- One policy trade-off arising from a geography and growth model is a spatial equity versus efficiency trade-off. This trade-off has two main consequences:
  - First, infrastructure policies that facilitate transport between regions, for example building or improvement of major road corridors will tend to increase both regional inequality and national growth.
  - On the other hand, infrastructure policies that facilitate transport within poor regions will have the opposite effect of decreasing regional inequality, but also constraining national growth (Komobile, 2013).

In assessing the likely regional impacts (in terms of under what conditions transport investment will benefit the „target" region and under what conditions an outward flow of investment and jobs would occur), suggested the following key issues that would be relevant:

- scale economies (for example, where these dominate, lower transport costs through improved accessibility may encourage an increased concentration of firms in core regions, until the point that diseconomies sets in)
- size of the local market
- local land and labour conditions
- the nature of backward and forward linkages in the local economy
- the nature and scale of transport improvements

However, also noted that the interplay of these factors is indeterminate — that is, it is impossible to predict outcomes using theory alone. It concluded that the impact of improved transport links on regional economies is context-specific and must be assessed on a case-by-case basis (SACTRA, 2000).

Beyond the initial effects of transport investment on journey times and costs, labour market, agglomeration and transport network effects also influence the long-term impacts of transport investment on economic growth and urban/regional development. Each of these wider economic impacts has a spatial dimension through their influence on the location and geography of economic and social activity. These spatial impacts have a number of different dimensions.

The first dimension is that the economic impacts may not be evenly spread. This means transport investment has the potential to cause redistribution of economic impacts between (and within) regions. Analysts should use caution when measuring benefits, such as new jobs created in one region, to ensure they are not miscounting redistribution as a benefit. The potential for redistribution is particularly relevant with inter-regional transport links. A second dimension is that, in an urban setting, local transport investment plays an important role in shaping the aesthetics and amenity of a community. Transport infrastructure and services can have a significant impact on urban form by enhancing or detracting from it, leading to an impact on the attractiveness of a city as place to live, work and visit. This will in turn affect the economic dynamism and culture associated with the city. Therefore, transport investment can have long-term impacts on economic growth and development, which go well beyond the initial benefits of travel time savings and lower vehicle operating costs (Ignatyev & NurtdinovIlgiz, 2018).

6. CONCLUSION

The role that transportation plays in logistics system is more complex than carrying the goods. The integration and promotion of business activities have to involve transportation systems at different stages. The integration of various applications brings the convenience through promoting the system of information flow and business operations. Transportation complexity can take effect only through highly quality management. By means of well-handled transport system, goods could be sent to the right place at right time in order to satisfy customers' demands. Transportation is the most important sub-function of logistics that creates time and place utility in goods. Reviewing the current condition, a strong system needs a clear frame of logistics and a proper transport implements and techniques to link the producing procedures.

Transport investment has a significant impact on where economic activity occurs. Over time, changes in access and mobility can lead to changes in the economic and social landscape of countries. It can influence the geography of agricultural production, manufacturing and the knowledge-based service sector through its impact on how easy and cost effective it is to move around. Transport costs and accessibility also influence where people choose to reside in relation to their place of employment and lifestyle preferences. The quality of transport infrastructure, in terms of amenity and aesthetics, plays a role in the overall live ability and attractiveness of cities. Modern thinking in economic geography describes cities as competing with each other (within and between countries) to attract highly-skilled people who can choose where they decide to live and work. One response to this competition is the investment that goes into major transport hubs around the world, which go beyond their utilitarian purpose and are designed to make a statement about the cities they service.

Policy makers and researchers are increasingly recognizing the connections between public health and transportation, but health improvements are typically framed from a physical health perspective rather than considering broader quality of life impacts. The analysed framework identified six transportation-related QOL dimensions: access, design, environmental issues, maintenance, mobility, safety and transparency. As this is an extensive topic, this paper concentrates on a limited range of specific questions that are seen here and in other developed countries as core to transport policy and which connect to other components of this research (Orazulike, 2018).

Therefore, it would be advisable to continue with further research on the subject, as the subject under examination has a broad context and the requirement to ensure an adequate quality of life for the population is crucial for every society. Open questions for further research in this area are:

- Creation of an economic model for assessing the impact of transport logistics on the quality of life for a selected region.
- Proposal of corporate measures and tools to eliminate negative impacts of transport logistics on the quality of life in the region.
- Extending the logistics manager's competence model with aspects of perception, assessment and influencing the impact of transport logistics in the context of quality of life.

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ROLE AND IMPORTANCE OF IMPLEMENTATION OF QUALITY MANAGEMENT IN BUS TRANSPORTATION

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Abstract

Considering increased passenger mobility, bus transportation has an increasing significance on the market. Creating passengers' trust is achieved through tangible and intangible elements of the service provided. The service, in the first place, has to have ensured quality standards that will be recognized by passengers and due to which passengers will remain faithful to the further use of the service. In order to ensure the quality of the service, namely to fulfil the needs of passengers, management has a role to continuously work on introducing and improving the elements that raise the quality of service. As the processes of acquisitions and mergers in the organization represent an opportunity for market positioning and significance for the economy, on the other hand are a major challenge for the management, because the integration process is often painstaking and the efforts of the management are needed for this path to successfully. Therefore, of extreme importance is the implementation of the best processes of each company in order to improve the quality of the service by merging the companies.

The aim of this paper is to examine passenger’s satisfaction with the service after introducing new elements aimed at improving the service, after the acquisition of the company. Main finds are based on understanding passenger’s real needs who stated their opinion through questionnaires which represents the basis of further development of business development strategy. Methodology and scope of the work consist of comparing author’s previous surveys and current survey in accordance with the Servqual model, which is the practical part of the paper, and theory part related to ensuring quality elements and the importance of its application.

Key words: quality control, implementation, management, bus transport

1. INTRODUCTION

Quality management and its application is always placed in the sphere of knowledge, skills and experience of the management, that are crucial for further development and progress of the organisation. In order to avoid negative trends of success of mergers/acquisitions, the company builds its competition on their own knowledge, by corporation communication of a good quality, by implementing and measuring quality system and by implementing changes. Although quality management is unavoidable process for the organisation to be successful, by inadequate management it can create expenses that are above planned and in that way it can bring the organisation into unfavourable financial position. Expenses of quality represent guidelines for the management to see if the goals that have been set will be achieved and what actions shall be taken on time so the goals are achieved. By implementing elements that influence achieving higher level of quality of service, the management is one step closer to achieving the success on the market. Some of the important elements that have been implemented in order to provide a better quality of service are: mandatory rules and procedures that are present in all processes, vehicle acquisition, i.e. "rejuvenation" of the fleet and its unification, change of organisational structure through the development of internal communication between management and the Group with the use of skills and knowledge, as well as developing awareness of the importance of quality. Quality control has become indispensable part in shaping the service, with the help of which the management measures the goals that have been set and detects possible dangers that may undermine the confidence of travellers. In bus transportation there is a great emphasis on the safety of passengers and the reliability of buses therefore it is important to establish three lines of quality control: preventive examinations in eight-week cycles, internal audit twice a year and Group audit once a year which is done by random sample method and Group audit of processes and procedures. Since these are complex processes that help to achieve maximal profit with minimal expenses, at the same time they contribute to achieving competitive advantage. For each transportation company the feedback related to the satisfaction with using the service provided is very important, which is achieved when the expectation of passenger is met and when he/she feels safe during consummation of the service. In order to achieve that, the organisation needs to be aware of the importance of passenger satisfaction and of the way it will be achieved, and it shall implement on time the key elements.

Servqual research method was chosen because it showed itself to be adequate for surveying passenger’s satisfaction and for measuring service quality in bus transport. The model is adjusted towards passenger’s needs, and as such gives a full picture in researching the needs of the passengers, and it also gives a full picture regarding the establishing future business strategy.

In bus transportation, since it deals with transportation of people, the quality of service provided represents big challenge from one side, and from the other side it represents a big problem for the reason that management is not aware of what are the factors that are important for the passenger during his/her estimation of the quality.

H1: After the acquisition in bus transportation it comes to the increase of the level of quality of service provided after certain period of time after the elements for quality management have been implemented.

H2: The gap between perception and expectations has decreased after the company has been acquired.

For proving set hypothesis, we will use primary research on the sample of passengers of the company Panturist d.d. before and after acquisition in companies Panturist d.d., Autotrans d.o.o. and Autoprometno poduzeće d.o.o. which has been done in three cycles through survey/questionnaire in the years 2013, 2018 and 2019.

The purpose is to prove that implementing adequate quality elements has influenced passenger satisfaction. The main goal of survey taken was to compare the level of satisfaction with all the segments of service before and after acquisition of the company which will be shown periodically and parallel through the surveys carried out since 2013[1] (Medic et al, 2013: 81-90; Medic et al, 2013: 273-284) on sample of Panturist's passengers before the acquisition, and later on during the merger of Panturist, APP and Autotrans companies (2017), and 2018[2], a year after the merger. (Pancic et al, 2018: 146-150)

2. IMPLEMENTATION OF ELEMENTS FOR INCREASING QUALITY OF SERVICE

Some of the important elements that are implemented for the purpose of providing better quality services in bus transportation are:

- mandatory rules and procedures that are present in all processes,
- procurement of vehicles, i.e. „rejuvenation "of the fleet and its unification,
- change of organisational structure
- developing internal communication between the management and the Group
- using current skills and knowledge
- developing awareness of the importance of quality

By implementation of these elements, raising the level of quality in different business segments is achieved, which contributes to creation of the service of good quality.

In bus transportation, high importance is put on the safety of passengers and on reliability of the buses, and therefore it is important to establish three lines of quality control:

- Preventive check-ups in eight-week cycles,
- Internal audit twice a year

[1] The survey was published in paper Quality Measuring in the International Bus Transport Aimed at Increasing Competitive Advantage and paper Quality management in the function of public transport papers and the data will be used in this paper for the purpose of comparing the survey before and after the acquisition.

[2] The survey was published in Importance of Service Quality in a Company's regional development - challenges and opportunities paper and the data will be used in this paper for the purpose of comparing the survey before and after the acquisition.

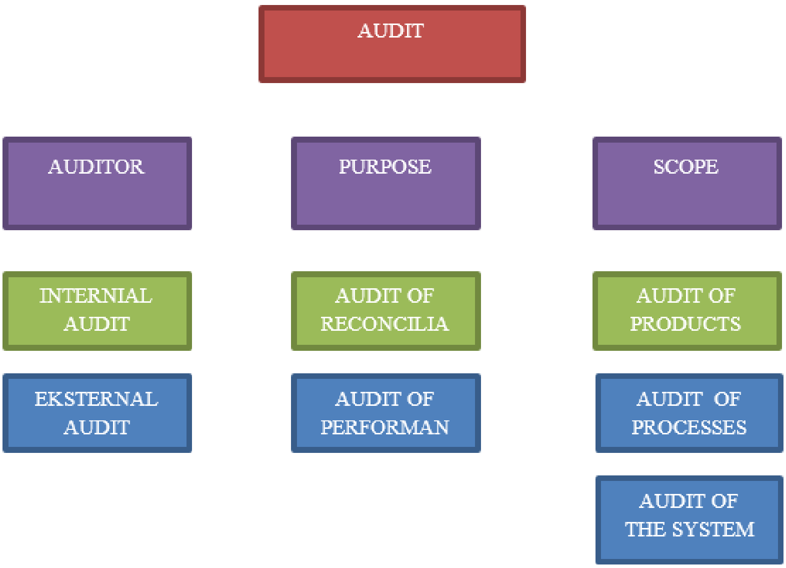
- Group audit once a year, which is done by random sample method
- Group audit of processes and procedures

Audit quality system as the element has significant importance in improving the level of quality in the organisation. Some of the goals of implementation and of continuous quality implementation are:

- determination of compliance of the management system in relation to requirements
- evaluation of the efficiency of the implemented management system
- detect non-compliance in processes
- assistance with fulfilling the requirements of the norms, i.e. rules, especially in the initial phase of implementation of quality management system
- collecting information that are necessary for evaluation of business management system from the side of the Board and Senior Management
- specific goals defined by the Board

In order for above mentioned goals to be realized, it is necessary to continuously carry out quality system audit, because otherwise the system will be inefficient, disharmonious, without clearly defined norms and goals where the employees will be demotivated for achieving the plans that influence both organisational and personal goals.

Figure 1. Audit of quality system



Source: https://vdocuments.mx/4-upravljanje-kvalitetom-55b07dab8caf1.html (Download date: 22.3.2019)

Figure 1 shows the type of audit for which previously has been explained in which time intervals it shall be conducted, as well as its purpose and scope. In order to control quality in different segments, it is necessary to conduct audit of products, processes and systems.

By implementing quality system organisation achieves added value on the market where passengers recognize image as safety, reliability, accuracy, kindness, experience in their consciousness and creation of long-term trust in the company that provides service to them. On the other hand, the employees transfer their satisfaction both inside and outside organisation, creating quality culture. All of that contributes also to creating new opportunities on domestic and foreign market.

The value of satisfying the needs id divided into several segments, of which the most important are (Ruza & Dvorski, 2000:570):

- freedom to choose the type of transport;
- social and personal contacts;
- accuracy and regularity of traffic;
- safety and protection in traffic;
- satisfactory relation between price and quality;
- reliability;
- speed

Namely, the passenger that regularly uses bus transportation service has clearly defined needs and expectations. Meeting or fulfilling previously mentioned values is what determines quality of the service.

The importance of these values, management must transfer to all segments of organisation and to all employees, because awareness of the importance of mentioned values will stimulate organisation to changes that will improve the level of quality and satisfaction with service provided.

3. METHODOLOGY OF THE RESEARCH

First research has been conducted by using a questionnaire. The questionnaire has been conducted at the end of 2013 and at the beginning of 2014 on the sample of 363 passengers in the county, intercounty and international bus transportation of the company Panturist d.d. The questionnaire is compiled according to the questionnaire for SERVQUAL measure instrument, and for the needs of this work it has been adjusted according to the needs of bus transportation. For evaluation Likert scale was used, with range 1 to 5, instead of 1-7, due to the fact that in Croatia the most common evaluation range is from 1 to 5, so as such it would be easier and more acceptable for respondents. The questionnaire consists of eight general questions, out of which four are related to demographical characteristics of employees. Besides general questions, it contains the first group of 22 questions that are related to passenger expectations and the second group of questions that are related to the passenger perception.

In the second survey conducted in 2018, there has been in total 925 respondents included. The survey among clients of the companies of Arriva Hrvatska d.o.o. Group - Autotrans d.o.o., Autoprometno poduzeće d.d. and Panturist d.d. – has been conducted in the first half of 2018. The main goal of the survey conducted was to compare the level of satisfaction with all segments of the service before and after acquisition of the companies.

The third survey among clients of Arriva Hrvatska d.o.o. Group – Autotrans d.o.o., Autoprometno poduzeće d.d. i Panturist d.d. – was conducted at the beginning of 2019, also by using pen-and-paper method – the passengers have been give the questionnaire that they have been filling during their journey or after it, with remark that their answers relate to the current bus operator. In this case, as well as in 2018 it was a random sample. Besides the fact that here as well the goal was to determine the level of satisfaction with all segments of the services provided by Arriva Hrvatska Group by using SERVQUAL model, this questionnaire has served as an estimation of eventual changes created after certain time after acquisitions have been made, i.e. after affiliation of APP and Autotrans to Arriva Group. The instrument that was used for testing so called SERVQUAL model was completely identical to the one from the last year. The sample consisted of 451 respondents; although in the survey there have been 460 respondents included, but some of them, after later check, were excluded due to inconsistency of their answers or because of large number of unanswered questions.

3.1. Socio-demographic structure and results of the survey

During the 2013/2014 survey, the largest part of the examinees was of age 14-18 (28.8%). Group between age 18-30 was almost the same (28,4%). It was followed by group 50 years and older (22,4%). Second to last group consisted of examinees age between 30-50 years (18,4%), and the smallest group was the one with examinees up to age of 14 (18,9%).

In the survey conducted 2018 a bit more than one third of the examinees was between the age of 18-30 (34%), and the rest of the age groups were around 25% - people of age 30-50 years old constituted 26,1% of the survey, people up to age of 18 constituted 21,1% of the survey, and the examinees who were over 50 years old constituted around 18.9% of the survey. Employed and/or self-employed people (44,6%) and pupils and students (39,6%) were the most numerous groups of users. They are followed by retired people (almost 10% of the examinees, i.e. 9.6%), and unemployed people (6.2%). This examinees structure reflects the real structure of groupation's service users, i.e. it's clear from the analysis that pupils/students and employed people consist of around 85% of the bus service users. When it comes to the sex, 60,8% of the examinees were female and 39,2% were male. Females make the majority in all age groups, and it's most noticeable in the oldest age group - people older than 50 years (where they make 66.1% of the examinees), and the smallest difference is in the youngest age group - examinees up to 18 years old where they make 57,1% of the examinees. As expected, examinee's age determines the parts in married and working statuses. Last socially-demographic question was regarding the marital status. Unmarried people hold the largest share (43,1%), followed by married people (36,9%), and after that all possible categories of singles, including the widowers/dowagers (20.1%) follow. It should be noted that this is due to the fact that there is a large number of young people.

Regarding the socially-demographic characteristics, some basic indicators such as age, sex, work and marital status were surveyed. First as a sample quality control, and then as a criterion for further testing. Two groups dominated regarding their work status: pupils and students (49,5%) and employed/self-employed people (33,9%). They are followed by retired people (8.9%), and unemployed people are next (7.7%). Same as in last year's survey, two most numerous groups make almost 85% of all of the examinees which is in accordance with the informations the groupation possess. Regarding the works status, it's expected that the young people dominate the survey, but people of age between 18-30 (41,6%) are the most numerous group. There are pupils and students in that group, but employed people also. Next one are people up to 18 years old (22.7%), then 30-50 years old (19.9%), and the least there are people older than age of 50 (15,8%). From this we can conclude that people up to age of 30 always make more than half of examinees because their percentage in the last survey was close to 60%, and it's almost 65% in this survey. Same as in previous surveys, according to the Graph 1 there were more female examinees, even slightly more than the last time - last time the ratio was 60.8% versus 39.2% in favour of females, but this year the ratio is even more dominant - 69% versus 31% in favour of females. This is also in accordance with the groupations current data. Last socially-demographic question was regarding the marital status. In accordance with the Graph 25 most numerous were unmarried people (50.7%), followed by all possible singles categories, including widowers/dowagers 25,2%). They are followed by married people 24,1%). Still, it should be noted that this is the result of the fact that there are a lot of young people.

In the further text, the results of the survey by stages will be shown, as well as their comparison before and after acquisition, and after certain period after acquisition of the companies has been made.

3.1.1. Comparison of the results 2014/2018

Table 1 shows comparison of research of satisfaction with the service in the set related to passenger expectations (2014 and 2018 Year).

Table 1. Statements in the SERVQUAL set "Expectations – ratios of response in percentages (%)"

	The arithmetic mean of the research results from 2014.	The arithmetic mean of the research results from 2018.	Difference
1. The buses we are driving in should have a clearly displayed company logo and be visible to passengers	4,28	4,40	0,12
2. The staff in the bus should be neat, clean and consistent with the company's dress code.	4,62	4,60	-0,02
3. Buses should have all necessary inventory so the passengers could have as interesting travel as possible (WC, Internet, TV and similar.)	4,34	4,35	0,01

4. The cleanliness of the bus should be on high level	4,58	4,68	0,1
5. Timetables should be regular and in accordance with regulations.	4,69	4,74	0,05
6. Timetables should be completely accurate so the passengers could come to the destination in time.	4,62	4,66	0,04
7. Driving personnel should always and frequently provide all relevant information so that passengers can be informed promptly.	4,62	4,54	-0,08
8. Driving personnel should provide passengers with all information at purchasing the tickets (price, timetables and other relevant information)	4,6	4,48	-0,12
9. Driving personnel should be ready to help anytime to the passengers with any type of problem they face.	4,5	4,35	-0,15
10. Bus companies should inform passengers in time of all changes and events related to public bus transportation.	4,66	4,57	-0,09
11. Driving personnel should assist passengers during loading and unloading of luggage on a daily basis.	4,42	4,38	-0,04
12. Driving personnel should quickly adjust to different type of passengers.	4,27	4,02	-0,25
13. Bus drivers should drive in a way that provides safety to the passengers.	4,66	4,66	0
14. Passengers should be able to rely on the driving staff.	4,62	4,67	0,05
15. Staff should answer professionally to the posed questions.	4,34	4,41	0,07
16. All employees of bus companies should be at equally high level of courtesy.	4,74	4,59	-0,15
17. Passengers should feel safe in the bus.	4,32	4,77	0,45
18. Driving personnel should show understanding for the passengers.	4,66	4,44	-0,22
19. Driving personnel should understand the real needs of passengers.	4,56	4,20	-0,36
20. Ticket sales should be accessible.	4,68	4,63	-0,05

21. Time of ticket sales should be adjusted to the passengers as much as possible.	4,47	4,48	0,01
22. There should exist the possibility of ticket purchase in the bus.	4,51	4,52	0,01
Total	**99,76**	**99,14**	**-0,62**

Source: Authors

According to the results from Table 1 passenger expectations in bus transportation have been higher in 2014 in comparison to 2018. In 2018 compared to 2014 the passengers expect higher level of security in driving, while they have decreased their expectations in the area of understanding their actual needs, understanding and adjustment.

In the next part, the table 2 with comparison of research of satisfaction with service in the set related to passenger perception will be shown from 2014 and 2018 Year.

Table 2. Claims in SERVQUAL set „Perception – ratios of response in percentages (%)"

	The arithmetic mean of the research results from 2014.	The arithmetic mean of the research results from 2018.	Difference
1. Panturist buses have clearly displayed logo	3,91	4,33	0,42
2. The staff in Panturist bus is always neat, clean and consistent with the company's *dress code*..	4,37	4,44	0,07
3. Panturist buses have all necessary inventory so the passengers could have as interesting travel as possible (WC, Internet, TV and similar.)	3,36	3,43	0,07
4. The cleanliness of the Panturist buses is on high level	3,88	4,02	0,14
5. Panturist timetables are regular and in accordance with regulations.	3,99	4,04	0,05
6. Timetables of Panturist buses are completely accurate so the passengers could come to the destination in time.	3,97	4,06	0,09
7. Driving personnel in Panturist buses always and frequently provides all relevant information so	4,18	4,25	0,07

that passengers can be informed promptly.			
8. Driving personnel in Panturist buses provides passengers with all information at purchasing the tickets (price, timetables and other relevant information)	4,22	4,3	0,08
9. Driving personnel is ready to help anytime to the passengers with any type of problem they face.	4,06	4,29	0,23
10. Panturist informs passengers in time of all changes and events related to public bus transportation.	3,83	3,93	0,1
11. Driving personnel in Panturist assists passengers during loading and unloading of luggage on a daily basis.	4,1	4,46	0,36
12. Personnel in Panturist quickly adjusts to different type of passengers.	3,91	4,18	0,27
13. Bus drivers in Panturist buses drive in a way that provides safety to the passengers.	4,16	4,43	0,27
14. Passengers are always able to rely on the driving staff.	4,16	4,41	0,25
15. Staff in Panturist answers professionally to the posed questions.	3,98	4,28	0,3
16. All employees of Panturist that I have been in contact with are at equally high level of courtesy.	4,23	4,14	-0,09
17. Passengers feel safe in Panturist buses.	3,81	4,45	0,64
18. Driving personnel is showing understanding for the passengers.	3,44	4,46	1,02
19. Personnel in Panturist understands the real needs of passengers.	3,94	4,24	0,3
20. Ticket sales in Panturist buses is accessible.	3,85	4,4	0,55
21. Time of ticket sales is adjusted to the passengers.	3,86	4,29	0,43
22. There exists the possibility of ticket purchase in the bus.	4,02	4,51	0,49
Total	**87,23**	**93,34**	**6,11**

Source: Authors

According to the results from the Table 2, perception of passengers in bus transportation has improved in comparison to 2014. In each segment it came to higher level of satisfaction, except in the segment of affability of the staff, which was described by „All employees of Panturist that I have been in contact with are at equally high level of courtesy “. It is visible that the passengers are more satisfied after acquisition of the companies, and the level on which the company should work on is education of employees on relationship with clients.

3.1.2. Comparison of the results 2018/2019

In order to test the differences between the survey from 2018 and survey from 2019, in the following table arithmetic means for all statements and given dimensions are compared in Table 3.

Table 3. Statements and dimensions of SERVQUAL set „Expectations“ (Comparison of the researches from 2018 and 2019) – Arithmetic means

	Arithmetic mean 2018	Arithmetic mean 2019
TANGIBLE ELEMENTS (MATERIAL CONDITIONS)		
1. The buses we are driving in should have a clearly displayed company logo and be visible to passengers	4,40	4,56
2. The staff in the bus should be neat, clean and consistent with the company's dress code.	4,60	4,71
3. Buses should have all necessary inventory so the passengers could have as interesting travel as possible (WC, Internet, TV and similar.)	4,35	4,51
4. The cleanliness of the bus should be on high level.	4,68	4,73
Average dimension value	*4,51*	*4,63*
RELIABILITY		
5. Timetables should be regular and in accordance with regulations.	4,74	4,83
6. Timetables should be completely accurate so the passengers could come to the destination in time.	4,66	4,72
7. Driving personnel should always and frequently provide all relevant information so that passengers can be informed promptly.	4,54	4,62
8. Driving personnel should provide passengers with all information at	4,48	4,54

purchasing the tickets (price, timetables and other relevant information)		
Average dimension value	*4,61*	*4,68*
AFFABILITY		
9. Driving personnel should be ready to help anytime to the passengers with any type of problem they face.	4,35	4,36
10. Bus companies should inform passengers in time of all changes and events related to public bus transportation.	4,57	4,67
11. Driving personnel should assist passengers during loading and unloading of luggage on a daily basis.	4,38	4,40
12. Driving personnel should quickly adjust to different type of passengers.	4,02	3,90
Average dimension value	*4,33*	*4,33*
COMPETENCE AND PASSENGER TRUST		
13. Bus drivers should drive in a way that provides safety to the passengers.	4,66	4,67
14. Passengers should be able to rely on the driving staff.	4,67	4,69
15. Staff should answer professionally to the posed questions.	4,41	4,42
16. All employees of bus companies should be at equally high level of courtesy.	4,59	4,61
17. Passengers should feel safe in the bus.	4,77	4,82
Average dimension value	*4,62*	*4,64*
ADJUSTMENT TO PASSENGERS		
18. Driving personnel should show understanding for the passengers.	4,44	4,44
19. Driving personnel should understand the real needs of passengers.	4,20	4,21
20. Ticket sales should be accessible.	4,63	4,74
21. Time of ticket sales should be adjusted to the passengers as much as possible.	4,48	4,55
22. There should exist the possibility of ticket purchase in the bus.	4,52	4,59
Average dimension value	*4,45*	*4,51*

Source: Authors

Although it seems that, when looking generally the Table 3, there are no special differences, at totally 7 variables, statistically significant differences are determined (p=0,05). In all these cases it has been determined that the expectations have even risen, except at variable “Driving personnel should quickly adjust to different type of passengers”, where the expectation has even somewhat decreased. When looking at the numbers, the biggest difference between arithmetical means has been noticed at two variables: “ The buses we are driving in should have a clearly displayed company logo and be visible to passengers“ and „Buses should have all necessary inventory so the passengers could have as interesting travel as possible (WC, Internet, TV and similar.)“, and if we are looking the dimensions, it is visible that this difference appeared at almost all variables that were measuring the dimension „Tangible elements“, i.e. in 3 out of totally 4 cases. On the other side, not one variable mentioned in this table has been part of the dimension „Competence and passenger trust “.

It is visible in table 3 that the average dimension value in the set „Expectations“ increased in 2019 in comparison with 2018.

Table 4. Statements of SERVQUAL set „Expectations“at which statistically significant differences between results from 2018 and 2019 have been determined ($p<0,05$)

	Arithmetic mean 2018	Arithmetic mean 2019	value
1. The buses we are driving in should have a clearly displayed company logo and be visible to passengers	4,40	4,56	11,612
2. The staff in the bus should be neat, clean and consistent with the company's dress code.	4,60	4,71	22,721
3. Buses should have all necessary inventory so the passengers could have as interesting travel as possible (WC, Internet, TV and similar.)	4,35	4,51	13,179
5. Timetables should be regular and in accordance with regulations.	4,74	4,83	26,351
10. Bus companies should inform passengers in time of all changes and events related to public bus transportation.	4,57	4,67	16,881
12. Driving personnel should quickly adjust to different type of passengers.	4,02	3,90	4,358
20. Ticket sales should be accessible.	4,63	4,74	22,797

Source: Authors

Regarding the dimensions, it can be said that in the Table 4 very significant and clear difference between passenger expectations in relation to the first dimension "tangible elements" has been determined. Namely, while in 2018 the arithmetic mean of all variables included in that dimension amounted 4,51, in repeated survey in 2019 that value amounted to 4,63. Out of that it can be concluded that the clients have increased their expectations in relation to this dimension, i.e. that their expectations are growing and that they are expecting higher standard in relation to this. At the other dimensions, there were no significant changes noted, i.e. the expectations have remained on approximately same level.

Table 5. Average values of SERVQUAL dimensions „Expectations“– researches from 2018 and 2019 (p<0,05)

AVERAGE DIMENSION VALUES	Arithmetic mean 2018	Arithmetic mean 2019
TANGIBLE ELEMENTS (MATERIAL CONDITIONS)	4,51	4,63
RELIABILITY	4,61	4,68
AFFABILITY	4,33	4,33
COMPETENCE AND PASSENGER TRUST	4,62	4,64
ADJUSTMENT TO PASSENGERS	4,45	4,51

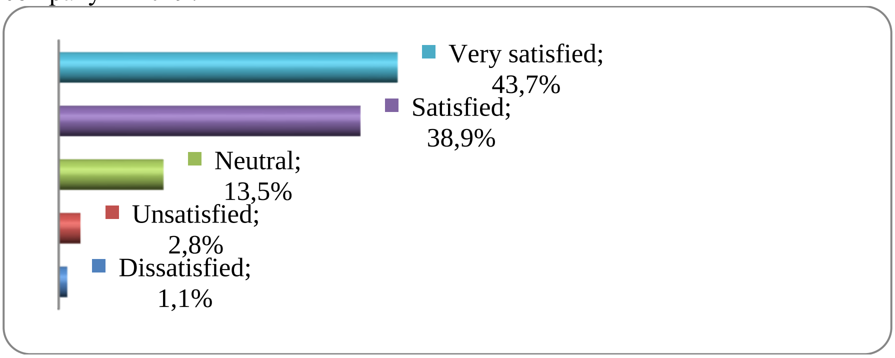
Source: Authors

In Table 5 it is visible, according to average arithmetic mean values, that the expectations in 2019 are higher in comparison to 2018.

According to the Table 5, the largest gap is when it comes to palpable elements of the service, meaning that the passengers have increasing demands regarding the journey experience. They want more content in the buses during their journeys which would make them unique. One of the elements is younger vehicle fleet which will have richer journey content, they also want to "freshen up" the logo and dress code in accordance with the seasonal offers.

The next question in questionnaire was „How satisfied are you by service provided by this bus transportation company?“, on which respondents could have answered by note in the range from 1 to 5 and by that to express their total satisfaction by transportation company by which the survey was taken. Looking in total, again over 80% respondents have declared that they are satisfied by service – out of which 38,9% are generally satisfied, and even more of them, 43,7%, are very satisfied. Those that are completely dissatisfied represent about 4%, and not satisfied nor dissatisfied 13,5%.

Graph 1. „How satisfied are you by service provided by this bus transportation company in 2019? “



Source: Authors

If we compare these results from 2019 with the ones from the previous 2018, they are almost identical, and very similar situation is when we look at the central tendency measures: in last year's survey, arithmetic mean of this variable amounted to 4,15, median 4,00, and standard deviation amounted to 0,909. According to this year's results, arithmetic mean is now somewhat higher – 4,21, median also amounts to 4,00, and standard deviation 0,862.

Table 6. Statements and dimensions of SERVQUAL set „Perception"(comparison of researches from 2018 and 2019) – arithmetic means

	Arithmetic mean 2018	Arithmetic mean 2019
TANGIBLE ELEMENTS (MATERIAL CONDITIONS)		
1. Buses of this transportation company have clearly displayed logo	4,33	4,56
2. The staff in this transportation company's bus is always neat, clean and consistent with the company's *dress code*..	4,44	4,58
3. Buses of this transportation company have all necessary inventory so the passengers could have as interesting travel as possible (WC, Internet, TV and similar.)	3,43	3,25
4. The cleanliness of the buses of this transportation company is on high level	4,02	4,00
Average dimension value	***4,06***	***4,10***
RELIABILITY		
5. Timetables of this transportation company are regular and in accordance with regulations.	4,04	4,24
6. Timetables of this company's buses are completely accurate so the passengers could come to the destination in time.	4,06	4,17
7. Driving personnel in buses of this transportation company always and frequently provides all relevant information so that passengers can be informed promptly.	4,25	4,32
8. Driving personnel in buses of this transportation company provides passengers with all information at purchasing the tickets (price, timetables and other relevant information)	4,30	4,34
Average dimension value	***4,16***	***4,27***
AFFABILITY		
9. Driving personnel is ready to help anytime to the passengers with any type of problem they face.	4,29	4,35

10. This transportation company informs passengers in time of all changes and events related to public bus transportation.	3,93	4,10
11. Driving personnel in this transportation company assists passengers during loading and unloading of luggage on a daily basis.	4,46	4,57
12. Personnel in this transportation company quickly adjusts to different type of passengers.	4,18	4,20
Average dimension value	***4,22***	***4,31***
COMPETENCE AND PASSENGER TRUST		
13. Bus drivers in buses of this company drive in a way that provides safety to the passengers.	4,43	4,50
14. Passengers are always able to rely on the driving staff.	4,41	4,48
15. Staff in this company answers professionally to the posed questions.	4,28	4,33
16. All employees of this company that I have been in contact with are at equally high level of courtesy.	4,14	4,14
17. Passengers feel safe in this company's buses.	4,45	4,47
Average dimension value	***4,34***	***4,38***
ADJUSTMENT TO PASSENGERS		
18. Driving personnel of this bus is showing understanding for the passengers.	4,46	4,54
19. Personnel of this transportation company understands the real needs of passengers.	4,24	4,28
20. Ticket sales in the buses of this transportation company is accessible.	4,40	4,48
21. Time of ticket sales is adjusted to the passengers.	4,29	4,33
22. There exists the possibility of ticket purchase in the bus.	4,51	4,57
Average dimension value	***4,38***	***4,44***

$p<0,05$
Source: Authors

As it can be seen, significant differences appeared at 7 variables. The same as at the part of questionnaire that measures “Expectations”, here also it is primarily about variables that measure “Tangible elements”, i.e. material conditions, equipment and similar.

In all variables shown below, it is about higher arithmetic means, and with that also the higher perception (in this case higher satisfaction) of certain services, except the statement “Panturist buses have all necessary inventory so the passengers could have as interesting travel as possible (WC, internet, TV and similar.)" where the arithmetic mean is statistically significantly lower, which brings to the conclusion that the satisfaction in this case has been decreased.

Table 7. Statements of SERVQUAL set Perception at which statistically significant differences between the results from 2018 and 2018 have been determined (p<0,05)

	Arithmetic mean 2018	Arithmetic mean 2019	F value
1. Buses of this transportation company have clearly displayed logo	4,33	4,56	31,795
2. The staff in this transportation company’s bus is always neat, clean and consistent with the company's *dress code…*	4,44	4,58	15,110
3. Buses of this transportation company have all necessary inventory so the passengers could have as interesting travel as possible (WC, Internet, TV and similar.)	3,43	3,25	7,440
5 Timetables of this transportation company are regular and in accordance with regulations…	4,04	4,24	1,152
6. Timetables of this company’s buses are completely accurate so the passengers could come to the destination in time.	4,06	4,17	0,126
10. This transportation company informs passengers in time of all changes and events related to public bus transportation.	3,93	4,10	3,142
11. Driving personnel in this transportation company assists passengers during loading and unloading of luggage.	4,46	4,57	10,690

Source: Authors

According to the Table 7 in which mentioned statements are linked to “Expectations” and if it is compared about which variables it is about, it is visible that it is generally about the same variables for which therefore we can say that the expectation has increased, but also the perception.

It can be concluded that in regard of some things the market, i.e. the users, has become more demanding, i.e. that higher and higher level of service is expected.

Regarding the comparison of dimensions, in comparison with the last year's research, higher results – expressed as arithmetic means – are noticeable at all dimensions, but significant differences are noticeable only in the case of two dimensions "Reliability" and "Affability". Although, when looking in total, it can be said that the clients have expressed somewhat higher satisfaction in this research in comparison with the research from 2018.

Table 8. Average values of SERVQUAL dimensions „Perception“– researches from 2018 and 2019 (p<0,05)

AVERAGE DIMENSION VALUES	Arithmetic mean 2018	Arithmetic mean 2019
TANGIBLE ELEMENTS (MATERIAL CONDITIONS)	4,06	4,10
RELIABILITY	4,16	4,27
AFFABILITY	4,22	4,31
COMPETENCE AND PASSENGER TRUST	4,34	4,38
ADJUSTMENT TO PASSENGERS	4,38	4,44

Source: Authors

What is the key element in this model is that it takes into consideration that tho the clients not all characteristics of service provided are of the same importance, i. e. For some elements they do not have big expectations, nor they think that some of the characteristic of the service should be "perfect" or of extremely good quality, and it is possible that the clients some of the moments of the service simply do not consider necessary (for instance it is possible that for the high number of clients, instant arrival of the salesmen in some shop with the question "Can I help you?" or "Are you looking for something special?" it is simply not necessary. Although, in practice and in literature reviewed, such situations rarely happen and usually the expectations are generally higher than the perception of current state.

4. CONCLUSION

For the organisation it is of extreme importance to implement the quality standards because they are bringing products/services at the higher level, and by that they create trust from the side of the clients. The higher level the quality of service exists, the cost significantly decreases for the organisation, because the clients are satisfied and there are no reclamations, complaints and eventual legal cases. The more clients' satisfaction is spread, the more frequent use of the service is, and the revenues of the organisation increase. Managing business processes is conditioned by understanding of all parts, but also of the people that manage these processes or conduct them.

Besides tangible elements that are important for raising the quality of the service, many transportation companies do not attach great importance to the elements such as kindness, taking care of loyalty, culture and similar, exactly for the reason they are invisible and for that reason they are considered irrelevant, which as the result contributes to the bad positioning on the market and creating favourable climate for those transportation companies that have understood and that are taking corrective actions and are working each day on improving the quality of the service provided. The results of the research show that the passengers are more satisfied by service provided after the acquisition, although they are showing that it shall be worked on intangible elements of the service. The results are supporting the fact that the company has improved its service by implementing the key elements that influenced the level of the service, and finally on the satisfaction of passengers. Further research in 2019 show that the expectations of passengers increased in comparison to the previous year and it supports the fact that of extreme importance is to continuously work on improving quality of the service. Research also shows that the passenger satisfaction increased in comparison to the previous year 2018, which is the result of investing in human resources, business processes and procedures, as well as in tangible elements of the service. According to that, hypotheses set confirm that after the acquisition in bus transportation it comes to increase of the quality of the service and that the gap between perception and expectations has decreased.

The largest gap is shown in palpable elements when comparing surveys of average values of all dimensions in 2019 compared to 2018. This information indicates that there is still open issue when it comes to the development strategy of investing into these elements, as well as additional passengers surveys what is the most important thing to them when it comes to investing in order to come closer to passenger's real desires and needs. Further surveys should be based on getting to know passengers needs and creating development strategy of these dimensions. New passenger survey on transport service satisfaction is recommended after increasing the service quality, with special focus on elements where the largest gap was during the last survey.

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RELATIONSHIP BETWEEN SIZE AND PROFITABILITY OF POLISH TRANSPORTATION COMPANIES

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Abstract

There is an ongoing debate in the literature on the relationship between the size of the firm and the profitability. Some researchers postulate that relationship is positive, which stems primarily form the economies of scale. Other researchers claim the opposite, i.e. the analysed relationship is negative which results form, inter alia, bureaucratization, which is typical for larger firms. Given the relationships between the size and the profitability of the firms might differ among various industries and regions and due to inconsistencies of results presented in the literature by other researches, in this study only one industry in one region is being analysed. The aim of this paper is to study the relationship between the size and the profitability of 3.000 road transportation companies registered in Poland in period 2013 – 2017. Poland has been selected for the study, because Polish road transportation fleet is the largest in European Union. This paper uses moving quartiles, Spearman rho and Kendall tau-b coefficients to analyse studied relationships. The results of this study indicate statistically significant and negative relationship between the size and the profitability of road transportation companies. Identified negative relationship is strong if the size is measured with total of assets, and weaker, but yet statistically significant if the size is measured with sales. This finding is of particular value for decision makers. The main limitations of this study are: analysed period, which comprise only the time of economic growth; and the region, as we analyse only road transportation companies registered in Poland. These both limitations are a good indication for further research, which ones carried out could allow for global conclusions regarding road transportation industry.

Key words: road transportation, size, profitability, performance

1. INTRODUCTION

Both size and profitability of companies have been since long subjects of many studies. This is primarily because nearly all companies are interested in profitability and growth or size. The majority of papers study independently either the size or the growth (Baum et al., 2001; Massey et al., 2006; Masurel & Montfort, 2006; Mazzucato & Parris, 2015; Megaravalli & Sampagnaro, 2019) or the profitability of companies (McGahan & Porter, 2002; Bowman & Helfat, 2001; Abu-Tapanjeh, 2006; Yoo & Kim, 2015) along with their determinants. Despite significant number of papers on either the size or the profitability of companies, insufficient attention has been paid to the mutual relation between the size and the profitability of companies (Singla, 2011; Nunes et al., 2009; Tyagi & Nauriyal, 2017). Furthermore, the results on mutual relationship between the size and the profitability of companies are frequently at contradictory or least inconsistent. Several scholars postulate the relationship between the size and the profitability of the firm is negative (Dhawan, 2001; Goddard et al., 2005), whereas other scholars claim the opposite (Nunes et al., 2009; Tyagi & Nauriyal, 2017), i.e. that the relationship between the size and the profitability of the firm is positive. These inconsistencies presented by various scholars, might result from underlying differences among various industries, countries or time horizons analysed. Hence, aforementioned inconsistencies call for further investigation of this domain, especially regarding specific industries, countries and periods, as at this stage, yet it is too early to arrive to general, holistic conclusions. Therefore, the objective of this paper, is to study only one industry in one country. The road transportation industry, has been selected for the study, because it plays a significant role in any economy in each country and because it has been insufficiently studied. According to the best knowledge of authors, there is no paper published on the relationship between the size and the profitability of transportation companies. The choice of Poland stems from the fact that road transportation companies registered in Poland deliver around 25% of all road carriages within EU, hence, selected companies, are significant, not only from Poland, but also from European perspective (PWC, 2016). It should be noted that the term road transportation companies registered in Poland is more adequate than the term Polish road transportation companies, since the shareholders of many studied companies are not the citizens of Poland but multinational companies, like DHL, Raben, GLS and others, while the companies registered in Poland are operating as their branches.

Given inconsistencies of research results presented in the literature for different industries, the objective of this paper is to study the relationship between the size and the profitability of transportation companies registered in Poland. The reminder of the paper is organized as follows: in section 2 the literature is being reviewed and the key findings obtained by other researchers are presented; in section 3 the research methodology and its different components like research design, data sources, sample of observations and selection of variables used in the study are disclosed. In section 4 the results of the study are being presented. The last section, of this study comprise discussion, conclusions, managerial implications, limitations of the study and indication of directions for future research.

2. LITERATURE REVIEW

The literature on various factors affecting profitability of companies is vast. In general, studied in the literature, determinants of profitability can be divided into: internal, which stem from various means of management and from the company itself (McGahan & Porter, 1997; Goddard et al., 2005) and external resulting from environment, including, inter alia, changes of gross domestic product, customer behaviours or competitors (Bowman & Helfat, 2001; McGahan & Porter, 2002 Korneta, 2018). Among most frequently studied internal profitability determinants are: age of the firm (Das, 1995; Dahlstrand & Stevenson, 2010), its indebtedness (Jordan et al., 1998; Hall et al., 2000), efficiency (Jovanovic, 1982; Yazdanfar, 2013), working capital management (Bagchi et al., 2012; Al-Debi'e, 2011), spending on research and development (Tyagi & Nauriyal, 2017), the structure of shareholders (Abu-Tapanjeh, 2006) and others, including the size. Size is one of internal determinants of profitability, which depends on the company itself. Despite intuitively positive relationship between firm size and profitability, there is an ongoing debate in the literature on its nature. Significant number of scholars claim relationship between the firm size and the profitability is positive. This is primarily because of advantages, which larger companies have over smaller ones. These advantages, inter alia, include: possibility to exploit economies of scale and scope, possession of more resources, formalized and more efficient procedures, higher spending on research, development and advertising, hence larger companies should outperform smaller ones in many areas, including profitability (Penrose, 1959; Hall & Weiss, 1967; Nunes et al., 2009; Tyagi & Nauriyal, 2017).

Simultaneously, a number of other scholars postulate the opposite, i.e. the relationship between the size and the profitability of the firm is negative. This is mostly because larger companies are subject to higher bureaucratization (Ahuja & Majumdar, 1998), have higher costs than they need to be (Leibenstein, 1976) and require more coordination from management, which makes managerial tasks difficult (Downs, 1967) and so profits of larger companies are lower (Pi & Timme, 1993; Dhawan; 2001; Goddard et al., 2005).

Inconsistent results presented by various scholars might stem from underlying differences between countries, time periods or industries studied, but not only. These differences might result also form methodology employed by various researchers. Size of the firm is usually measured with total of sales, total of assets or the number of employees (Anton, 2018; Tyagi & Nauriyal, 2017; Yazdanfar, 2013). The use of different proxies of size might imply different results. Kartikasari Dwi and Merianti Marisa (2016) found that the size measured with total of assets has a negative impact on manufacturing Indonesian companies, whereas size measured with sales has a positive impact on these companies.

3. METHODOLODY

The data used in this study is from Emerging Markets Information Service (EMIS) database. In particular, 8.723 observations relating to 3.000 Polish transportation companies, covering a 5-years period between 2013 and 2017, were obtained. All the observations come from financial statements of studied companies disclosed in EMIS database. Since the data relating to each of the 5 contemplated periods of all 3.000 companies has not been available in stated database (potential 15.000), the number of observations is reduced and amounts to 8.723. In this study quantities obtained from financial statements are being used. Such approach has already been done with success by many researches and decision makers. The reasons, to employ quantities calculated on figures from financial statements, among others, comprise: estimation of bankruptcy predictors (Altman, 1968), evaluation of performance of the companies (Kumar & Ravi, 2007; Xiping, 2014; Korneta, 2018), critical success factors identification (Korneta, 2019), and to design performance management systems (Korneta & Krzyszkowski, 2018).

Table 1 contains variables used in this study together with their acronyms and the details of calculations. The profitability of companies is most frequently measured, in the literature, with return on equity (ROE), return on assets (ROA) and return on sales (ROS) ratios (Lam & Lee, 2012; Baah-Acquah et al., 2017; Tyagi & Nauriyal 2017). In this study ROE as a proxy for the profitability of studied companies is being used, as this ratio is the closest to shareholders wealth. ROE is therefore, a dependent variable in this study.

In the extant literature, size of the companies is usually measured with total of sales, total of assets or the number of employees, scaled by the natural logarithm (Anton, 2018; Tyagi & Nauriyal, 2017; Yazdanfar, 2013). In this study total of sales and total of assets are being used as proxies of size of studied companies. These variables are considered independent in the study.

Table 1. Variables used in the study

Variable	Acronym	Description
Profitability	ROE	Ratio of net result to equity
Size 1	SIZES	Natural logarithm of yearly sales revenue in PLN million
Size 2	SIZETA	Natural logarithm of total of assets in PLN million

Source: own elaboration

Once, the variables has been selected to the study, descriptive statistics of each variable are being analysed. In the next step of the research, normal distribution of employed variables is being verified. This verification is due to the fact that the majority of test of significance assumes normality of both tested variables to be met or at least approximately met. Normality assumption is being verified with the use of Doornik-Hansen, Shapiro-Wilk, Lilliefors, Jarque-Bera tests. All of these statistical test have the same null hypothesis, claiming the data are normally distributed (Siddiqi, 2014).

Next, contemplated relationships between studied variables are being visualized on graphs. Visualization of the considered relationships have been achieved through the use of moving medians. This approach is to determine if the relations differ between considered variables in different ranges (Arce, 2005). Median values of both variables in a moving window containing data of 200 observations are being calculated. Similarly, the moving first and third quartiles to quantify the distribution of data around the median are being calculated. Once the relations have been identified the Spearman rho and the Kendall tau-b coefficients are being calculated. Both of these statistics are non-parametric rank correlation measures, used to measure the ordinal associations between two studied quantities (Bonett & Wright, 2000; Corder & Foreman, 2014).

4. RESULTS

Table 2 contains a descriptive statistic of variables used in the study. The mean value of ROE, in a period between 2013 and 2017, of studied Polish transportation companies amounted to 0,29. A wide range of variations among ROE variables must be noted, as indicated by their standard deviations, minimum and maximum values. The mean value of SIZES variable of 3,02 indicates that mean sales revenue of studied companies is PLN 20,5 million (around EUR 4,8 million), whereas the highest yearly sales revenue (SIZES=8,77) amounted to PLN 6,4 billion (around EUR 1,5 billion). The use of natural logarithms allows to present on one graph, all of these observations together. The mean value of SIZETA variable of 2,31 indicates that mean total of assets value of studied companies is PLN 10,1 million (around EUR 2,4 million), whereas the highest total of assets (SIZETA=10,89) totalled PLN 53,6 billion (around EUR 12,8 billion).

Table 2. Descriptive statistics of 3.000 Polish road transportation companies in the period 2013-2017

Variable	Mean	SD	Median	Min	Max	Skewness	Kurtosis
ROE	0,29	8,37	0,18	-122	743	79,45	7118,57
SIZES	3,02	1,15	2,81	0	8,77	0,98	1,88
SIZETA	2,31	1,35	2,01	0,01	10,89	1,35	2,81

Source: Author's compilation based on 8.723 observations, from EMIS Database, 2019

Table 3 provides results of 4 different normality tests. Since none of the variables have p-value greater than 0.05, the null hypothesis, stating the data are normally distributed, must be rejected. Based on aforementioned results, the decision is made that Speraman's Coefficient of Rank Correlation and Kendall Tau-B are the most appropriate choice for further research.

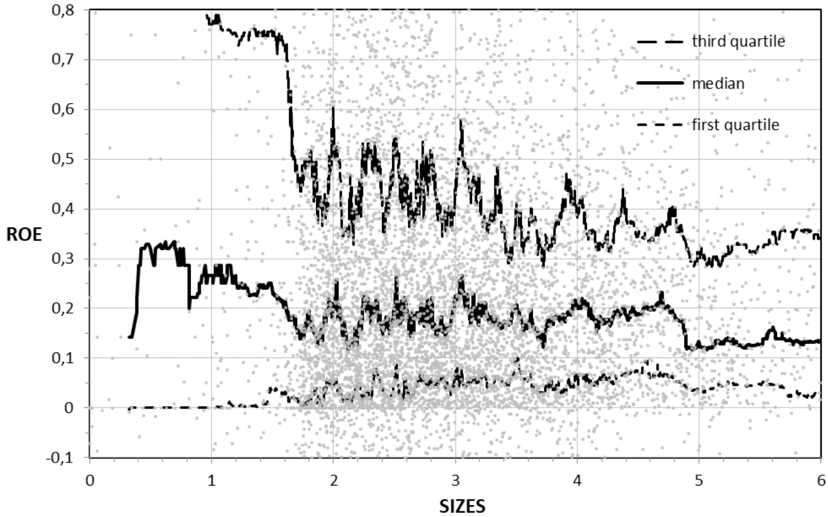
Table 3. Tests of normal distribution

Test /variable	**Doornik-Hansen**	**Shapiro-Wilk**	**Lilliefors**	**Jarque-Bera**
ROE	2,9688e+08	0,0262	0,4269	1,8425e+10
P	<0,0001	<0,0001	<0,0001	<0,0001
SIZES	1267,37	0,9442	0,0772	2703,82
p	<0,0001	<0,0001	<0,0001	<0,0001
SIZETA	2957,38	0,911255	0,091926	5535,86
p	<0,0001	<0,0001	<0,0001	<0,0001

Source: Author's compilation based on 8.723 observations, from EMIS Database, 2019

In Figure 1 the original data were plotted and using the methods provided in methodology section the moving medians, the first and the third quartiles were obtained. It is apparent that the moving median and third quartile are declining with the growth of sales (SIZES variable). Although the declining tendency is the sharpest for lower SIZES values, up to 1,8, it should be noted that the majority of observations has a value above stated threshold. In the range over 1,8 (SIZE variable) the negative tendency, although yet visible, is week.

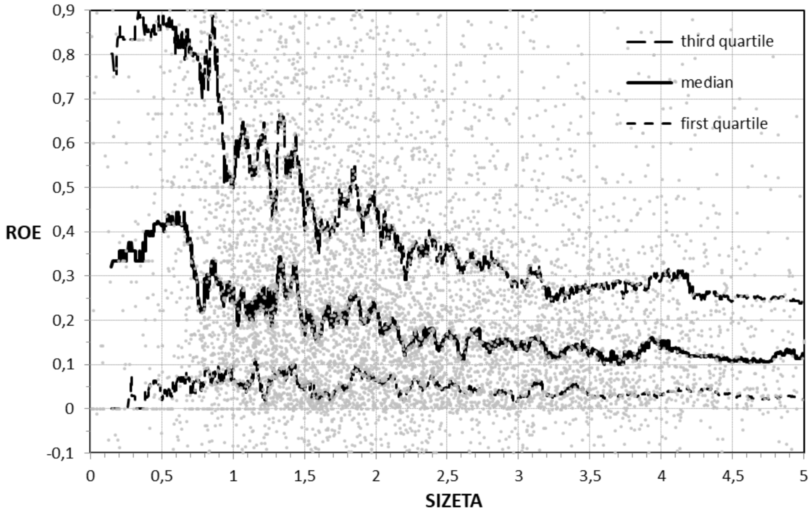
Figure 1. The relationship between SIZES and ROE variables with the moving median, first and third quartile



Source: Author's compilation based on 8.723 observations, from EMIS Database, 2019

In Figure 2 the original data, the moving median, the first and the third quartile for SIZETA and SIZES variables were plotted. It is apparent that both the moving median and the moving third quartile display evident declining tendency, which is characteristic for the whole sample.

Figure 2. The relation between SIZETA and ROE variables with the moving median, first and third quartile



Source: Author's compilation based on 8.723 observations, from EMIS Database, 2019

Table 4 presents results of statistical tests of relations between ROE and both size variables (SIZES, SIZATA), i.e. the Spearman rho and the Kendall tau-b with p-values (one side).

Table 4. Results of statistical tests of relations between GRS and studied variables. p-values are one side values.

	Spearman		Kendall	
	coefficient	p	Tau-B	p
SIZES	-0,0162	0,0655	-0,0116	0,0522
SIZETA	-0,1937	<0,0001	-0,1337	<0,0001

Source: Author's compilation based on 8.723 observations, from EMIS Database, 2019

Obtained and presented in Table 4 results confirmed negative relationships between profitability and both size variables. It should be noted however, the relationships between SIZES and ROE are statistically significant with p-values above 0,05 (or below 0,1), while the negative relationships between SIZETA and ROE are statistically more significant, i.e. the p-values are below 0,05.

5. DISCUSSION AND CONCLUSION

The results of this study show clearly the relationship between the size and the profitability of transportation companies registered in Poland is negative and statistically significant with p values below 0,1 or 0,5, regarding size measured with sales and total of assets, respectively. The difference in p values and coefficients for

SIZES and SIZETA variables indicate that, the relationship between the size measured with total of assets and profitability is considerably stronger than the relationship between the size measured with sales and profitability. Therefore, there are two practical implications of this study. The first is that studied transportation companies should expect lower profitability rates when they grow, i.e. the side effect of growth is decreasing of profitability in studied industry. The second is that, stated negative relationship between size and profitability is weak in terms of size measured with sales (Spearman coefficient -0,0162; Kendall Tau-B -0,0116) and significantly stronger in terms of size measured with total of assets (Spearman coefficient -0,1937; Kendall Tau-B -0,1337). Hence, growing transportation companies, in order to remain profitable should control levels of total of assets, as this variable has a significant impact on their profitability. Growing sales have considerably lower impact on profitability. One of the practical recommendations for studied companies is to consider outsourcing of fixed assets (primarily car fleet) and to shorten trade receivable cycles as these positions are supposed to make up for the highest share of total of assets, which as indicated should be minimized.

The results of this study are aligned to results presented by other scholars (Ahuja & Majumdar, 1998; Leibenstein, 1976; Downs, 1967; Pi & Timme 1993; Dhawan 2001; Goddard et al., 2005), who postulate the relationship between the size and the profitability of the firm is negative. The results of this study are opposite to the findings of scholars who postulate that larger companies have advantages over smaller companies and so are deemed to be more profitable (Penrose, 1959; Hall & Weiss, 1967; Nunes et al., 2009; Tyagi & Nauriyal, 2017). Therefore, the results of this study indicate that the significance of economies of scale and scope and other advantages related to large size companies is weaker than the significance of disadvantages related to large size companies, like bureaucratization, or management difficulties resulting from higher complexity, for transportation companies registered in Poland. The findings of this study, as compared to results obtained by other researchers indicate also that there might exist underlying differences among various industries, hence specific industries should be studied separately.

This study has however, several limitations. Firstly, it should be noted the sample used in this study comprise only Polish transportation companies. As a consequence, the findings, of this paper might not be generalizable to other countries or other industries. Secondly, it must be noted that the studied period is relatively short, i.e. it comprise only the time of economic growth. Contemplated relationships, might differ in the times of recessions. Both of aforementioned limitations have been done deliberately as the aim of this paper is to arrive to conclusions only for transportation industry, which differs significantly from other industries, especially manufacturing ones.

Aforementioned limitations of the study are a good indication for further research. The results of studies of the relationships between the size and the profitability of the transportation companies, in other regions, especially outside European Union could successfully contribute to confirm the results of this study and allow to generalize the findings for the whole transportation industry. It would be also, very interesting to study the relationships between the size of companies and their profitability, or the default risk during economy slowdowns. On the one hand, if the macroeconomy conditions revers, smaller transportation companies, possessing less resources have greater chances of going bankrupt than larger ones, and so should be less profitable. On the other hand, smaller companies, as postulated by Ahuja and Majumdar (1998), are less bureaucratized and so have greater chance of adjusting quickly to changing market conditions and in that way to outperform larger companies in terms of profitability.

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THE DETERMINANTS OF MARITIME PASSENGER TRANSPORT TO CROATIAN ISLANDS

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Abstract

The paper shows the determinants of passenger transportation to and off major Croatian islands based on correlations. Due to lacking time series, we use the simplest statistical associations based on cross-section correlation. The results show that major determinants of passenger transportation to and off Croatian islands are the number of island inhabitants, the number of registered tourist arrivals, as well as the number of registered beds, while the number of vehicles transported to the islands is statistically associated to the economic activity on the island represented by total on-island company revenues. The purpose of the paper is to help predict and plan future maritime transportation requirements of Croatian islands.

Key words: islands development planning, maritime passenger transport, cross-section correlation

1. INTRODUCTION

Insular Croatia numbers more than thousand islands and islets, 48 of which permanently inhabited and 38 of these are regularly connected to the mainland either by a bridge or by an all year long maritime line. For these, we have limited statistical data, while for a smaller group of 12 larger islands we have a more detailed statistical database. The goal of the paper is to use all the available data to help predict and plan future maritime transportation requirements of Croatian islands.

Maritime passenger transport is an essential transportation service for the development of any coastal area. In this paper, we analyse statistical associations between data of the maritime passenger transport connecting Croatian islands and data representing industries, services, and activities regarded as determinants of island economies. We concentrate on simple statistical associations and Ordinary Least Square (OLS) correlations due to data limitations, i.e. lacking longer time series.

Specifically, we analysed both the number of passengers and the number of vehicles transported to the islands by daily, all year maritime lines as well as to the islands having a bridge to the mainland (Krk and Pag). Islands interconnected by a bridge (Cres and Lošinj, Ugljan and Pašman) were analysed as an island group. Because of missing data, we excluded the island of Suđurađ from the analysis.

2. LITERATURE REVIEW

Maritime passenger transport represents an essential service necessary for development of Croatian coastal area (Debelić, 2018), thus requires special attention from the public policies perspective (Debelić et al., 2015 & 2016). The quality of public port management system represents one of the key action areas necessary for achieving economic development goals (Debelić et al. 2018). Provision of public maritime passenger transportation services represents the other one, and its determinants are the main research focus presented in this paper. The port service complexity and quality was researched by Bendeković et al. (2010) providing wider insight to the problem of port services quality while Gaur (2005), Grosso & Monteiro (2008), Notteboom (2011) and Duran et al. (2017) provided more insight into port planning and quantitative analysis approaches into the field. In the maritime passengers, transport research the strong focus on port management was presented in the Kesić (2003) while Kesić & Jugović (2006) elaborated on specificities of maritime passenger ports management. Kesić & Debelić (2014) provided analysis of competitiveness growth possibilities and limitations of Croatian ports. Paixao Casaca et al. (2010) analysed port choice in the European short sea shipping market from different port authorities' perspectives while Rak et al. (2016) performed research on modelling of railway port infrastructure management systems offering more insight into modern management approaches applicable to port infrastructure.

3. DATA AND METHODS

The first cross-section analysis encompassed the inhabited Croatian islands with available statistical data: the sample of 38 island groups having regular maritime lines. The analysis does not include the island of Krk, the southern half of the island of Pag and the peninsula of Pelješac, because of lack of data. We aggregated the data for the two island groups of Cres-Lošinj and Ugljan-Pašman because of their bridge interconnectedness.

The second cross-section analysis encompassed the 12 largest islands only having a larger and better database suitable for a more thorough statistical analysis.

We tested all available variables, but used only the ones that were statistically significant at $p < 0.05$ in further analyses. The dependent variable of primary interest are “passengers” and “vehicles” i.e. number of passengers and number of vehicles in regular maritime transport. All calculations were performed in E-views 9.0 statistical-econometric package. The data sources are the Central Bureau of Statistics, the Agency for Coastal Maritime Traffic, and county port authorities and captains.

To find the determinants of passenger transport to and off major Croatian islands, we tested the Ordinary Least Squares (OLS) Pearson correlations between the dependent variables of interest: the transportation of passengers and the transportation of vehicles, and several independent variables that were collected. The data shortcomings are obvious: no time series were available, so no sophisticated time series, cross correlation or pooled data analysis was possible. Thus, no falsification of causal conjectures was possible, only statistical associations (Gujarati, 2009; Maddala, 2001).

4. RESULTS AND DISCUSSION

The two dependent variables of interest that were extensively tested for statistical associations were passenger and vehicle transportation.

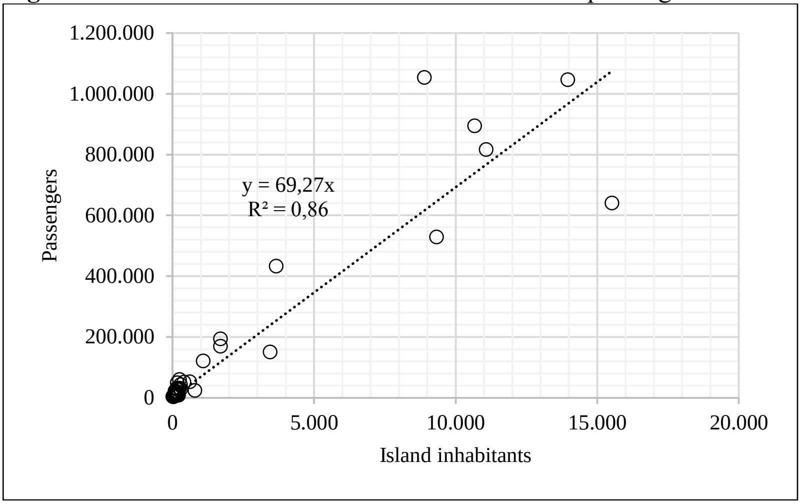
4.1. Passenger Transport

The most important dependent variable is the number of passenger landings on an island by means of liner shipping. The most important variable for explaining island maritime passenger transport landings is the number of island inhabitants (Table 1). Not only are the shipping lines here to serve domestic population requirements, but also, the shipping transport to the islands is relatively evenly distributed in relation to the number of inhabitants on the islands. We can read in Table 1 that passenger transport onto the islands may be explained with 86% by the variable of registered local population (R^2=0.86). The value of the independent population variable coefficient of 69.27 means that for one inhabitant on the island we have 69 passengers in maritime transport and this ratio is significant at the level of $p<0.0001$. On average, this means that the best individual predictor of passenger transport is exactly the number of inhabitants on an island. Figure 1 shows this relationship.

The number of inhabitants of an island is the best individual predictor of the number of passengers in maritime transport to that island:

$$\text{PASSENGERS} = 69.27 \cdot \text{INHABITANTS} \quad [R^2=0.86, p<0.001]$$

Figure 10. Correlation between island inhabitants and passengers



Source: Authors

Maritime passenger transport to islands is mostly explained by a population variable (R2=0.697, p<0.001). The value of the coefficient of the population variable is 69,271, meaning that an island inhabitant uses maritime transportation on average 69 times a year with a standard error of ± 3.87 (Table 1). Unfortunately, a strict separation between tourist passenger travellers and domicile population travellers was not possible, and our attempts to arrive to a statistically significant model were not successful. We shall try to explain the passenger transport according to the needs and identify those variables that are at the same time statistically significant and possess certain explanatory power. It is obvious that the function of line shipping to and off the Croatian islands has the primary function of providing the transportation to the domestic population continuously throughout the year and not only as required by the tourist season.

Table 14. Correlation between the number of passengers and the number of inhabitants

Dependent Variable: PASSENGERS
Method: Least Squares
Included observations: 38

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INHABITANTS	69.27101	3.874403	17.87915	0.0000

R-squared	0.862184	Mean dependent var	174324.8
Adjusted R-squared	0.862184	S.D. dependent var	308240.4
S.E. of regression	114430.0	Akaike info criterion	26.15928
Sum squared resid	4.84E+11	Schwarz criterion	26.20237
Log likelihood	-496.0263	Hannan-Quinn criter.	26.17461

Source: Authors' calculation using Eviews 9.0.

Tourism is the basic economic activity on the islands and the need for transport of tourists is well included in the number of registered beds on an island for tourism purposes that we added to the basic population variables in Table 2.

Table 15. Correlation between the number of passengers, beds and inhabitants
Dependent Variable: PASSENGERS
Method: Least Squares
Included observations: 38

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BEDS	8.344920	3.296315	2.531590	0.0159
INHABITANTS	52.00238	7.721787	6.734501	0.0000

R-squared	0.883011	Mean dependent var	174324.8
Adjusted R-squared	0.879761	S.D. dependent var	308240.4
S.E. of regression	106883.8	Akaike info criterion	26.04807
Sum squared resid	4.11E+11	Schwarz criterion	26.13426
Log likelihood	-492.9133	Hannan-Quinn criter.	26.07873

Source: Authors' calculation using Eviews 9.0.

However, private needs of inhabitants continue to explain the greatest part of maritime passenger linear transport to islands:

$$\text{PASSENGERS} = 8.34 \cdot \text{BEDS} + 52.00 \cdot \text{INHABITANS} \quad [R^2=0.88,\ p<0.001]$$

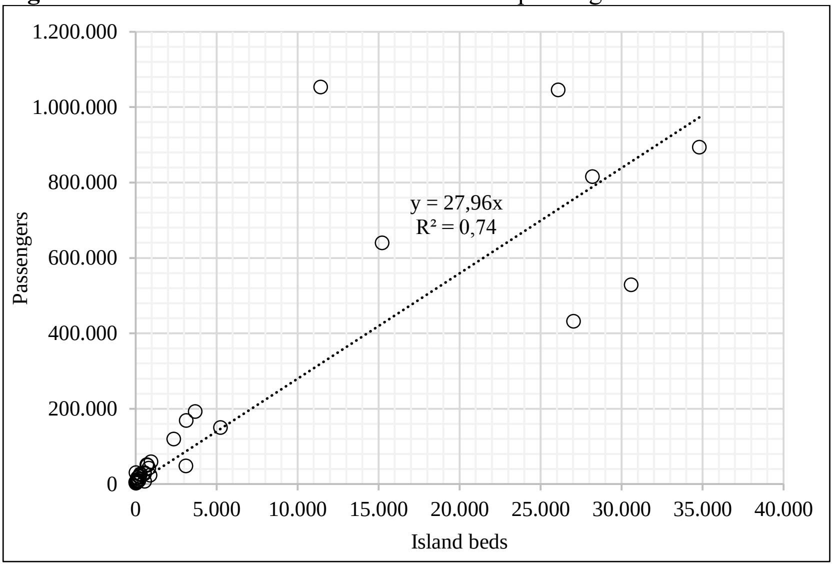
What we immediately observe, is the non-linearity and heteroscedasticity of the relationship between main variables. However, this does not change the fact that the number of inhabitants and the number of beds are still best common predictors of the number of tourists on the islands. Regardless of heteroscedasticity, the Ordinary Least Squares (OLS) is still the Best Linear Unbiased Estimator (BLUE).

From the line shipping and passenger reasons of travel point of view, two basic passenger categories self-evidently pop out: the islands' inhabitants and tourists.

From the statistical relation between the number of beds and the number of passengers on the islands, it is obvious that tourist activity generates a significant part of maritime passenger transport on islands. However, inverse causality creates multicollinearity between variables. In other words, tourist activity on islands is the most important activity on the islands that allows the local population to live there. The only form of transport communication with the shore for the islanders is line shipping. However, this communication has two purposes: private and business. The major business activity on islands is tourism. The number of beds is the only statistically significant variable correlated with the number of passengers.

The number of beds best represents tourist passenger activity (Figure 2).

Figure 11. Correlation between island beds and passengers



Source: Authors

The following relation from Table 3 best describes the relationship between the number of passengers and the number of beds on an island:

$$PASSENGERS = 27.96 \cdot BEDS \qquad [R^2=0.74,\ p<0.001]$$

With 28 passengers per year per bed, the number of beds is also a very good predictor of the number of line shipping passenger travels. From the table, it follows that without considering other variables; the number of registered beds for tourism purposes on the island explains 74% of the number of passengers bound to the islands. On average, there are almost 28 passengers in shipping line passenger travels per registered bed (Table 3).

Table 16. Correlation between the number of passengers, and the number of beds

Dependent Variable: PASSENGERS
Method: Least Squares
Included observations: 38

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BEDS	27.95506	2.290736	12.20353	0.0000

R-squared	0.735626	Mean dependent var	174324.8
Adjusted R-squared	0.735626	S.D. dependent var	308240.4
S.E. of regression	158489.0	Akaike info criterion	26.81072
Sum squared resid	9.29E+11	Schwarz criterion	26.85382
Log likelihood	-508.4037	Hannan-Quinn criter.	26.82605

Source: Authors' calculation using Eviews 9.0.

Since data was not available for all 38 islands of interest, it was necessary to reduce the sample to only 12 islands. We excluded the island of Krk because of its bridge connection to the mainland and missing accurate data. In addition, we considered the islands of Cres and Lošinj, as well as the islands of Ugljan and Pašman as common transport-economic units. A somewhat larger set of data was available for these 12 islands enabling us better analysis. To begin with, we were able to confirm previous measurements and statistical associations (Table 4).

As in the previous case of 38 islands, maritime passenger transport to the 12 largest islands is mostly explained by the population variable (R^2=0.697, $p<0.001$). The value of the coefficient of the population variable is 69,207, which means that an island inhabitant uses maritime transportation on average 69 times a year with a standard error of ±7. The larger standard error is due to a smaller sample. The previous disclaimer still applies: it was not possible to separate tourist arrivals from the inhabitants, but we shall seek to collect some additional data in the future and deduce the number of tourist passenger transport from that.

Table 17. Correlation between the number of passengers and the number of beds

Dependent Variable: PASSENGERS
Method: Least Squares
Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INHABITANTS	69.20672	7.065517	9.794998	0.0000

R-squared	0.697470	Mean dependent var	505769.8
Adjusted R-squared	0.697470	S.D. dependent var	379151.5
S.E. of regression	208543.5	Akaike info criterion	27.41334
Sum squared resid	4.78E+11	Schwarz criterion	27.45375
Log likelihood	-163.4800	Hannan-Quinn criter.	27.39838

Source: Authors' calculation using Eviews 9.0.

After the number of inhabitants, the beds registered for tourism purposes are the next most significant variable statistically related to the number of passengers in ship passenger transportation.

From table 5 it is visible that the total number of passengers in maritime transport is explained with 42% by the number of beds: on average, almost 28 ± 4 passengers per bed (Table 5).

Table 18. Correlation between the number of passengers and the number of beds

Dependent Variable: PASSENGERS
Method: Least Squares
Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BEDS	27.95239	4.189216	6.672464	0.0000

R-squared	0.417289	Mean dependent var	505769.8
Adjusted R-squared	0.417289	S.D. dependent var	379151.5
S.E. of regression	289427.1	Akaike info criterion	28.06885
Sum squared resid	9.21E+11	Schwarz criterion	28.10926
Log likelihood	-167.4131	Hannan-Quinn criter.	28.05389

Source: Authors' calculation using Eviews 9.0.

These results, carried out on a smaller sample of only 12 large islands, fully correspond to previous data carried out on more than 38 islands. Unlike the 38 islands sample, a 12 large islands sample is available for recorded tourist arrivals, which have proved to be statistically significant in explaining the number of passengers in liner shipping (Table 6).

Table 19. Correlation between the number of passengers and tourist arrivals

Dependent Variable: PASSENGERS
Method: Least Squares
Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TOURIST ARRIVALS	2.644405	0.460559	5.741724	0.0001

R-squared	0.264156	Mean dependent var	505769.8
Adjusted R-squared	0.264156	S.D. dependent var	379151.5
S.E. of regression	325241.2	Akaike info criterion	28.30218
Sum squared resid	1.16E+12	Schwarz criterion	28.34259
Log likelihood	-168.8131	Hannan-Quinn criter.	28.28722

Source: Authors' calculation using Eviews 9.0.

The most important individual variable for explaining the number of inhabitants on an island is its surface (R^2=0.417, p<0.001) (Table 7).

Table 20. Correlation between the number of inhabitants and island area

Dependent Variable: INHABITANTS
Method: Least Squares
Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ISLAND AREA IN KM^2	31.70600	4.921535	6.442299	0.0000

R-squared	0.417170	Mean dependent var	6819.167
Adjusted R-squared	0.417170	S.D. dependent var	5335.669
S.E. of regression	4073.426	Akaike info criterion	19.54201
Sum squared resid	1.83E+08	Schwarz criterion	19.58242
Log likelihood	-116.2521	Hannan-Quinn criter.	19.52705

Source: Authors' calculation using Eviews 9.0.

In contrast to the domicile island population that uses maritime transport on average 69 times a year (parameter value = 69 ± 7, R2 = 0.417, p <0.001), tourist arrivals affect the realization of maritime passenger transport with a value of 2.6 ± 0.5 (R2 = 0.264, p <0.001). This argues in favour of the fact that maritime passenger transport for tourism purposes is statistically significant, but in total, rather small and explained by only 26% of the dependent variable of the total number of passengers:

$$PASSENGERS = 2.64 \cdot TOURIST\ ARRIVALS \qquad [R^2=0.264, p<0,001]$$

Although at first glance this seems a rather small number, a single tourist arrival generates on average 2.6 ± 0.5, hence between 2 and 3 passenger travels.

4.2. Vehicle Transport

Crossing to the second most important variable coastal line shipping on Croatian islands: transport, ie the number of recorded arrivals of vehicles on islands or island groups (Cres-Lošinj and Ugljan-Pašman). The two most statistically significant variables were population ($p < 0.001$) and number of beds ($p = 0.004$) with $R^2 = 0.897$. The needs of the local population and the needs of tourists explain 90% of the demand for ship vehicle transport (Table 8).

Table 21. Correlation between the number of vehicles, number of inhabitants and beds

Dependent Variable: VEHICLES
Method: Least Squares
Included observations: 30

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BEDS	3.097198	0.989227	3.130926	0.0041
INHABITANTS	13.13171	2.315081	5.672247	0.0000

R-squared	0.896605	Mean dependent var	56253.07
Adjusted R-squared	0.892913	S.D. dependent var	97661.65
S.E. of regression	31958.98	Akaike info criterion	23.64663
Sum squared resid	2.86E+10	Schwarz criterion	23.74005
Log likelihood	-352.6995	Hannan-Quinn criter.	23.67652

Source: Authors' calculation using Eviews 9.0.

The variable "business income" is a better predictor of the number of vehicles than any other tested variable. Thus, vehicle transport in and from the islands can best be explained by a combination of variables representing the number of inhabitants on the island and the income of the entrepreneurs on the islands. One of the reasons why this combination of variables has a higher R^2 is that the transport of vehicles on islands is an indicator of both island population and economic activity. On the downside, there is multicollinearity between these variables as income of entrepreneurs correlates with the number of inhabitants. The most important variable influenced by the total number of vehicles transported by ferries is "business income", an aggregate economic activity variable, which is also closely related to the island size and population (Table 9).

Table 22. Correlation between the number of transported vehicles and business income

Dependent Variable: VEHICLES
Method: Least Squares
Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BUSINESS INCOME in mil. kn	235.0743	23.51658	9.996111	0.0000
R-squared	0.735982	Mean dependent var		139028.4
Adjusted R-squared	0.735982	S.D. dependent var		112626.5
S.E. of regression	57870.57	Akaike info criterion		24.84946
Sum squared resid	3.68E+10	Schwarz criterion		24.88987
Log likelihood	-148.0968	Hannan-Quinn criter.		24.83450

Source: Authors' calculation using Eviews 9.0.

Business income is the best single indicator of vehicle transportation to the islands:

VEHICLES = 235.07 · BUSINESS INCOME [R^2=0.74, p<0,001]

Income is the best indicator of economic activity and the consequent need for mobility. Tourism is the most important island economic activity, and thus it is not surprising that the income of the entrepreneurs is collinear with the variables related to tourism. This somewhat complicates the modelling.

In continuation, we also analysed the ratio of the number of passengers and the number of vehicles transported (Table 10).

Table 23. Correlation between the number of passengers and transported vehicles

Dependent Variable: PASSENGERS
Method: Least Squares
Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
VEHICLES	3.325185	0.349194	9.522444	0.0000
R-squared	0.656259	Mean dependent var		505769.8
Adjusted R-squared	0.656259	S.D. dependent var		379151.5
S.E. of regression	222294.5	Akaike info criterion		27.54105
Sum squared resid	5.44E+11	Schwarz criterion		27.58146
Log likelihood	-164.2463	Hannan-Quinn criter.		27.52609

Source: Authors' calculation using Eviews 9.0.

Vehicle transportation statistics shows that for every vehicle registered on the island, there were 3.3 passengers on the ferry, irrespective of whether they came to the island by car, as there is no separate record of passengers in and off the vehicles.

The following is an attempt to unite several statistically significant variables to explain the number of passengers. The two variables highlight the mutual non-linearity. This is entrepreneurial income of millions of kuna and the number of inhabitants of the island (Table 11).

Table 24. Correlation between number of passengers, business income and inhabitants

Dependent Variable: PASSENGERS
Method: Least Squares
Included observations: 29

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BUSINESS INCOME in mil. kn	301.6566	113.5698	2.656135	0.0131
INHABITANTS	46.52616	9.466079	4.915040	0.0000

R-squared	0.879614	Mean dependent var	225912.3
Adjusted R-squared	0.875156	S.D. dependent var	337490.3
S.E. of regression	119246.6	Akaike info criterion	26.28225
Sum squared resid	3.84E+11	Schwarz criterion	26.37654
Log likelihood	-379.0926	Hannan-Quinn criter.	26.31178

Source: Authors' calculation using Eviews 9.0.

The first variable associates economic activity and the economic need with the transport service while the variables of the population encompass private citizens' needs.

4.3. Research limitations and prospectives

The limitations of this study are lacking comprehensive time-series data and incoherent cross-sectional data across islands. We had to reduce our sample from 38 to 12 islands to be able to have a common set of cross-section variables.

In the future we envision to be able to construct a set of panel/pooled data and to be able to gain more information both on individual islands, but also by using panel/pooled data statistical methods to gain better overview on behaviour that is common to all Croatian islands. This knowledge may be used to improve future policy recommendations.

5. CONCLUSION

The results show that major determinants of passenger transportation to and off Croatian islands are the number of island inhabitants, the number of registered tourist arrivals, as well as the number of registered beds, while the number of vehicles transported to the islands is statistically associated to the economic activity on the island represented by total on-island company revenues.

We conclude that passenger and vehicle transportation to and from Croatian islands is predominantly determined by the number of inhabitants on the island. Larger islands have larger populations, and larger populations are able to accommodate a larger number of tourists. Main economic activities on islands closely relate to tourism. After the number of inhabitants, tourist arrivals are the next most significant variable describing the number of passengers in line shipping to the islands. Entrepreneurial income best describes car transportation in Ro-Ro ferry transport. Together with the number of inhabitants, economic activity expressed in million kuna of entrepreneurial income is the best determinant of the number of vehicles in maritime transport to the islands. Entrepreneurial income is the variable statistically most closely related to tourism.

This paper represents a humble start of what we hope to be a thorough and systematic future econometric analysis of the maritime transportation to Croatian islands.

6. ACKNOWLEDGMENTS

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THE DANUBE PORTS AS MULTIMODAL TRANSPORT HUBS AND THEIR LOGISTICS SERVICES

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Abstract

Till the first part of the 20th century inland ports used to be taken as places on the waterway where water transport met with other modes of transport. Increase of volume of cargo transported by water transport in the second part of the 20th century, building of larger and faster inland vessels caused the disproportion between the performance of water transport and transhipment capacity of inland ports. Therefore, it was necessary to increase the performance of handling equipment of inland ports, to enlarge land area of ports, to modify of shipbuilding so that transhipment of cargo could be faster and to reduce downtimes during transhipment of vessels in ports. At present inland ports are the hubs on the waterway where different logistics operations and services are carried out such as transhipment, storage, transport of cargo by different modes of transport. The Danube River is the main axis of waterways for ten European countries located in Central and East Europe. There are located 34 inland ports of different performances that provide various logistics services to their customers. The basic goal of the paper is to focus on the selected Danube ports, to analyse and to compare them from different points of view and to prepare the list of recommendations that could help them to increase their handling performances.

Key words: inland ports, hubs, logistics services, Danube River, Danube ports, performance

1. INTRODUCTION

The Danube River that is the second longest European river after the Volga flows through ten European countries of Central and Southeast Europe. It rises in Germany and flows into the Black Sea in the Ukraine and Romania. Since opening the Main – Danube Canal in 1992 the Danube has been linked to the waterways of Western Europe and has been the part of the waterway Rhine – Main – Danube. This waterway that flows through fifteen European countries links the North and Black Seas. It is over 3,500 km long. According to European Agreement of Main Inland Waterways of the International Importance (AGN) the Danube River is classified into classes due to safety and smoothness of navigation.

Danube inland ports are also part of this agreement and have to fill some criteria, for instance, they have to be situated on the waterway of international importance, they have to be linked to the main road or railway lines or their handling capacity has to be over 0.5 million tons of cargo a year. According to this agreement there are 34 inland ports on the Danube. These inland ports differ in their handling equipment, devices or outputs. On one hand the most of them are located on the Lower Danube, on the other hand the least of them are on the Upper Danube.

The basic goal of the paper is to focus on the Danube River, its inland ports and compare them according to their transhipment.

2. THE DANUBE RIVER

The Danube originates as a confluence of two German mountain rivers (the Breg and Brigach) in the Black Forest near Donaueschingen in Germany. The total length of the Danube, from the confluence to the estuary into the Black Sea, is 2,845 kilometres (some references refer to 2,580 kilometres). The commercial navigation carries out from Kelheim in the length of 2,414 km. The total surface area of the basin is 801,463 square kilometres and belongs to the sea catchment area of the Black Sea.

Commercial navigation on the Danube is carried out from Kelheim (rkm 2,414.72). The Danube flows through ten European countries (Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Moldova and the Ukraine) and four capital cities (Vienna, Bratislava, Budapest and Belgrade). With this number the Danube can be included among the waterways that flows through the largest number of countries in the world. Four Danube countries are only located on one bank of the Danube (Croatia - right bank, Bulgaria - right bank, Moldova - left bank and Ukraine - left bank). Shortly before the Black Sea, it creates the Danube Delta. (Hasenbichter et al., 2013)

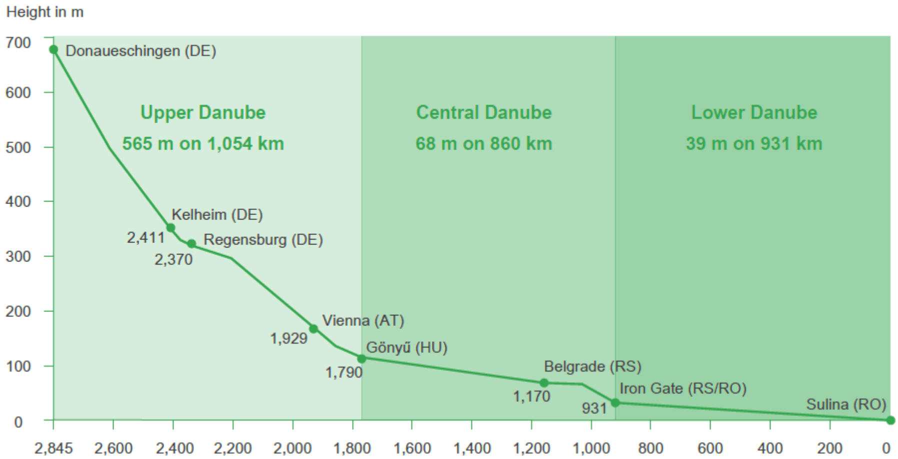
2.1. The division of the Danube

According to the gradient, the Danube River is divided into three sections (Figure 1). The Upper Danube, which is 624 kilometres long, has the character of a mountain river. It runs through Germany, Austria, Slovakia and Hungary (in the end it forms the natural border between Slovakia and Hungary). It starts in the German town of Kelheim (rkm 2,414.72), where the Danube links to the Main-Danube Canal, and ends in a Hungarian town of Gonyu (rkm 1,791.33). Its gradient is 37 cm per kilometre. There are located sixteen of eighteen dams on the Danube. Most of them are located in Austria, remaining in Germany, one of them is located in Slovakia. The biggest dam on this stretch of the Danube is Gabcikovo in Slovakia that was put in operation in October 1992. Downstream travel speed of vessels is from 16 to 18 kilometres per hour, upstream travel speed of vessels is from 9 to 13 kilometres per hour.

On its middle and lower part, the Danube has got the character of a lowland river. The middle Danube is 860 kilometres long; it is from Gonyu (rkm 1,791.33) to Drobeta Turnu Severin (rkm 931.00). It flows through Slovakia, Hungary, Croatia, Serbia and Romania. Close to Drobeta Turnu Severin there is located the biggest dam on the Danube (Iron Gates I). Its gradient is 8 centimetres per kilometre. Downstream travel speed of vessels is from 18 to 20 kilometres per hour, upstream travel speed of vessels is from 9 to 13 kilometres per hour.

The lower part of the Danube is from Drobeta Turnu Severin (rkm 931.00) to the estuary into the Black Sea (rkm 0.00). There is one dam on this part of the Danube called Iron Gates II. Its gradient is 4 centimetres per kilometre. Downstream travel speed of vessels is from 18 to 20 kilometres per hour, upstream travel speed of vessels is from 11 to 15 kilometres per hour (Hasenbichter et al., 2013).

Figure 1. Gradient curve of the Danube



Source: Manual on Danube Navigation

According to AGN, the Danube River can be divided into some classes. Each class defines maximal dimensions of motor cargo vessels or pushed convoys due to safety and smoothness of traffic and navigation on the waterway.

The Danube is classified as class VIb from Regensburg to Budapest. On this stretch of the Danube the pushed convoys can sail that consist of a pusher (a motorized vessel used for pushing) and four non-motorized pushed barges. There is also the bottleneck (a stretch long 69 kilometres between Straubing a Vilshofen) where the Danube is classified as class VIa.

Between Budapest and Belgrade, the Danube is classified as class VIc. This stretch of the Danube is for a pushed convoy that consists of a pusher and six pushed barges.

Between Belgrade and the Danube Delta the Danube River is classified as class VII. It means, there can sail pushed convoys with nine barges and smaller seagoing vessels (between Braila and the Danube Delta) (Hasenbichter et al., 2013).

2.2. Cargo transport on the Danube

According to Danube Commission, the volumes of cargo transported on the Danube River have increased in the last few years (Table 1). In 2016, about 59,729 thousand tons of cargo was transported on the Danube, it was more about 4.86 % in comparison with previous year. In this value there are also included transports of cargo not only in the Danube countries but also on the Danube branches and its canals (the Main-Danube Canal and the Canal Danube-Black Sea). The most cargo was transported in Romania (22,018 thousand tons). It was 36.86 % of total volume of cargo. Romania was followed by the Ukraine (5,399 thousand tons) and Hungary (3,590 thousand tons). In the same year 1,800 thousand of cargo was transported in Slovakia that was 3.01 % of total volume of cargo (Danube navigation statistics).

Table 1. The volume of cargo transported on the Danube between 2011 and 2016 (in thousand tons)

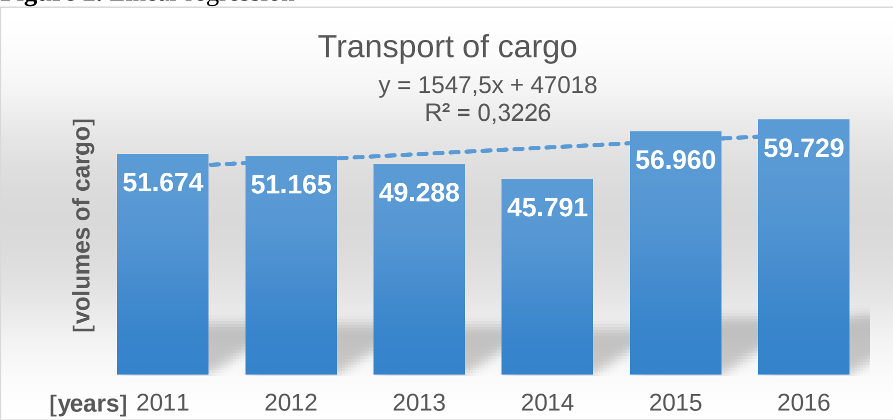
year	2011	2012	2013	2014	2015	2016
Volume of cargo (t)	51,674	51,165	49,288	45,791	56,960	59,729

Source: Danube Navigation Statistics

2.3. The prediction of development of transported cargo on the Danube River

We used the method of least square for linear regression and prediction of development of transported cargo on the Danube River until 2020. We used the values of transported cargo on the Danube between 2011 and 2016 for the calculation of equation (Table 1).

Figure 2. Linear regression



Source: Authors

The coefficient of correlation has got the value of 0,57. According to generated equation

$$y = 1547{,}5x + 47018 \qquad (1)$$

where y is the volume of cargo that was transported on the Danube, and x is a year when the volume of cargo was transported, we can calculate the development of transported cargo on the Danube for 2019 and 2020. In 2020 we predict that about 62,493 thousands of tons will be transported on the Danube (Table 2).

Table 2. The prediction of the development of transported cargo on the Danube River for 2019 and 2020

Year	2019	2020
Volume of transported cargo (t)	60,945,5	62,493

Source: Authors

3. INLAND PORTS

3.1. Inland ports in the role of logistics hubs

In the first part of the 20th century inland ports used to be places on the waterway where inland water transport met with other modes of transport (rail and road transport). Transport of cargo used to take about two thirds of operating time and transhipment of cargo in inland ports used to take only one third of this time. The situation changed after the Second World War due to the increase of volume of cargo which was transported by water transport, the introduction of pushed technology, the increase of transport capacity of vessels and their speed. These factors caused the disproportion between the performance and efficiency of inland water transport and handling facilities and devices of inland ports. Therefore, it was necessary to increase their efficiency, to enlarge of port area and to build a new generation of inland vessels. Nowadays inlands ports are transport hubs on the waterway (a navigable river, lake or canal). They consist of transhipment areas where cargo is handled by cranes, is stored in warehouses or on open storage areas or is transported by other modes of transport to the customers. Inland ports also offer other functions and services (Dávid, 2017; Skočibušić et al., 2011).

An important part of each inland port is its connection to other modes of transport (road and railway transport). Railway transport mainly carries out transport of bulk cargo for longer distances. Road transport mainly carries out transport of general cargo and containers. It is used by companies which are located in its surrounding.

Inland ports should be designed and constructed to provide:

- a fast and safe navigation of vessels from a waterway to a port,
- smooth and safe manoeuvring of vessels on water area of port, their anchoring, formation of convoys,

- a fast loading / unloading of cargo between vessels and the land of port,
- a direct connection with other modes of transport.

A lot of factors influence on the location of inland ports. From the point of economic view inland ports are situated near industrial and commercial centres. From the point of ground view, the configuration of ground and its geological structure are very important for its final construction. From the point of territorial view, the total area and its surrounding are important for the location of basins, transhipment areas, handling and storage facilities (cranes, warehouse), infrastructure (roads and railways) and other building which are important for operation of inland port (Dávid, 2017).

3.2. Division of inland ports

According to the purpose inland ports can be divided into:

1. Business (public) ports that transfer bulk, general, liquid cargo including containers between vessels and other modes of transport by cranes. They also store cargo in the warehouses or on the open storage areas, transport, pack them to the customers. They usually consist of water and land area. Land area of port is equipped by handling facilities (gantry or container cranes) and infrastructure (roads and railway) which enables transport of cargo between port and its customers. Business ports are situated near large commercial and industrial areas. They are usually divided into various transhipment sectors according to cargo which are transferred there, for instance transhipment areas for bulk, general and liquid cargo, container terminals, Ro-Ro Ramp for cars, areas for transhipment of oversize or overload cargo.
2. Industrial ports are used for transhipment of raw materials, semi-finished o finished products between vessels and the land of port by private companies. They are usually equipped by specialized handling facilities.
3. Passenger ports are used for embarking or disembarking of passengers between vessels and the area of port. They are usually situated in the city centres. Their area does not take up too much space.
4. Shipyard ports are used for mending or reconstruction of vessels. They are equipped by gantry cranes, ship lifts, dry or floating docks, warehouses and workshops.
5. Specialized ports are designed for special purposes and special vessels such as military, army, sport, fishing or recreation ports.

Business (public) and industrial ports are the most import ports from the point of transport view (Dávid, 2017; Kubec, 1993)

3.3. Production indicators of works in the ports

The economic goal of works in the port is to fulfil its financial profit. The individual items of the profit have got direct or indirect bonds on the operational activity indicators.

The budget items are:

- cargo turnover: amount of cargo in tonnes that is transhipped by handling devices of port during the reporting period,
- cargo structure: the structure of the particular type of transhipped cargo,
- turnover of passengers: total number of passengers transported to a passenger port by the passenger fleet for the reporting period,
- vessel turnover: number of vessels divided into vessels and boats which the port serves during the reporting period,
- dwell of vessels: time that vessels dwell in port, it is related to transhipment of cargo, waiting for loading or unloading of cargo, formation of convoys and the provision of services,
- turnover of wagons: number of manipulated all types of freight wagons for the reporting period,
- dwell of wagons: dwell time of railway wagons in the port private sidings in hours (calculated from the takeover of the wagon by workers of the port to its handover by the railway undertaking staff),
- port throughput: the ability of transhiment areas of port to handle of cargo in a particular required structure and work variation over the reporting period,
- navigation period: the number of days when a vessel can carry cargo or persons to the port,
- inter-navigation period: number of days during voyage is stopped due to low or high water level, freezing of the waterway,
- labour productivity: expresses physical units per worker in main activity, ie. in tonooperations for the reporting period (month, quarter, half year, navigation period) (Záležák, 2000).

We use the port throughput for the comparison of cargo transhipment in the Danube ports (see subchapter 4.1.).

3.4. Direct and indirect transhipment of cargo

In the ports, cargo can be transhipped by two ways. In the first way (direct transhipment of cargo) cargo is transhipped between vessels and other means of transport (trucks or wagons) by handling devices of the port. It is very hard to harmonize cargo transport between vessels and other means of transport; therefore, the part of cargo is stored in the warehouses or on the open storage areas before it is transported to the customers by other modes of transport. It is called indirect transhipment of cargo (Záležák, 2000).

3.5. Inland ports of the international importance

According to AGN (European agreement on Main Inland Waterways of the International Importance) inland port have to fill some criteria:

- ✓ they have to be situated on a European waterway,

- ✓ they have to be capable of accommodating vessels or pushed convoys used on the relevant European waterway in conformity with its class,
- ✓ they have to be connected to main road and railway lines,
- ✓ its total cargo handling capacity has to be at least 0,5 million tons of cargo a year,
- ✓ they have to offer suitable conditions for the development of a port industrial zone,
- ✓ they have to provide handling of standardized containers,
- ✓ they have to have all the facilities necessary for usual operations in international traffic (Dávid, 2017).

4. THE DANUBE INLAND PORTS

On the Danube there are 34 inland ports of the international importance (Fig. 3) that differ in the volume of transhipped cargo, technical equipment, transhipment technology etc.

Figure 3. Danube ports

Source: via donau

4.1. Biggest Danube ports

According to Danube Commission, the Danube inland ports transhipped about 36,939 tons of cargo in 2016 (see Table 3). In this table there are included only the ports that transhipped over 1.0 million tons of cargo per year.

Table 3. The Danube ports that transhipped over 1,0 million tons of cargo between 2013 and 2016 (in thousands of tons)

Port	Year			
	2013	2014	2015	2016
Izmail	2,654	3,021	4,521	5,327
Reni	2,729	1,465	248	201
Galati	3,515	3,515	4,318	4,466

Braila	2,358	2,358	2,217	849
Tulcea	2,159	2,159	2,550	1,559
Giurgiu	..	..	..	1,012
Calarasi	..	..	..	1,130
Lom	..	..	..	3,216
Russe	1,166	1,166	..	3,797
Vidin	1,224	1,224	..	..
Svishtov	1,213	1,213	..	..
Oriahovo	2,613	2,613	..	..
Smederevo	..	1,553	1,813	2,466
Belgrade	..	1,056	831	828
Novi Sad	1,545	1,278	980	1,325
Pančevo	1,103	1,281	651	1,040
Dunaújváros	1,053	1,046	1,341	962
Budapest	789	1,109	1,118	1,367
Bratislava	2,373	1,793	1,362	1,483
Vienna	1,665	1,372	970	1,068
Linz	4,356	4,335	3,814	3,995
Regensburg	1,645	2,198	1,579	848
Total	34,160	35,755	28,313	36,939

Source: Danube navigation statistics

On the Upper Danube there were four ports, which of one port was in Germany, two ports were in Austria and one port was in Slovakia. These ports transhipped about 20 % of total volume of transhipped cargo. The port of Vienna transhipped the largest volume of cargo on this part of the Danube in 2016.

On the Middle Danube there were six ports, which of two of them were in Hungary and four of them were located in Serbia. These ports transhipped about 21.6 % of total volume of transhipped cargo. The port of Smeredevo transhipped the largest volume of cargo on this part of the Danube in 2016.

On the Lower Danube there are located the most Danube inland ports that transhipped the largest volume of cargo (about 58.4 % of total volume of transhipped cargo) in 2016. The most inland ports were in Romania (five of them), then in Bulgaria (four of them) and the Ukraine (two of them). The port of Izmail that is the combination of inland and maritime port transhipped the biggest volume of cargo on this part of the Danube in 2016 (Danube navigation statistics).

Generally, the Danube inland ports provide huge scale of logistics services. They do not only tranship or store all types of cargo but they also transport it by other modes of transport and do other services related to cargo, fleet or passengers. (Danube navigation statistics) (Galieriková & Sosedová, 2018).

4.2. Inland ports on the Upper Danube

On the Upper Danube there are nine inland ports of the international importance. Two of them are located in Germany, five of them are in Austria, the only one is in Slovakia and Hungary.

The port of Regensburg is the largest port in Germany that is located on the right side of the Danube (river kilometres (rkm) 2,373 -2,379). The total area of the port is about 180 ha, there are three basins. In the port there are also a Ro-Ro ramp and Ro-La terminal. Bulk and general cargo are transhipped by gantry cranes between inland barges and trucks or wagons. There is also a transhipment area for transhipment of oversize and overload cargo (up to 200 t). The port has got some open storage areas and warehouses, there are also a car terminal, oil tanks and grain storage silos.

The port of Vienna is the largest Austrian port that is located in three parts such as Lobau (rkm 1,917), Albern (rkm 1,918) and Freudenau (rkm 1,920) on the right and left bank of the Danube. The total area of the port is about 300 ha. In each part of the port there is located a basin. In the parts Freudenau and Albern there are transhipped bulk and general cargo such as agriculture products, building materials, metal, cars and containers. Mineral products are transhipped in Lobau. In Freudenau there are located a Ro-Ro ramp and container terminal, in Albern there is also grain storage silos. The port also has equipment for cargo storage.

The port of Bratislava is the largest port in Slovakia that is located on the left bank of the Danube (rkm 1,867 and 1,865). The land of the port, which is about 144 ha, is divided into two parts: winter harbour (old part of the port) and Palenisko (a new part of the port). In winter harbour there are two basins used for transhipment of bulk and general cargo (especially pellets and fertilizers). In Palenisko there is a basin that was built in the 1970s and 1980s. In the basin there are located transhipment sections for transhipment of containers, cars, oversize and overload cargo and liquid cargo. The port also has equipment for cargo storage and has got a good connection to other modes of transport (Dávid, 2017; Seitz et al., 2003; Danube ports).

4.3. Inland ports on the Middle Danube

On the middle Danube there are ten inland ports of the international importance. Two of them are located in Slovakia, five of them are in Hungary, one of them is in Croatia and two of them are in Serbia.

The port of Budapest is the largest Hungarian port that is located on the left side of the Danube (rkm 1,640). The total area of the port is 152 ha, it has got three basins (one of them is used for protection and wintering of vessels). The port is used for transhipment of bulk, general, liquid cargo, cars and containers. There is also a Ro-Ro ramp and a pneumatic device with covered warehouses. The port is directly connected to public transport network of the city of Budapest.

The port of Vukovar is the only one port in Croatia that is located on the right bank of the Danube River. The total area of the port is about 3.5 ha and it can tranship bulk, general, liquid cargo including containers and oversize and overload cargo. It is equipped by gantry and mobile cranes, pneumatic devices, open and covered storage areas.

The port of Belgrade is one of the biggest ports in Serbia that is located on the right side of the Danube (rkm 1,168). The total area of the port is 100 ha, and it has got the only one port basin. The port handles bulk, general cargo and containers by gantry or mobile cranes. It also has open storage areas and warehouses for cargo storage. A container terminal, which is also located in the port, offers different services like maintenance, storage, filling or emptying of containers. The port is directly connected to public infrastructure of the city of Belgrade (Dávid, 2017; Seitz et al., 2003; Danube ports).

4.4. Inland ports on the Lower Danube

On the Lower Danube there are fifteen inland ports of the international importance. Ten of them are located in Romania, three of them are in Bulgaria and one of them is in Serbia and the Ukraine.

The port of Ruse is the largest Bulgarian port that is located on the right bank of the Danube (rkm 491). The port tranships bulk, general and liquid cargo, containers and cars. Except transhipment and storage of cargo the port offers different services such as filling of fuels, water, and sewage collection. The port is directly connected to other modes of transport of the town of Ruse.

The port of Galati is the largest Romanian inland port which can also accommodate smaller seagoing vessels. It consists of three parts that are located on the left bank of the Danube between rkm 160 and 140.8. Handling devices of the port (gantry, mobile or floating cranes) tranship bulk, general, liquid cargo including oversize and overload cargo. Except cargo transhipment and its storage, the port offers different services such as filling of fuel and water, sewage collection, shipbuilding. The parts of the port are directly connected to public road and railway transport of the city of Galati.

In Moldova, there is the only one inland port (the port of Giurgiulesti) located on the left bank of the Danube (rkm 133.8). The total area of the port is about 120 ha, and it tranships all types of cargo. It is also accessible for small seagoing vessels.

According to AGN there is the only one Ukrainian inland port (the port of Reni) located on the left bank of the Danube (rkm 127.8). The total area of the port is about 93 ha and it tranships bulk, general, liquid cargo, containers, cars, oversize and overload cargo. The port is equipped by gantry, mobile and floating cranes, conveyor belts, Ro-Ro ramp, open storage areas and warehouses. It is also accessible for smaller seagoing vessels (Dávid, 2017; Seitz et al., 2003; Danube ports).

5. CONCLUSIONS

The Danube is the most important inland river for ten European countries located in Central and Southeast Europe. Since completing the Main – Danube Canal, which links the Danube with the waterways of Western Europe, motor cargo vessels or pushed convoys have been transporting cargo between the North and Black Seas. In spite of the fact that it is the second longest European river the volume of transported cargo is lower than on the Rhine River. Since the 1990s most Danube countries have undergone the political and economic changes that have influenced on navigation badly.

Till the first part of the 20th century inland ports used to be places where inland water transport met with other modes of transport (road or railway transport). They only transhipped cargo between vessels and means of transport of road and railway transport or stored it on open storage areas or in warehouses. Since the second part of the 20th century inland ports have undergone significant transformation processes as the result of changes that have happened in global market. They have become transport hubs that offer different logistics services to their customers.

On the Danube there are more than 30 inland ports of the international importance, most of them are located on the Lower Danube in Romania and Bulgaria. According to Danube Commission these ports transhipped the highest volume of cargo in 2016. On the other hand, the lowest number of inland ports are located on the Upper Danube these ports also transhipped the smallest volume of cargo. Generally, the Danube inland ports play the function of transport hubs. Except transport, transhipment and storage of cargo they provide a lot of different logistics services according to the customers' requirements.

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IV. DISTRIBUTION LOGISTICS

A SCIENCE MAPPING AND LITERATURE REVIEW APPROACH TO ANALYSING THE RELATIONS AMONG THE TERMS LOGISTICS CENTER AND DISTRIBUTION CENTER

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Abstract

Modern development has recognized the importance of coordinated logistics, which must function at the regional and global level. However, a need for uniform definitions and naming of logistics services, facilities, systems and functions is present. Terminology in the field of logistics centers is becoming increasingly important because the number of terms correlated with it is large and most terms are used interchangeably without any distinction. In the field of logistics and distribution centers, this problem is clearly evident and can be seen by anyone researching any aspect of these concepts. Various definitions of terms are used by different authors, for example “logistics center”, “freight village”, “plate forme logistique”, “plat forme multimodales”, “distribution center”, “interporto”, “transport centre” etc.. The importance of the logistics center theme has stimulated research into the problems of clarifying ambiguity and classifying concepts that are used in the field of logistics centers and/or distribution centers and warehouses. There has not yet been a clear answer on the delimitation among the two most broadly used terms, which are “logistics center” and “distribution center”. The present paper applies science mapping and literature review in order to find which term is used more often, which researchers are most prominent in this research field, and whether definitions of both terms exist and what are their relations. The main research finding is a lack of consensus among scholars on whether the terms are the same or in a different hierarchical order in the logistics network.

Key words: Logistics center, distribution center, science mapping, literature review

1. INTRODUCTION

The concept of the warehouse as a place of storage of raw materials, semi-finished products, and products, is known the longest and goes back to ancient Egyptians. Warehousing as we know it today began to develop more rapidly during the period of colonization when new trade routes emerged, requiring storage facilities, from production to target markets and customers. The storage needs and concepts as we know today began to develop more rapidly during the period of colonization when new trade routes emerged that required storage facilities, from production to target markets and customers. The need for a distinction between logistics and distribution centers emerged in the 20th century, with the development of urbanization and increases in commerce and transport.

The occurrence of the terms distribution center and logistics center is more difficult to place accurately on the timeline. To a large extent, this is related to mixed definitions of these terms offered by various authors (Rimienė & Grundey, 2007). Thus, some authors connect the distribution center to the operation of the warehouse, either as a supernumerary or as a subset. Rimienė & Grundey (2007) claim that the term logistics center appeared in the 1970s. Distribution activities and storage are also included among the functions of the logistics center. According to the authors Rimienė & Grundey (2007), distribution management came to the forefront in the 1950s when companies developed new approaches to the market. The use of computer-controlled devices started to enable calculation and planning of new market tactics, such as market segmentation and additional profit maximization. With the development of the supply chain concept in the 1980s, the concept of consolidation developed. The term logistics center is, therefore, more recent and is a consequence of the development of the operation of distribution centers. Logistic centers have shifted to larger or smaller regional centers by providing services to the wider international environment (Du & Bergqvist, 2010). Recently, these concepts have been extended to the concept of logistic platforms worldwide, where several logistics trials and pilot projects have been dedicated to establishing LPs or in some cases regional LPs, going beyond the framework of a logistics center (Gajšek et al., 2018).

The differences between logistics and distribution centers are in the number of functions. Authors Rimienė & Grundey (2007) thus explain that there are three levels of logistics facilities, which can be attributed to activities that developed with the development of global trading. Distribution centers add the task of transport and transshipment to basic warehousing activities. Logistic centers also deal with the management of material and supplies and the final composition of products. In their recent work on logistics platforms, several authors rely on the findings of Meidute (2005) on logistics centers: “This phenomenon has not yet received an agreed name […]. The main terms for logistics centers utilized in Europe can be varied by country.” (Gajšek & Rosi, 2015).

With the emergence of the concept of a logistics center, which represents an important element in the management and control of goods flows, many definitions have emerged that define logistics centers and equate them with other concepts and concepts such as transport centers, ports, intermodal terminals, distribution centers, "Freight Villages", traffic nodes, etc. (Özdemir, 2010). The concept of Freight

Villages is defined as a designated area within which all transport, logistics, and distribution activities are carried out, both for national and international transit; these activities are performed by various contractors (The European Logistics Platforms Association, 2019). The Plate Forme Logistique and Plat Forme Multimodales concept is a French concept that follows the concept of logistics platforms that the authors equate with the Freight Villages concept. Leal & Salas (2009) equate the logistics platform with the Freight Villages concept and define it as a specialized area with the infrastructure and services needed for co-modal transport and value-added services where different agents coordinate activities to achieve competitiveness of products using the available infrastructure. The German concepts (Güterverkehrszentrum) are based on the assumption of rationalization of spatial and functional urbanized systems. The Italian significance of Interporto is linked to the strategy of liberalizing port services and increasing competition between ports aimed at promoting Italian exports and transit through Italian ports.

The term logistics center is very popular in the professional field and science. However, it is important to emphasize that there is often a misunderstanding of the variety of meanings of terms, such as logistics centers, distribution centers, or even freight terminals. The mismatch of terminology in logistics can have negative consequences for both economic and social functioning as well as for the development of environmental protection systems. Adopting the literature review is an expedient approach to gaining an in-depth understanding of the use of different terms for the same set of functions. With the combination of science mapping and a qualitative literature review, this paper aims to perform an in-depth analysis of the current literature in the field of logistics/distribution centers in order to determine the relationship among the terms "logistics center" and "distribution center" and to determine in which ways the terms are used in relevant literature, thus achieving the goals posed in the paper title. The main research question therefore is to determine in what scope, relation and context scholars use the terms logistics center and distribution center, and ultimately, to give a proposal for unification of scholarly use of bot terms in accordance to their common definitions.

2. METHODOLOGY

The study used a three-stage examination of the literature summarizing the research field of logistics center vs. distribution center. A science mapping approach was used in the review for bibliometric analysis and scientific analysis.

Bibliometric search in Scopus was the first step of the review process and was performed in June 2019. For purposes of filling the literature pool, the search string "logistics cent*" AND "distribution cent*" was used to search for publications. Since the main research aim is focused on examining the use of both terms in the literature, only publications concerning both terms in their various forms (such as singular/plural or British/American spelling of the word center) were searched for. The search was performed in Scopus because it is found to cover more journals and delivers more publications than e.g. WOS (Aghaei, et al., 2013). Moreover, all the publications that were the result of searching in WOS were also included in Scopus search results. We searched in the whole document, not only in the title, abstract, and keywords, to ensure that all publications mentioning both terms were included. 549 documents were found, and out of those, 50.6 % were journal papers; 42 % were conference papers; 3.8 % reviews; 2 % books or book chapters; and 1,45 % other sources. In accordance with the set research goals, all the search results were included in the literature analysis.

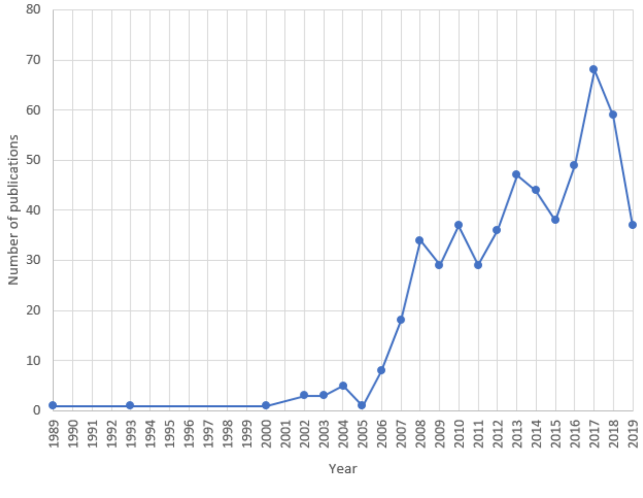
After the basic bibliometric search, scientometric analysis was conducted by utilizing the text-mining tool VOSviewer (van Eck & Waltman, 2014). The publications from the literature pool were analyzed first according to their publication year to determine whether there is a growing body of literature using the considered terms. Next, the most relevant sources of documents were determined in order to pinpoint the research fields that utilize the terms most. Then, a keyword analysis was performed to analyze the author keywords and find which expressions are most often used in the literature and their interrelations, which also enabled a visual display of the topics that are of largest interest to the research field. Moreover, an analysis of the most relevant authors and publications was performed in order to identify the main influential forces in the considered research field.

Based on results from the scientometric analysis, a qualitative literature review was performed which included the most cited publications from the literature pool to determine in what ways the most prominent scholars use the terms. The main goal of this part was to perform a deeper analysis of the use of both terms and to possibly find a commonly used definition to explain the relationship between these terms.

3. RESULTS

The 549 results from the literature pool were first analyzed from the perspective of their year of publication (see Fig. 1). Since this paper is published in 2019, the number of results for this year is expected to rise significantly by the end of the year (the literature pool includes publications, published up to June 2019).

Figure 1. Time distribution of results

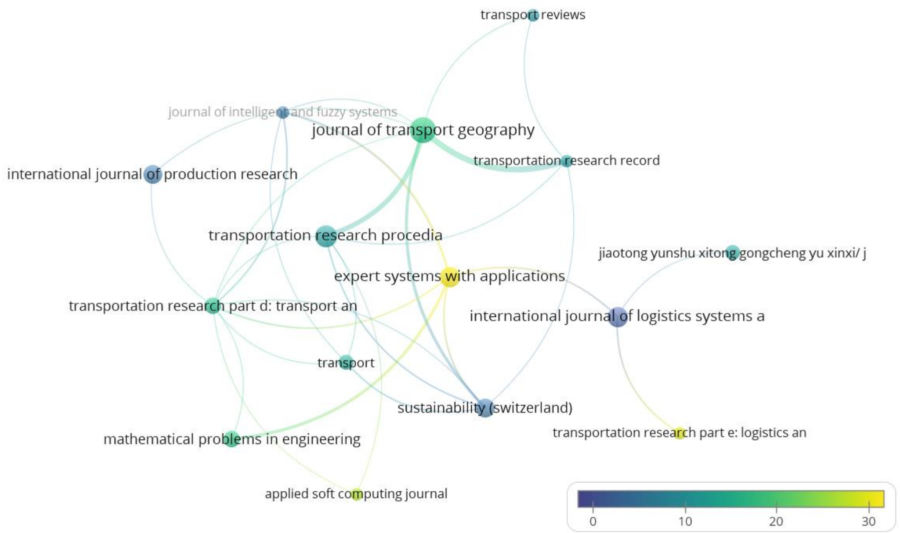


The first releases in this area originate from 1989, and an increase in publications is recorded after 2005. Most results in the area of simultaneous use of the term "logistics center" and "distribution center" were in 2017 (68 documents).

3.1 Publication sources

An analysis of sources of publications (journals, conferences, books) was performed in order to determine where scholars, researching the selected field, mostly publish their results, and which sources are most cited and therefore most relevant for the research field. VOSviewer identified 343 unique sources. For further analysis, only sources with at least 3 publications in the literature pool and that were cited at least 15 times were included. This way, only the most relevant sources were included in the science mapping process in this stage. Out of the unique sources, 19 met the given threshold. One of those, Transportation research procedia is connected to publishing conference papers, others are scientific journals (see Fig. 2.). The size of the nodes indicates the output of individual sources in terms of the total number of publications and the color of the node indicates the average number of citations of a document, published in that source. The most productive source in those terms is Journal of transport geography (11 documents, 192 citations), followed by Expert systems with applications (7 documents, 1142 cittaions) and Transportation research procedia (8 documents, 86 citations). The color and thickness of the links between sources point to sources that have cited each other. The strongest connection in this regard can be detected among the pair of Expert systems with applications and Mathematical problems in engineering, and the pair of Journal of transport geography and Transportation research procedia. Only 15 sources have links (citations) among them, so only those are shown on the figure.

Figure 2. Visualization of sources



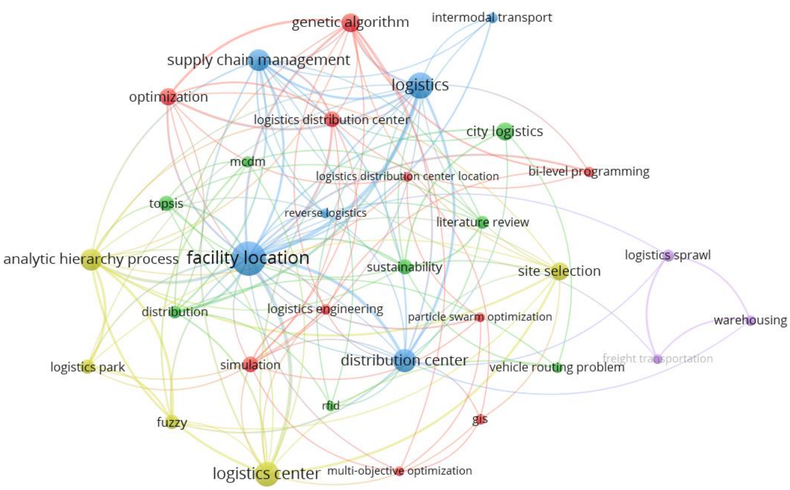
3.2 Keyword analysis

Keyword research is particularly appropriate in this case since it enables the identification of the core content of existing research and describes the research topics. The network of the author keywords defines what the most important elements of research in a specific field are can be essential for understanding the field (Su & Lee, 2010). The keyword co-occurrence also presents a different level of science and bibliography research which potentially establishes the relationships among network actors (Su & Lee, 2010).

With the co-occurrence of author keywords analysis, the inter-closeness among them can be determined (van Eck & Waltman, 2014). There are a total of 1430 unique author keywords in the entire database of documents used. With the inclusion criteria set so that the minimum number of occurrences of a keyword is set at 5, 45 author keywords remained. A further refinement of keyword hits was made to combine synonyms (for example »urban logistics« and »city logistics«; »distribution center« and »distribution centre«). Finally, 32 keywords were used to generate the visualization of author keywords (Fig. 3). Keywords are also divided into clusters within which the keywords have closer internal relationships. As with the previous figure, the size of the node and font indicate a keyword's occurrence frequency. The most frequently studied keywords include »facility location«, »logistics«, »logistics center«, »distribution center«, and "supply chain management". The keyword "logistics center" is mostly connected with location (»site selection«, »location selection«, etc.) and "distribution center" is mostly connected with logistics/SCM and location.

As the analysis showed, there is no notable connection between »logistics center« and »distribution center« itself, which points to the fact that authors do not use both terms interchangeably or do not perform research that would focus on various aspects of difference among the two concepts.

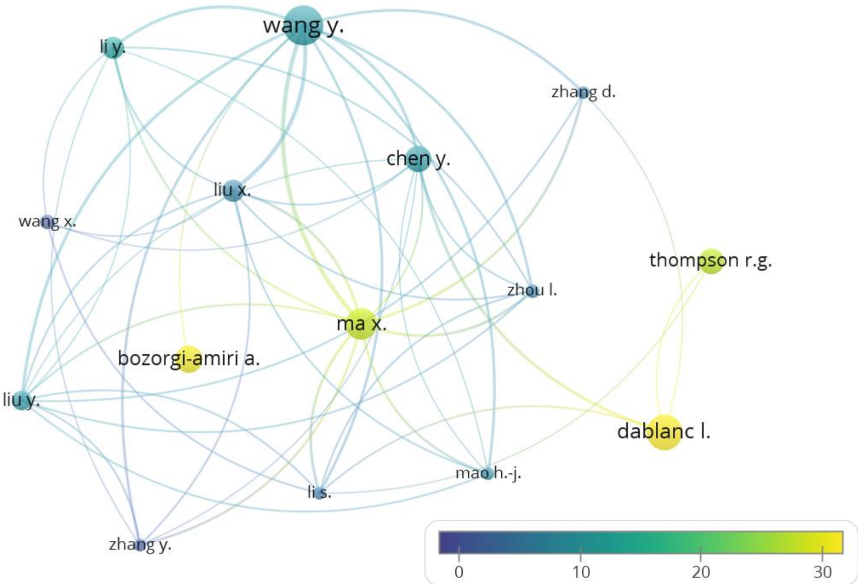
Figure 3. Visualization of author keywords (connections show interrelated keywords)



3.3 Scholars in the field of logistics and distribution centers research

The analysis of most cited authors in the field of logistics/distribution centers was also carried out using VOSviewer. 1142 scholars were identified as contributiong to the research field. In this part, the minimum number of documents and minimum citation number of a scholar were set at 3 and 20 respectively to ensure inclusion of the most important publications and scholars. As a result, a total of 24 scholars met the threshold, but only 15 of them relate to each other and are therefore shown on the network (Fig. 4). The font and circle size for each scholar indicates their number of publications in the literature pool, and the colour of the node represents the number of citations of the scholar.

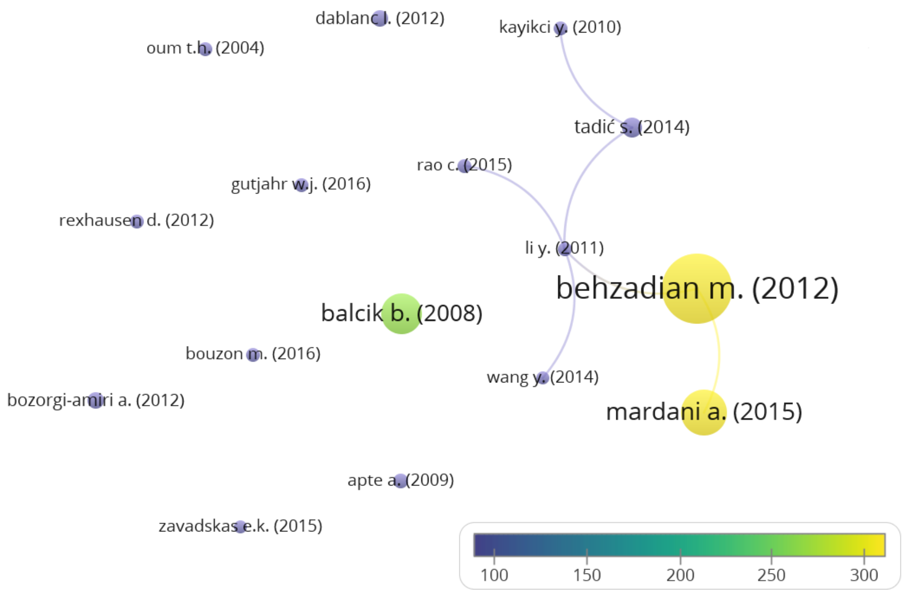
Figure 4. Visualization of scholars in logistics and distribution centers publications (weights: citation)



3.4. Document analysis

The purpose of this part of the research is to examine the citation number of each document, which will point to the most important and influential publications on the topic of logistics and distribution centers. In this case, the minimum number of citations of each document was set at 50, which resulted in the inclusion of 17 documents, which were also the subject of further investigation in the qualitative discussion of the literature pool (Fig. 5). Behzadian, M., Balcik, B., Merdani, A., and Tadič, S., whose paper proved to be the most cited in the literature pool, are authors who mainly deal with methodology (Topsis, Fuzzy, ..) and their work is, therefore, most relevant for almost all scholars in the considered field.

Figure 5. Visualization of the most cited documents



4. QUALITATIVE REVIEW

Displayed bibliometric analysis and science mapping of the literature is the basis for qualitative work, which will focus on the field of summarizing the main research areas within the logistics/distribution centers research field. The five clusters of keywords identified in Fig. 3 are not separated but are interconnected as a whole. For example, the keyword »logistics center« has a strong link with »location selection«, which has an important link with the »distribution center«.

As mentioned above, the separation between logistics centers and distribution centers is difficult to place in a multitude of different definitions. Many authors tend to analyze the historical development of logistics services and facilities and consequently also define the concept of a logistics center or a distribution center (Rimienė & Grundey, 2007; Gafurov, et al. 2014; Montwiłł, 2014; Skjött-Larsen, et al., 2003; Özdemir, 2010; Kabashkin, 2007; Cheung, et al., 2003). Meidute (2005) defines a logistics center as a link that combines different types of transport with the task of promoting intermodality. The author equates the concept of a logistics center with an intermodal terminal, which is a key element of the intermodal transport chain. Rimienė and Grundey (2007) state that the most comprehensive explanation of the concept of a logistics center is related to the understanding of distribution centers, central warehouses, freight/transport terminals, transport hubs, logistics platforms, freight villages, etc. Only some authors who define the logistics/distribution center in their work are mentioned here, but one definition or rather concept stands out as the most comprehensive. Du and Bergqvist (2010) developed a conceptual framework of international logistics centers to define characteristics of logistics centers with cluster analysis of diverse terms and concepts which relate to logistics centers, and with that, this paper can be seen as the most important from the viewpoint of classifications of various development stages of distribution and logistics centers.

There have been multiple studies focusing on researching aspects of logistics centers or distribution centers, however, there are only a few studies that mention both terms at the same time (logistics center and distribution center). The key documents in this field have already been presented here with bibliometric and science mapping approaches, and in the following, we provide an analysis of the definitions of these terms within these documents based on the publications, which mention logistics centers and distribution centers and have been cited 50 times or more. There are 17 publications that fit the criteria (see Fig. 4). These publications were read and analyzed based on their mention or use of the terms distribution and logistics center. The results of this analysis are shown in Table 1.

Table 1. Analysis of the use of "logistics center" and "distribution center" in most cited papers from the literature pool.

Authors	Publication title	Use of terms
Behzadian, Otaghsara, Yazdani, & Ignatius, 2012	A state-of the-art survey of TOPSIS applications	The paper does not directly mention distribution or logistics centers, it only mentions the terms in titles of papers it analyses.
Mardani, Jusoh, & Zavadskas, 2015	Fuzzy multiple criteria decision-making techniques and applications – two decades review from 1994 to 2014	The paper does not directly mention distribution or logistics centers, it only mentions the terms in titles of papers it analyses.
Balcik, Beamon, & Smilowitz, 2008	Last mile distribution in humanitarian relief	Mentions the United Nations Joint Logistics Centre (UNJLC). Defines distribution centers as tertiary hubs (local and temporary distribution centers) as the beginning of last mile delivery to deliver relief supplies.
Tadić, Zečević, & Krstić, 2014	A novel hybrid MCDM model based on fuzzy DEMANTEL, fuzzy ANP and fuzzy VIKOR for city logistics concept selection	The paper defines a logistics center as one of the initiatives in city logistics that "enable the consolidation of flows starting outside the specific metropolitan area or the city, with the aim of unifying transport activities within the area or the city." It defines different categories of logistics centers: freight villages, city logistics terminals, satellite terminals, intermodal terminals.

		Distribution centers (or warehouses) are defined as points on the outskirts of the central city area where freight is transshipped to smaller vehicles for further distribution.
Bozorgi-Amiri, Jabalameli, Alinaghian, & Heydari, 2012	A modified particle swarm optimization for disaster relief logistics under uncertain environment	(Relief) distribution centers are used as nodes where supplies are stored and from which supplies are shipped to affected areas in a relief operation. Logistics centers are only mentioned in the literature review.
Dablanc, & Ross, 2012	Atlanta: a mega logistics center in the Piedmont Atlantic Megaregion (PAM)	The paper recognises that the city of Atlanta is a “logistics centre” in the PAM region, and uses the term “distribution centre” as a name for a warehousing/freight forwarding hub.
Apte, 2010	Humanitarian logistics: A new field of research and action	The paper defines distribution centers as an important part of humanitarian logistics. They represent critical facilities for relief efforts and supply emergency supplies and services. The term “logistics center” is mentioned only in the literature review.
Rao, Goh., Zhao, & Zheng, 2015	Location selection of city logistics centers under sustainability	The paper describes a City logistics center as a key logistics node, and uses the definition that a CLC is “a logistics facility that is situated in relatively close proximity to the geographic area that it serves, from which consolidated deliveries are performed within that vicinity (…), and a range of other value-added logistics and retail services can also be provided at the CLC.” The term “distribution center” is mentioned only in the references.
Li, Liu, & Chen, 2011	Selection of logistics center location using Axiomatic Fuzzy Set and TOPSIS methodology in logistics management	No definition of a logistics center is given. The term “distribution center” is mentioned only in the literature review.
Kayikci, 2010	A conceptual model for intermodal freight logistics centre location decision	The paper uses the definition: “An intermodal freight logistics center is a cluster of quality industrial/intermodal /distribution/logistics buildings located within a secure perimeter where a

		range of support services are provided by every user." The term "distribution center" is mentioned only in the literature review.
Bouzon, Govindan, Rodriguez, & Campos, 2016	Identification and analysis of reverse logistics barriers using fuzzy Delphi method and AHP	The terms "distribution center" and "logistics center" are mentioned only in the literature review.
Gutjahr, & Nolz, 2016	Multicriteria optimization in humanitarian aid	The paper uses the term "distribution center" for describing the intermediate facility connecting suppliers and areas needing relief supplies. The term "logistics center" is mentioned only in the literature review.
Rexhauen, Pibernik, & Kaiser, 2012	Customer-facing supply chain practices – the impact of demand and distribution management on supply chain success	The terms "distribution center" and "logistics center" are mentioned only in the references.
Oum, & Park, 2004	Multinational firms' location preference for regional distribution centers: focus on the northeast Asian region	The paper defines a firm's distribution center as "a base for providing raw materials, components, and/or finished goods to its surrounding region, in connection with the rest of its global logistics system". A logistics center is seen as a broad term describing a concentration on logistics activities in a wider geographical area, such as a city.
Wang, Ma, Lao, & Wang, 2014	A fuzzy-based customer clustering approach with hierarchical structure for logistics network optimization	A distribution center is seen as a transport hub, operated by logistics companies. The term "logistics center" is mentioned only in the references.
Zavadskas, Turskis, & Bagočius, 2015	Multi-criteria selection of deep-water port in the eastern Baltic sea	The paper equates the terms logistics center and distribution center (e.g. "(…) adds to the port's attractiveness by readying lands for a port-related Export Processing Zone or Distribution Centre (logistic centre) for potential investors." It does not offer a definition of any term.

Soto-Silva, Nadal-Roig, González-Araya, & Pla-Aragones, 2016	Operational research models applied to the fresh fruit supply chain	The terms “distribution center” and “logistics center” are mentioned only in the literature review.

Overall, it is evident that the most cited papers, which contain both “distribution center” and “logistics center” in their text, would not offer much insight into information regarding the main goal of the present research, which is to find a delimitation between logistics and distribution centers. For this reason, a qualitative examination of publications that have both terms in their keywords (logistics center and distribution center) was performed. Out of the 549 Scopus documents in the literature pool, both terms are contained in 21 publications’ keywords, meaning that those publications are concerned directly with those concepts. Chang and Lin (2017) find that most of the cities do not have both types of centers (logistics and distribution), and thus there is a problem to compare the differences. Ying (2014) uses the term Logistics Distribution Center in his work and defines Logistics center as a new concept that is mainly in use in academic and corporate circles in Asian countries, and even there, the term can have a broader meaning that focuses on a wide array of logistics activities an facilities, including various freight terminals and operators, and a narrower meaning which focuses on the management efficiency of logistics and behavior. Even then, the paper does not offer a definition of a logistics center, but rather focuses on its locating and role in the logistics network. Ren and Peng (2014) see a logistics center as a second level node and as a supporting facility for logistics parks that aim to maximize efficiency using the centralization and scale effect. A logistics center is an important terminal in a logistics system, and it plays an important role in the whole logistics system, whereas distribution centers are supporting actors for logistics centers in a logistics network and need to be allocated accordingly (e.g. Sternad et al., 2018). Changjiang and Jinxing (2009) studied the site selection of logistics distribution centers and proposed a model for it. They used the term “logistics distribution center”, but they do not define the term itself, nor is the scope of activity in such a center determined. Chou (2010) pointed out that in order to reduce the international supply chain operation cost (see e.g Sternad (2018) for more details about this), the company needs to invest in international logistics centers, because their role as bases for merchandise transportation and distribution has become increasingly important. Yu et al. (2009) find that logistics centers are used as a facility to improve commodity handling (sorting, storage, processing) and its location needs to be determined precisely in order to enable overcoming barriers in the transportation process. They do not, however, define a distribution center, even though the paper title talks about locating distribution centers in logistics. Guan et al. (2009) point out the role logistics centers have in ensuring efficiency in logistics by enabling storage, transport, and distribution processes, whereas distribution centers have limitations due to competition and their inability to process demands from a single customer. They do not, however, delimitate both terms further.

Qualitative analysis of the most relevant publications in the literature pool has inevitably shown that the terms “logistics center” and “distribution center” are commonly used, but there are no sources that would clearly define both terms and show their common points and differences. Publications that use both terms either define just one or the other or do not define them at all.

5. CONCLUSION

Researchers use the terms “logistics center” and “distribution center” vastly, but there does not seem to be a consensus on the meaning of both terms and especially on their relationship. Based on the results of the presented research, we can conclude that the terms are most often not viewed as synonyms, but this is not the generally accepted norm either. Various authors use various combinations of both terms; even terms like “logistics distribution center” appear in the relevant literature. Therefore, the main conclusion of this paper is that there is a dire need to unify the terminology used in the logistics field when it comes to logistics and distribution centers. We can conclude with some reservations that most scholars see distribution centers as a narrower concept than logistics centers, where distribution centers most often serve as a warehousing and transshipment facility, and logistics centers include a broader scope of services, including value-adding services, and encompass a larger array of customers and logistics providers.

Further research should focus on determining the attitude of scholars and practitioners towards the terms logistics center and distribution center and mostly on evaluating their differences and relationships. With this, scholarly and practitioner work will have a better understanding of the concepts and a framework to use when talking about logistics facilities. A deeper literature review with the goal of extracting definitions for both terms from the literature concerning only one of the two concepts individually should also be performed.

In the meantime, however, we advise scholars and practitioners to include a definition of the used terms and an explanation of their relationships when both terms are being used simultaneously. By using an already existing hierarchy of different scopes of logistics centers, such as that by Du and Bergqvist, an additional layer of clarity can be achieved in the logistics centers research field as well.

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LOGISTICS 4.0 IN WAREHOUSING – CURRENT STATE AND TRENDS

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Abstract

The aim of the article is to analyse the state of advancement of the Logistics 4.0 concept from the perspective of science and practice – evaluation of the current situation and the main trends for its development in warehousing. In the theoretical part, a systematic review of the literature was carried out – the subject of the bibliographic analysis were scientific articles indexed in the Scopus and Web of Science databases. The aim of the theoretical part is to identify key topics, people, research centres, countries, fields of science and journals – important for the development of Logistics 4.0. In the practical part the characteristics of the PROMAG case study – a fully autonomous and automatic AutoMAG Mover storage system – are presented, illustrating the main area of global interest within the framework of warehouse intralogistics 4.0. The aim of the practical part is to show the advancement of the Logistics 4.0 application in warehouses.

Logistics 4.0 is most often located in the following fields: Engineering and Computer Science. This shows that Logistics 4.0 deals very much with modern technical and technological issues. Evidently there is a strong trend towards autonomous and automatic functioning of facilities in the storage area. Within Logistics 4.0 two distinct trends of interest can be distinguished: processual and technical – technological.

The analysis of the state of knowledge in the field of Logistics 4.0 is based on articles from two scientific databases – Scopus and Web of Science. The key area of interest in intralogistics 4.0 is illustrated by one selected example. In the future, the author plans to expand and deepen the analysis of articles dedicated to Logistics 4.0 (new sources) and carry out surveys on Logistics 4.0 among Polish intralogistics companies The digitization of warehouse intralogistics 4.0 implies the need to change the roles and tasks of people operating in this area. It creates both threats and opportunities for employers and employees.

Keywords: Logistics 4.0, Industry 4.0, systematic literature review, Scopus, Web of Science, warehousing, storage systems, autonomy, automatization, case study

1. INTRODUCTION

In the era of the 4th industrial revolution, against the backdrop of broadly understood digitalization, the transformation of business logic is taking place. Its visible manifestation in the organization of processes is the increase of their autonomy through the wide application of automation. A typical element for Industry 4.0 and Logistics 4.0 is putting modern informatics and information technologies into practice. Contemporary warehouse intralogistics 4.0 is based primarily on artificial intelligence and technological equipment. The functioning of Industry 4.0 is not possible without complementary existence next to Logistics 4.0. An intelligent factory indisputably needs an intelligent warehouse.

The Industry 4.0 stream, whose beginnings go back to 2011, has for several years been the area in which strictly logistic issues are also discussed – Industry 4.0 inclusive of Logistics 4.0. Since 2015, however, we have been able to observe progressive autonomy of Logistics 4.0 – its formal release as a separate thematic stream. The subject of interest of this article is generally Logistics 4.0, in particular warehouse intralogistics 4.0, at the intersection of science (articles from Scopus and Web of Science databases) and practice (case study – the AutoMAG Mover warehousing system by the PROMAG company). As of now, Scopus and Web of Science databases do not contain many publications on this subject – hence the list of references in this article is so short. Logistics 4.0, however, is an evolving topic and apart from Scopus and Web of Science databases, much more about this subject is being published in other sources (e.g. Google Scholar).

The research problem of the article focuses on assessing the advancement of Logistics 4.0 in the warehouse logistics system. The aim of the article is to analyse the state of advancement of the Logistics 4.0 concept from the perspective of science and practice – evaluation of the current situation and the main trends for its development in warehousing. The aim of the theoretical part is to identify key topics, people, research centres, countries, fields of science and journals – important for the development of Logistics 4.0. The aim of the practical part is to show the advancement of the Logistics 4.0 application in warehouses. In the article, the author performed the theoretical meta analysis of the Logistics 4.0 concept (Scopus and Web of Science databases) and presented a practical solution in this area from the Polish market (case study).

The paper is organized as follows: section 1 – introduction (research problem, goals – general, theoretical, practical), section 2 – state of Logistics 4.0 in scientific literature (Scopus and Web of Science databases); section 3 – subject of research (PROMAG S.A. company); section 4 – case study (autonomous automatic warehouse AutoMAG Mover system); section 5 – general conclusion (summary).

2. STATE OF LOGISTICS 4.0 IN SCIENTIFIC LITERATURE

2.1. Logistics 4.0 in the Scopus Database

Based on the search criterion “logistics 4.0” as of 1.12.2018, only 20 potential articles were identified in the Scopus database that have this term in their title, abstract or keywords. Further analysis of 19 articles was conducted (one article was excluded – accidental hit, an article from before the establishment of the term Logistics 4.0).

The distribution of the number of articles about Logistics 4.0 is as follows: 2015 – 1, 2016 – 3, 2017 – 3, 2018 – 9, 2019 – 3. The most cited authors are: Polak-Sopinska A., Wisniewski Z., Wrobel-Lachowska M. – 4 articles each. The most important research centres where the concept of Logistics 4.0 is discussed are: Lodz University of Technology (4 affiliations) and Otto von Guericke University of Magdeburg (2 affiliations). From the national perspective, Logistics 4.0 first of all is discussed in: Poland (6 articles) and Germany (5 articles). Logistics 4.0 is most often located in the following fields: Engineering (12 articles), Computer Science (10 articles), Social Sciences (6 articles), Business Management and Accounting (4 articles), Mathematics (4 articles). Publications about Logistics 4.0 mostly take the form of conference papers (10 articles) or articles (7 articles). They are usually placed in journals (7 articles), as book series (7 articles) and conference proceedings (5 articles). The most important titles in the Logistics 4.0 topic are: Advances in Intelligent Systems and Computing (5 articles), Journal of Applied Engineering Science (2 articles) and Proceedings, GOL’2018: International Conference On Logistics Operations Management (2 articles). Apart from two articles in German, English is the dominant language of publications.

The identified 19 articles cover a broad spectrum of topics related to Logistics 4.0., e.g. they take up the issues of: education and theory of information (a large collection of articles), as well as transport, maintenance, ergonomics (single publications). From the perspective of the subject of this article, publications devoted to the general assumptions of Logistics 4.0 (6 articles) comprise:

1. The framework of Logistics 4.0 Maturity Model (Oleśków-Szłapka & Stachowiak, 2019),
2. Industry 4.0, Logistics 4.0 and materials – Chances and solutions (Glistau & Machado, 2018),
3. Costs of transaction in Logistics 4.0 and influence of innovation networks (Loureiro et al., 2018),
4. Logistics 4.0 and emerging sustainable business models (Strandhagen et al., 2017),
5. Industry 4.0 implications in logistics: an overview (Barreto et al., 2017),
6. Logistics 4.0: The vision of the Internet of Autonomous Things (Hompel & Kerner, 2015).

Oleśków-Szłapka and Stachowiak present the framework of Logistics 4.0 Maturity Model, developed to provide companies with an opportunity to assess the current status with respect to Logistics 4.0 and develop a road map for the improvement process (Oleśków-Szłapka & Stachowiak, 2019). Glistau and Machado – 1 citation – present the overview of important solutions in Industry 4.0 and Logistics 4.0 as two of the most important trends in production and logistics (Glistau &

Machado, 2018). Loureiro, Simões and Cartaxo focus on the reduction of transaction costs through Logistics 4.0 in information systems (Loureiro et al., 2018). Strandhagen, Vallandingham, Fragapane, Strandhagen, Stangeland and Sharma – 3 citations – present current trends in the drive towards Logistics 4.0 as an element of Industry 4.0 (Strandhagen et al., 2017). Barreto, Amaral and Pereira – 7 citations – present reflections regarding adequate requirements and issues enabling organizations to be efficient and fully operational in the Logistics 4.0 context (Barreto et al., 2017). Hompel and Kerner – 6 citations – present the question of changing the paradigm in the fourth industrial revolution according to the vision of Logistics 4.0 (Hompel & Kerner, 2015).

Of the 19 identified articles, only 2 of them are strictly thematically related to warehousing:

1. Technical potentials and challenges within internal Logistics 4.0 (Schmidtke et al., 2018),
2. Proceedings, GOL'2018: the 4th IEEE International Conference on Logistics Operations Management (GOL, 2018).

Schmidtke, Behrendt, Thater and Meixner present the impacts of changes on the logistics sector within Industry 4.0 as well as on technical potentials for internal logistics (Schmidtke et al., 2018). Proceedings, GOL present technical potentials and challenges within internal Logistics 4.0 (GOL, 2018).

In the literature query, attention was also drawn to three other articles, which although are not directly related to warehousing, may have significance for this field of logistics:

1. Ethanol loading and dispatch operation: A discussion on management practices and Logistics 4.0 (Jacintho et al., 2018),
2. The development of telematics in the context of the concepts of "Industry 4.0" and "Logistics 4.0" (Bujak, 2018),
3. Logistics 4.0 – A challenge for simulation (Timm & Lorig, 2016).

Jacintho, Da Silva, Do Nascimento, Poveda, Cevoli and Ribeiro present a new model of loading and dispatch operation of an ethanol plant based on management within Logistics 4.0 (Jacintho et al., 2018). Bujak indicates trends and directions of changes in the implementation of the latest telematics solutions (Bujak, 2018). Timm and Lorig discuss two integrating approaches to simulate decision makers and logistic processes in the context of Logistics 4.0 [Timm & Lorig, 2016).

2.2. Logistics 4.0 in the Web of Science Database

Based on the search criterion "logistics 4.0" as of 1.12.2018, only 7 potential articles were identified in the Web of Science database that have this term in their title, abstract or keywords. All 7 articles were analysed further: 5 articles are the same articles that appeared earlier in the Scopus database, 2 articles are new – they are only available in the Web of Science database.

The distribution of the number of articles about Logistics 4.0 is as follows: 2015 – 1, 2016 – 1, 2017 – 2, 2018 – 3. The most cited authors are: Polak-Sopinska A., Wisniewski Z., Wrobel-Lachowska M. – 2 articles each. The most important research centres where the concept of Logistics 4.0 is discussed are: Lodz University of Technology and Norwegian University of Science and Technology – 2 affiliations each. From the national perspective, Logistics 4.0 first of all is discussed in: Germany (3 articles), Norway (2 articles) and Poland (2 articles). Logistics 4.0 is most often located in the following fields: Engineering (3 articles), Computer Science (2 articles), Operations Research Management Science (2 articles). Publications about Logistics 4.0 most often take the form of proceedings papers (6 articles), the form of articles is rare (1 article). The most important title in the Logistics 4.0 topic is Advances in Intelligent Systems and Computing (2 articles). All 7 articles are published in English.

Of the 7 identified articles related to Logistics 4.0, the subject of education and theory of information dominates (which is not the matter of interest for this article). From general papers devoted to the concept of Logistics 4.0, the article entitled “Logistics 4.0 and emerging sustainable business models” (Strandhagen et al., 2017) – 1 citation – is repeated. Among the papers related specifically to warehousing, the article entitled “Technical potentials and challenges within internal logistics 4.0” (Schmidtke et al., 2018) is repeated – this is the only paper in the Web of Science database that deals with the subject matter of logistics within the framework of Logistics 4.0. Other papers, although not directly related to warehousing, may have significance for this field of logistics. The article entitled “Logistics 4.0 – A challenge for simulation” (Timm & Lorig, 2016) – 1 citation – is repeated.

In the context of the subject of this article, among the two new papers (appearing only in the Web of Science database), the article by Wang – Logistics 4.0 Solution New Challenges and Opportunities (Wang, 2016) – draws attention. Wang presents the outline of the vision of “Logistics 4.0” – the definition and proposition of some basic technical components of Logistics 4.0 with two laboratory cases how to implement the technologies in Logistics 4.0 (Wang, 2016). The second of the new papers concerns education (no relation to the subject of this article).

2.3. Logistics 4.0 in the Industry 4.0 stream in the Scopus and Web of Science Database

In connection with the resulting low number of identified articles devoted to Logistics 4.0, the author decided to carry out a preliminary, broader literature search. The search was also conducted on 1.12.2018 and consisted in an attempt to specify the defined criteria in titles, abstracts or keywords. The adopted search criteria included: 1 – “logistics*”, 2 – “warehouse*”, 3 – “industry 4.0”. The results of the literature search are presented in Table 1.

Table 1. Number of articles dedicated to logistics (1), warehousing (2) and Industry 4.0 (3) – compilation based on the Scopus Database and the Web of Science Database

Query	Scopus	Web of Science
1	451 590	325 151
2	31 264	16 748
3	3 526	2 157
1 + 2	3 435	1 907
1 + 3	187	130
2 + 3	35	29
1 + 2 + 3	17	12

Source: own study

It has been observed that logistic issues, thematically related to warehousing, are also indexed within the Industry 4.0 term (as a historically earlier concept). Thus, Logistics 4.0 (although not mentioned directly from the label) also has its great achievements within the Industry 4.0 stream. Therefore, a more thorough search was carried out on 10 April 2019 by specifying the defined criteria in titles, abstracts and keywords. The adopted search criteria included: “warehouse*” and “industry 4.0”. The results of the literature search are presented in Table 2.

Table 2. Literature trends about warehousing within the Industry 4.0 stream based on the Scopus Database

Topics / Year	19	18	17	16	15	14	13
robots	1	8					
RFID	1	3	2		1		1
modelling, optimization, simulation	1	3	1			1	
cyber physical systems		2	3	1			
data warehouse		3	2				
Big Data	1	2			1		
autonomous vehicles		1	2		1		
Internet of Things		1	2	1			
multi agent systems	1	1	1				
general, concept		2		1			

Source: own study

Based on 52 articles, warehouse intralogistics 4.0 is shaped by several trends, with two being predominant: robotics and RFID (Table 2). The analysis of the publication points out that within the scope of warehouse intralogistics 4.0, special interest focuses primarily on the possibilities offered by solutions related to autonomous automatization. For this reason, in the next practical part of this article, a case study of the automatization of warehouse processes will be discussed in detail, which shows the implementation of the concept of Logistics 4.0 in practice.

3. CHARACTERISTICS OF PROMAG S.A.

The subject of the case study is a company PROMAG S.A. (https://promag.pl, 07.12.2018), which has been operating on the market since 1982. For over 30 years, by combining extensive experience with modern solutions, PROMAG has been setting standards in Polish internal logistics. The mission of PROMAG is “to be an advisor and preferred business partner for our customers in the field of comprehensive warehouse equipment”. The vision of PROMAG is contained in the following words: “to optimize our customers’ warehouse space according to the most recent technical achievements in order to make it safe, ergonomic and efficient”.

The structure of the PROMAG company consists of: headquarters in Poznań, 10 customer service branches in Poland (Bydgoszcz, Bytom, Gdańsk, Kraków, Lublin, Łódź, Poznań, Szczecin, Warszawa, Wrocław), e-commerce sales via the online store www.e-promag.pl, a logistics centre with the area of 24 thousand square metres in

Koninko near Poznań, own production facilities with the area of 13 thousand square metres in Bolechowo near Poznań.

PROMAG, as a producer and integrator of comprehensive warehouse equipment, supports clients in the field of internal logistics by: logistics audit, technical consultancy, measurements and design, integration and production of storage systems and internal transport equipment, delivery and assembly of offered systems, notification of equipment to UDT, service and inspections, training in safe work in the warehouse.

The PROMAG offer is comprehensive and includes: automatic storage and transport systems in the warehouse, racks, forklifts, hoisting equipment, loading systems, packaging equipment, metal furniture, complementary storage equipment.

PROMAG actively supports the development of Polish intralogistics. In 2015 a cyclical forum “WAREHOUSE OF THE FUTURE” was initiated. The leading topics have so far been: “Warehouse of the future – how to reduce the costs of your business?”, “The future of business in the era of automatization and robotization”, “Warehouse 4.0 – digital integration of processes in intralogistics”, “Logistics 4.0 – evolution or revolution in warehouses?”.

In 2015 in Poznań, at the PROMAG Warehouse Technology Centre, which is the only such centre in Poland, a multimedia and practical exhibition “WAREHOUSE OF THE FUTURE” was opened (https://www.magazyn-przyszlosci.pl, 07.12.2018). The aim of the exhibition is to present interactively trends and the most modern solutions related to intralogistics. The central part of the exhibition is a fully automated transport line, picking, palletizing and storing in the warehouse where the latest technologies and solutions in the field of robotics and automation and product identification are applied.

A distinctive feature of PROMAG on the Polish intralogistics market is their look into the future, consisting in professional taking into account currently prevailing trends and using modern technologies.

4. CHARACTERISTICS OF THE AUTONOMOUS AUTOMATIC WAREHOUSE AUTOMAG MOVER

The AutoMAG Mover warehouse is a fully autonomous and automatic storage system, a development of semi – automatic dense storage system using AutoMAG Shuttle trolleys with an AutoMAG Mover transfer trolley and AutoMAG Lift vertical conveyors (https://www.automag-system.pl, 14.12.2018). The aim of this solution is to completely eliminate forklifts from the goods storage area and increase the efficiency and safety of warehouse processes.

The AutoMAG Mover system works as follows:

– step 1: delivery of a pallet load unit (PLU) to an automated system by a horizontal conveyor,

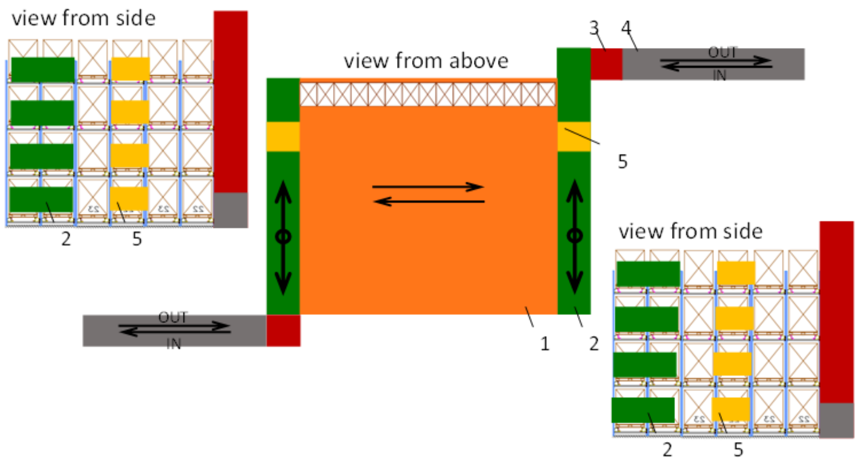
– step 2: transfer of a PLU from the horizontal conveyor to the AutoMAG Lift vertical conveyor,

– step 3: PLU transport by the AutoMAG Lift vertical conveyor to the required level in the rack block,

– step 4: loading of a PLU on the AutoMAG Mover transfer trolley along the shelf block to achieve the location of the designated rack channel,
– step 5: moving a PLU with the AutoMAG Shuttle trolley to the inside of the rack channel,
– step 6: return of the AutoMAG Mover transfer trolley to the AutoMAG Lift vertical conveyor in order to load the next PLU (steps 5 and 6 cannot be carried out simultaneously, because the AutoMAG Mover is not a pallet carrier, the pallet carrier is the AutoMAG Shuttle; so the AutoMAG Mover can only return for a pallet when the AutoMAG Shuttle is on it; so in step 5 the AutoMAG Stuttle transports the pallet to the rack channel and goes back to the AutoMAG Mover).

The AutoMAG Mover system offers a number of configuration variants. This article presents only two selected solutions: the flow of goods according to the FIFO principle in fast – moving warehouses (Figure 1) and the implementation of the flow of goods according to the LIFO principle for low – capacity warehouses (Figure 2).

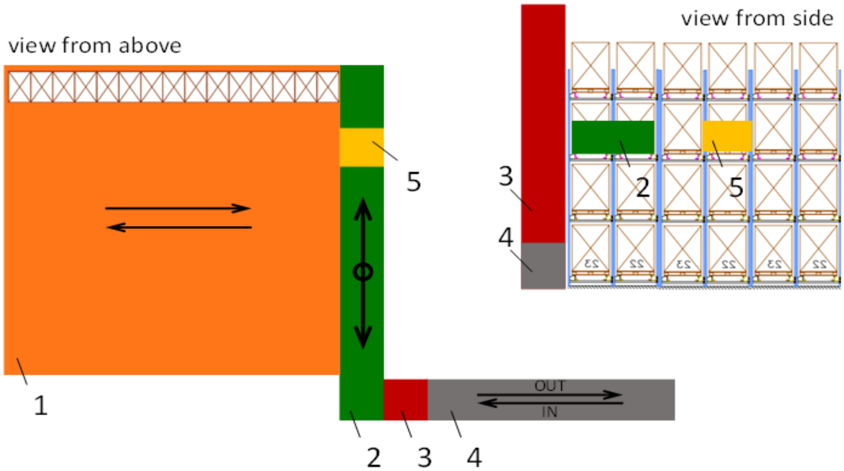
Figure 1. Diagram of the flow of goods according to the FIFO principle in fast – moving warehouses



Legend: (1) dense storage shelves, (2) transfer trolley AutoMAG Mover – 1 piece in each level of storage, (3) vertical conveyors AutoMAG Lift – 2 pieces, (4) horizontal conveyor – 2 pieces, (5) shuttle trolley AutoMAG Shuttle – 1 piece in each level of storage.
Source: own study

Regarding Figure 1, when reversible conveyors are used, loading and unloading can take place on both sides of the rack block, but it is more often the case that on one side there is loading and on the other unloading.

Figure 2. Diagram of the flow of goods according to the LIFO principle for low – capacity warehouses



Legend: (1) dense storage shelves, (2) transfer trolley AutoMAG Mover – 1 piece, (3) vertical conveyors AutoMAG Lift – 1 piece, (4) horizontal conveyor – 1 piece, (5) shuttle trolley AutoMAG Shuttle – 1 piece.
Source: own study

In low – capacity warehouses, the platform of the AutoMAG Lift vertical conveyor enables movement between levels in the rack block of not only a pallet load unit but also of the AutoMAG Mover transfer trolley and the AutoMAG Shuttle trolley. While in high – capacity warehouses, vertical conveyors collaborate with the AutoMAG Mover located at each level of storage in the rack block, guaranteeing high efficiency of work. The management of such a system is carried out using the WMS class software.

The main benefits that can be achieved by implementing the AutoMAG Mover system include: total automatization – eliminating forklift trucks from the area of goods storage, the ability to work 24 hours a day, increasing the efficiency of warehouse processes, fast and quiet pallet movement, shortening the time of warehouse operations, reducing fixed costs in warehouses, reducing the average storage cost of a pallet unit, high utilization coefficient of warehouse, constant control and inventory update, increased work safety, elimination of errors resulting from manual warehouse management.

The autonomous AutoMAG Mover system is used in fast and slow – moving warehouses (criterion – throughput), with a relatively small diversified range of goods. The AutoMAG Mover automatic system also works well in cold stores due to the high utilization coefficient of the warehouse volume, which allows to reduce the operating costs of such an object. The AutoMAG Mover system by PROMAG is therefore a flexible, versatile and modular solution.

5. CONCLUSION

At the moment the number of articles devoted to Logistics 4.0 is very small – Scopus (19), Web of Science (7). However, the dynamics of the growth of the number of articles is very rapid (year to year) – Scopus (200%), Web of Science (100%). In correspondence with the number of articles, also the number of citations of articles about Logistics 4.0 is very small – Scopus (8 articles), Web of Science (2 articles). The average citation for Scopus is 3.625 (with a citation range from 1 to 7), for Web of Science 0.429 (with a citation range from 1 to 1). Thus, the broader (number of articles) and more prestigious (number of citations) knowledge base on Logistics 4.0 is Scopus.

The most common practice is to put the "logistics 4.0" term in the title, abstract and keywords (Scopus 10 from 19 articles, Web of Science 4 from 7 articles). From the remaining articles in the Scopus database 1 article has the search term in the title and abstract, 1 in the abstract and keywords, 1only in the title, 3 only in the abstract, 4 only in keywords. From the remaining articles in the Web of Science database the search term only in the title, only in the abstract or only in the key words, is always included in only 1 of 3 articles. Therefore, the most effective publishing strategy is to put the "logistics 4.0" term wherever possible.

The most cited authors are: Polak-Sopinska A., Wisniewski Z. and Wrobel-Lachowska M. However, their papers concern the educational trend (no direct connection with the subject of this article). Logistics 4.0 is mainly the topic of interest in such countries as: Germany (mainly Otto von Guericke University of Magdeburg), Poland (mainly Lodz University of Technology) and Norway (Norwegian University of Science and Technology). Logistics 4.0 is most often located in the following fields: Engineering and Computer Science. This shows that Logistics 4.0 deals very much with modern technical and technological issues.

As part of Logistics 4.0, warehouse intralogistics enjoys niche interest. As part of the wider Industry 4.0 stream, the interest in Logistics 4.0 focuses primarily on storage systems, especially in terms of their autonomy and automatization. So, most papers about warehousing in Industry 4.0 / Logistics 4.0 present some form of an automated warehouse. In this context, this article presents a case study from the Polish market of warehouse intralogistics 4.0 – an autonomous and automatic storage system AutoMAG Mover by the PROMAG company. There is evidently a strong trend towards autonomous and automatic functioning of facilities in the storage area, as well as more widely throughout the entire warehouse (all areas).

Articles about Logistics 4.0 usually take the form of proceedings or conference papers with English as the dominant language. The leader among journals publishing about Logistics 4.0 is, without a doubt, "Advances in Intelligent Systems and Computing". Therefore, at the moment the most up-to-date knowledge about Logistics 4.0 can be collected by participating in dedicated conferences.

More extensive knowledge about Logistics 4.0 can be found in other databases of scientific articles (of lower rank) e.g. Google Scholar. The articles e.g. "Logistics 4.0 – a new paradigm or set of known solutions?" (Szymańska et al., 2017), also confirm the existence of a deficit of publications devoted strictly to Logistics 4.0.

To sum up, Logistics 4.0 is a young concept, functioning only for several years. Within Logistics 4.0, two distinct trends of interest can be distinguished: processual – focusing on the organization and efficiency of logistics activities and technical-technological – focusing on providing modern tools that facilitate the physical implementation of the flow of goods. Previous experience of the author of this article with Physical Internet (PI) (Domański et al., 2018) confirms that such a dichotomy is a characteristic feature of new logistic concepts emerging today.

The added value of this article is a summary of the development of Logistics 4.0 at the current stage of its evolution. The literature analysis draws attention to the main topics, trends, people, research centres, countries, fields of science and journals. The analysis of the practice shows that business implementations of Logistics 4.0 are very advanced relative to scientific concepts. In the future, the author plans to deepen the analysis of the articles contained in section 2.3 (Table 2) and conduct surveys on Logistics 4.0 among Polish intralogistics companies.

Automated storage (retrieval) systems have existed since 1970. Therefore, automated systems alone should not be identified as intralogistics (warehouse) 4.0. So what else should Logistics 4.0 contain? There is still no reference definition of Logistics 4.0.

6. ACKNOWLEDGMENT

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THE IMPORTANCE OF TRADE, RETAIL AND LOGISTICS - THE CASE OF THE REPUBLIC OF CROATIA

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Abstract

The lack of harmonization between retail capacity (in quantitative terms) and the level of economic development of the Republic of Croatia was the incentive for this research paper. It is necessary to analyse the economic structure on the one hand, and the development of retail trade in a qualitative sense on the other. The aim of this paper is to evaluate the importance of trade and retail logistics in the development of the Croatian economy. The purpose of this paper is to highlight the importance of retail logistics in the development of contemporary retail formats. Therefore, based on the available literature, the paper firstly analyses the characteristics of retail logistics and its importance in the development of new retail formats. Furtherly, based on the available secondary sources (Eurostat, Deloitte, GfK GeoMarketing and others), the paper analyses the retail importance and development for the Republic of Croatia and other selected European countries. Data are analysed and graphically presented by usual statistical methods. New development processes arising from retail development 4.0 also provide new insights into the retail formats and distribution channels. They certainly should be applied when assessing retail development and the role of retail in future economic development in a particular country. Therefore, the future of retail logistics is also perceived from the way of solving contemporary economic problems. Obtained findings should enrich the understanding of new development opportunities in certain countries and regions, at the base of new retail formats, retail logistics and contemporary supply chain management. Furtherly, they should also enrich the existing knowledge about the possibilities of economic policy action on the development of retail forms. The main research limitations arise from the lack of recent data on retail capacity and new retail formats (especially those on online retail capacity).

Key words: retail logistics, supply chain management, economic structure, retail development, the Republic of Croatia

1. INTRODUCTION

This paper addresses the importance of retail and trade logistics. The starting point is the importance of trade in the economy of a country. In every national economy, trade has long been known as (Alfier, 1967): (a) a precondition for functioning, (b) an essential component of structure; (c) the relevant measure of development; (d) a significant development factor. Based on the historical analysis of trade, it was concluded that its importance in the national economy was steadily increasing, as trade was constantly taking over new tasks and functions. This is related to the processes of concentration, cooperation and new ideas. Namely, it has been recognized that only competitive advantages are not sufficient to ensure the development of a trading company, but innovations also need to be introduced (cf. Oehme, 1983, pp.36 - 72).

Concentration processes are especially important because they have enabled the development of new retail formats. In market-developed countries, these processes accelerated as early as the mid-1960s (see Beckermann & Rau, 1977, p. 39). In the processes of concentration, but also of cooperation, vertical marketing systems are developing, which are becoming increasingly important (Barth et al., 2002). Corporate, administrative and contract vertical marketing systems are usual nowadays (Kotler & Keller, 2006, pp. 486 - 488) and particularly interesting for this paper are vertical marketing systems run by retailers (e.g. retailers' cooperatives). In all these processes of retail development and new retail formats, trade logistics is of particular importance, as it enables the trade to perform its basic functions: bridging time, bridging space and creating product assortment. Therefore, the impact of trade logistics on retail development and new retail formats deserves special attention.

The share of gross domestic product (GDP) of trade in total GDP in a single economy can be taken as an indicator of the importance of trade in the national economy (Knežević, 2011) or the share of gross value added of trade in total gross value added. Data from Eurostat (according to NACE, Rev 2G) refer to distributive trade - Section G - Wholesale and retail trade; repair of motor vehicles and motorcycles; and to its components:

- Division 45 - Wholesale and retail trade and repair of motor vehicles and motorcycles;
- Division 46 - Wholesale trade, except of motor vehicles and motorcycles;
- Division 47 - Retail trade, except of motor vehicles and motorcycles.

There are different indicators of the importance (significance) and the development of retail in a national economy (Segetlija, 2012, pp. 56-60). In this paper, the following indicators of the importance of trade and retail are selected:

- share of trade in gross value added;
- share of retail in gross value added;
- share of retail turnover in gross domestic product.

The development of retail sales in the Republic of Croatia and the selected European countries in this paper is analysed based on the following indicators:

- sales area per capita;
- share of retail turnover via mail and Internet in total retail.

The quality of trade logistics will be represented in this paper by the Logistic Performance Index (LPI) published by the World Bank in Washington. This index is calculated based on a specific questionnaire for logistics service companies and performance ratings. The LPI is calculated for 160 countries, which can then be compared. This index shows the achievement of the quality of domestic logistics companies, but it is also an important indicator for the cooperation of international companies, and thus especially important for assessing the conditions for economic development in a particular country (Weltbank Logistics Performance Index 2018: Österreich mit Platz 4 Weltspitze). LPI value is derived on accurate measurement and using grades 1 to 5 for six key factors (Zekić et al., 2017, pp. 93 – 95; Weltbank Logistik Performance Index 2018: Österreich mit Platz 4 Weltspitze, 2018):

- the efficiency of customs procedures and enforcement of customs regulations;
- quality of trade and transport infrastructure;
- competence and quality of logistic services: transportation by trucks, freight forwarding services and customs procedures (logistic competence);
- simplicity and prices for international shipments;
- tracking & tracing capabilities;
- the frequency of achieving the scheduled delivery time to the recipient (timeliness).

In the analysis of the importance and development of retail and trade logistics, the data for the Republic of Croatia (HR) and selected European countries (commercially and economically developed countries and transition countries) were used. Selected countries for comparison with the Republic of Croatia are Austria (AT), Germany (DE), France (FR), United Kingdom (UK), Italy (IT), Estonia (EE), Hungary (HU), Poland (PL) and Bulgaria (BG).

2. RETAIL FORMATS AND RETAIL LOGISTICS

Since retail development refers to changes in retail formats in the retail structure, it is necessary to list those formats, and then to emphasize the importance of retail logistics in creating and developing retail formats.

2.1. Retail formats

The following retail formats are considered in this paper (usp. Segetlija, 2012, pp. 16-26):

- a retail business (retail by an independent owner and so-called corporate retail);
- retail "facility" (so-called sales line, one or more business units);
- retail business unit (in-store or out-of-store business unit or business unit containing both channels);
- retail service;
- product groups or individual items (so-called categories).

With the development of concentration, corporate retail is gaining importance. It includes (Kotler & Keller, 2006):

- corporate retail chains;
- voluntary chains;
- retailer cooperatives (headquarters);
- consumer cooperation;
- franchise organizations;
- sales conglomerates.

The retail format deserves special attention in this paper. It is the integral result of the following decisions (Lerchenmüller, 1992; Lerchenmüller, 2003):

- on functions (task-based);
- on instruments (marketing);
- about the factors of the workflow (as an organizational solution).

The retail format can be taken as a group (category) of retail formats with the same or similar marketing instruments, related to (Eitner et al., 2008): profession, location, size of sales area, dimensions and composition of the product range, services, method of contact with customers and pricing. This represents the retail mix, appearing in retailers' retail formats (Lewy & Weitz, 2012). However, in designing retail format, logistical considerations are important as well, since business logistics is about flows (material, value and information) and organizational solutions are important.

The terms "retail format" and "retail store type" are generally understood as synonyms, but there is also an understanding according to which "retail format" is taken in systematics that crosses the boundaries of a trading company. According to this view, "retail store type" refers to their systematization of business units within a particular trading company (Ahlert & Kenning, 2007). There are various systematizations of retail formats (see Segetlija, 2012, pp.21 – 25; Gittenberger et al., 2013, p.12). However, the difficulty in systematization is represented by the integration of functions, since retail via mail and the Internet also include wholesale functions. Therefore, flows within distribution channels are important as well.

On the other hand, the logistics point of view of retail format design is related to the supply chain management within which they operate. Specifically, a large retail company can dominate the supply chain and manage not only distribution channels, but also upstream flows. This emphasizes the importance of large retail chains in managing and integrating all echelons in the supply chain. In this way, they direct and develop the production itself.

There are many communication, sales and logistics channels in the managing retail format in supply. Thus multichannel retail is developing within which the retail format, in addition to the stationary retail, is also performing electronic (Internet) retail. However, multiple channels can be used within electronic retail as well. Contrary to the traditional multichannel system, multichannel retailing means that at least one channel of a company is a stationary store and one other channel of the same company is an online store (Heinemann, 2008). Furthermore, there is also a cross-channel retailing, when Internet retail integrates with the physical store and the catalogue retail (Groß et.al, 2014). Ultimately, the integration of communication channels can develop omnichannel retail, with full integration of all channels. The individual characteristics of a retail format, given the above mentioned cross-channel options, create its "business model". The application of contemporary information technologies in integration with business partners is essential for the business model (Bosilj-Vukšić & Kovačić, 2004). Therefore, electronic retail can also be defined as a retail channel, and no longer just a retail format (Levy & Weitz, 2012).

In the selected business models, business processes are improving and thus the overall value chains. A retail company realizes its competitive advantages based on its size and market power (large stores, branch companies, etc.). However, the emergence of new business models creates competitive pressure on conventional, stationary retailers, who find themselves in a new competitive situation, which encourages adaptation processes (Leukert & Gläß, 2017). Such developments indicate the importance of retail logistics in new models of distribution channels. They are developed within retail supply chains, i.e. supply chains run by large retailers. Their importance arises from the fact that they can affect all other upstream supply chain members (e.g. manufacturing companies, logistics service companies, various intermediaries, etc.).

2.2. Retail logistics and its importance

Trade logistics is rarely explicitly defined. The reasons for this may be the characteristics of the logistics that cross the boundaries of particular sectors or companies. Therefore, trade logistics can generally be defined as follows (Toporowski, 1996, p. 12): „Trade logistics covers all activities of planning, managing and controlling the flow of goods from suppliers to customers, i.e. delivery of right goods in right condition, right packaging, at the right time, in the right quantity, in the right place and at the lowest total cost for the company".

In the contemporary stage of business logistics development related to supply chain management, Kotzab (2012, p. 212) state that "trade logistics involves the integrated planning, implementation, design and control of total flows of goods and related information between a trading company and its suppliers, within a trading company and between a trading company and its customers". According to the same author (Kotzab, 2012, p. 213), trade logistics is a complex logistics system. Depending on the retail format, the flow of goods and related information can pass many intermediate stops from suppliers to final consumers. Therefore, trade logistics is in many cases a multi-tier logistics system. It covers all activities of a trading company to secure the procurement of goods according to the wishes of customers and to prepare and deliver the goods to retail stores or directly to customers (Krampe & Lücke, 2006, p.26).

Considering the different stages of material flows (from the supply market to the sales market and back), the decisions in the field of supply logistics, distribution logistics and disposal logistics come into focus in trade logistics. These decisions can also be seen as an expression of marketing logistics (Kotzab, 2012). It can be pointed out that many trading companies have focused their logistics on a just-in-time principle.

Since business logistics in the contemporary stage of its development is oriented towards flows that cross the boundaries of companies, trade logistics refers to the concept of supply chain management (SCM) as well. The retail format is important for trade logistics because logistics tasks that need to be performed, especially differ among various retail formats (Hoffer, 2009, p. 112). It was already pointed out that there is a multiplicity of communication, sales and logistics channels in the functioning of the retail format in the supply chain.

The importance of trade logistics stems from the importance of trade itself in the national economy. Such considerations particularly show data on the share of trade in a country's gross domestic product and the share of trade logistics in the overall logistics market of a country (Kuhn et al., 2018, p. 718). In this regard, it is believed that logistics activities will continue to gain in importance in the future due to increasing competition and the development of online retail. Therefore, for many trading companies, logistics will become a central factor in competition. This problem will be solved by trading companies either by developing logistics in their own company or by using the services of logistics companies.

3. CONTEMPORARY DEVELOPMENT PROCESSES

In considering contemporary development processes, the agrarian, industrial and digital revolution are discussed, but also about the trade revolution. The most important is the digital revolution as the third industrial revolution (Bendel, 2017). There are four stages within the industrial revolution (Frick, 2017). The first industrial revolution was related to the invention of the steam engine, and the second was based on electricity. The focus of the third industrial revolution was further automation through digitization and new information technologies. The fourth industrial revolution (Industry 4.0) relates to individualization, i.e. the hybridization of customers and the integration of customers and business partners in business processes. The focus is on the growing digitization of earlier analogous techniques and the integration of cyber-physical systems. It is the future that begins. New technologies such as 3D printing increase the speed of new product development through faster prototype development (Scheer, 2017).

Based on the term Industry 4.0, which includes the framework of a goal-oriented transformation of industrial production, similar considerations have become relevant for agriculture (Krombholz, 2018). It is important to note here that for the Agriculture 4.0 phase, further digitization and robotization of agriculture will be relevant, like the Industry 4.0 phase.

When it comes to the retail revolution, which is on the horizon, the term Retail 4.0 is used. The study "Revolution Retail 4.0" provides a graphical representation of all four retail revolutions in Europe (Sehl, 2016). The period of the first retail revolution lasted 78 years (from 1885 to 1963). Then began selling in stores (its predecessor ware trade fair and traveling, mobile retail sale). The focus of innovation were resources, and digitization had not yet been used. Retail 2.0. lasted from 1963 to 1995. Introduced technologies have made it possible to cope with the complexity of costs and reduce them. The focus was on processes. It was the time when digitalization began (Digitalization 1.0.). At that time, product and assortment data could be monitored electronically. The time of the third retail revolution lasted from 1995 to

2016. It refers to the virtualization of the store and the purchasing process. The focus is on connecting retail to its environment through contemporary information technology (Digitalization 2.0). The fourth retail revolution (2016 and beyond) means the further development of digitalization (Digitalization 3.0) and the exploitation of information on customer needs and behaviour. The focus is on value chains and business models. It was estimated in that study that only those who would accept the changes would survive and that 25% of European trading companies would fail as victims to a new "purification" of the market (Ptock, 2016).

The change in the investment paradigm for certain retail formats is essential for the retail revolution. According to research in the Federal Republic of Germany (Online-Handel - Mögliche räumliche Auswirkungen auf Innenstädte, Stadtteil und Ortszentren, 2017), it was important to replace investments in personnel with the investments in space in the period from 1970 to 2010. From 2000 onwards, investments in space should be replaced by investments in the information.

Changes within Retail 4.0. can have four points of view (Rehme, 2018):

- as changes in the profession itself;
- as changes in the construction of stores;
- as changes in the leisure industry;
- as changes in logistics.

Changes in the profession are in a new approach to the creation of the offer. Products are not presented in mass, but positioned to facilitate consumer activity, because it is no longer based on what is in the product range, but what the consumer owns. Thus, the retailer has the task of activating the consumer in this procurement-production-purchase process. CRM (Customer Relationship Management) now includes the overall consumer behaviour in the context of his/her life, so that the focus is on the person (not just the customer).

In the construction of stores, consumer activity must be stimulated with a lower number of products. Retail space becomes an experience space, where it is important to connect physical space in the store (interior) with people and the digital experience space.

Everything is also linked to the leisure industry, which will function in a new way, as it will connect individual offers. Also, some retail formats and amusement parks will not perform on their own, which will alter certain city amenities.

Under the terms of Retail 4.0, major changes will occur in logistics as special delivery companies and autonomous driving will develop.

Logistics 4.0 is evolving with all these changes. Digitalization is also essential in these processes (Kille & Meißner, Hrsg., 2016). Requirements through Industry 4.0. and e-commerce have accelerated the selection processes in logistics and its revolution in the Logistics 4.0 phase. However, the digitalization process has evolved faster in logistics than in other economic sectors. In the definition of Logistics 4.0, its broader and narrower senses are stated (Oeser, 2018). Logistics 4.0. (broadly) describes the impact of Industry 4.0 on logistics, its joint (with industry) design and support for its coordinating role that crosses the boundaries of business functions and company. In the narrow sense, Logistics 4.0 is the networking and linking of products, facilities, partners (suppliers, manufacturers, wholesalers, retailers and logistics service providers) and customers through information and communication technology

(ICT) with decentralized decision-making structures to increase efficiency (e.g. through transparency, automation and process acceleration, error reduction and connectivity) and effectiveness (e.g. through flexibility and individualized services, processes and products).

It should be emphasized that the development of logistics has always been linked to the development of production. It has been established (Skaret, 2015) that Logistics 1.0. was current in the 18th century, related to mechanization. Logistics 2.0. was developed in the 19th century and related to electrification. Logistics 3.0. existed in the 20th century when automation was essential. Logistics 4.0. is developing in the 21st century, related to the development of CPS (cyber-physical systems). Finally, it should be noted that the following three trends are important in retail logistics (Gärtner, 2019): concentration, IT integration and automation.

4. TRADE, RETAIL AND RETAIL LOGISTICS IN THE REPUBLIC OF CROATIA

The importance of retail logistics firstly stems from the importance and development of trade itself and especially retail in the national economy.

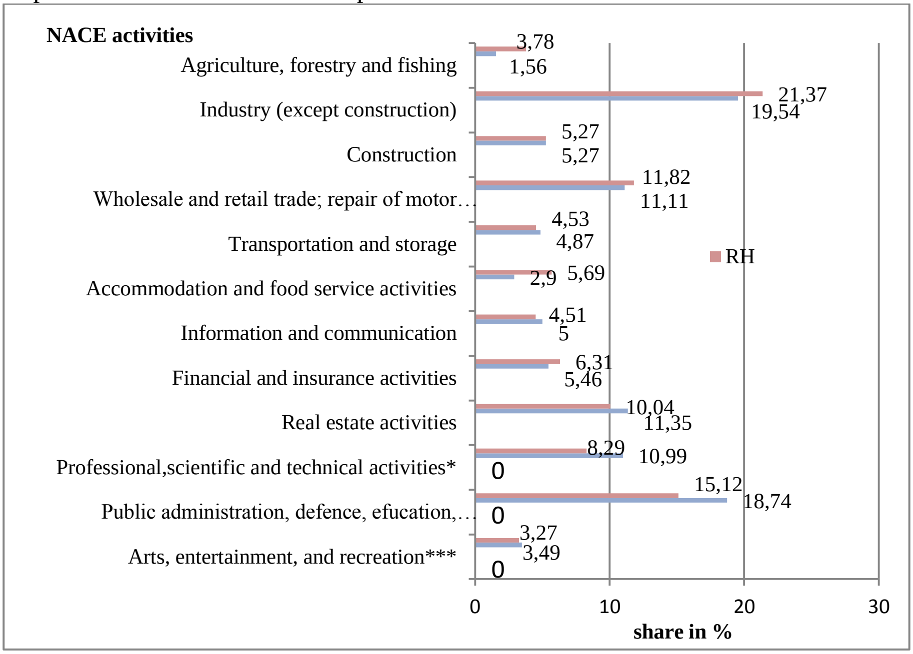
4.1. The importance of trade and retail

The importance of trade in the economy of the Republic of Croatia will be examined by shares in the gross value added of all activities.

Graph 1 shows the shares of all individual activities (in %) in value creation (in gross value added) in Croatia and throughout the European Union (EU-28) in 2016. It is evident that in 2016, the share of gross value added of trade in the gross value added of all activities was 11.82% in the Republic of Croatia and 11.11% in the European Union. The share of gross value added of transport and storage (as logistics activities) was 4.53% in the Republic of Croatia and 4.87% in the European Union.

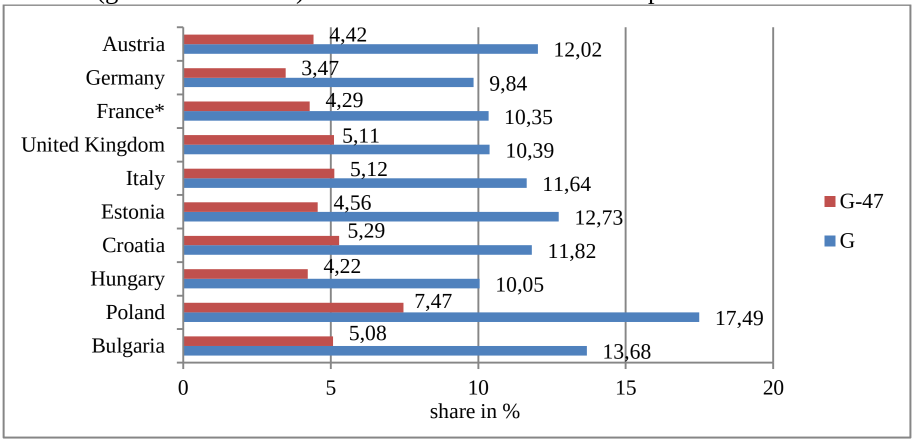
Graph 2 shows the shares of total distributive trade (G) and retail trade except of motor vehicles and motorcycles (G-47) in generating gross value added of all activities in selected European countries in 2016. It can be concluded that overall trade, and in particular retail in the Republic of Croatia are more important than in the more developed countries selected (Austria, Germany, France, United Kingdom, Italy). According to the source for this graph, the share of retail trade activities except retail trade of motor vehicles and motorcycles (G-47) in gross value added of all activities in the European Union (EU-28) in 2016 was 4.44%, while it was 5.21 % in the Republic of Croatia. Such importance of trade and retail in the Republic of Croatia and in other transition countries mostly stems from the relatively higher consumption, expressed in retail turnover (partly tourism spending) in relation to the GDP.

Graph 1. Shares (in %) of value creation (gross value added) by activities in the Republic of Croatia and the European Union in 2016



Annotation: *Professional, scientific and technical activities; administrative and support service activities; **Public administration, defence, education, human health and social work activities. ** * Arts, entertainment and recreation; other service activities; activities of the household and extraterritorial organizations and bodies.
Source: National accounts aggregates by industry up to NACE A*64, Eurostat 2019

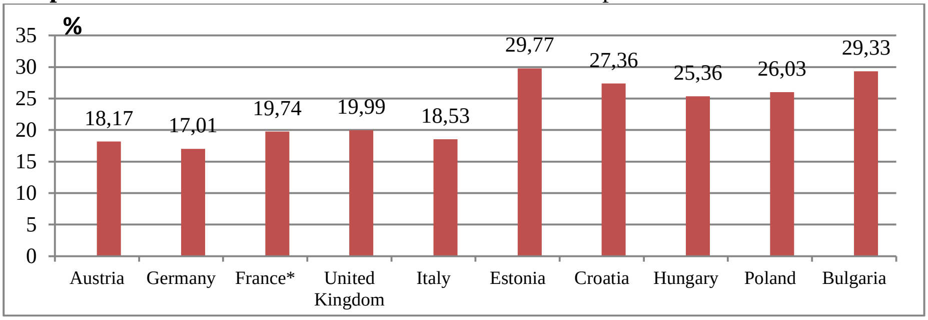
Graph 2. Shares (in %) of distributive trade (G) and retail trade (G-47) in value creation (gross value added) of all activities in selected European countries in 2016



Annotation: * provisional
Source: National accounts aggregates by industry (up to NACE A*64), Eurostat, 2019

The ratio between retail turnover and gross domestic product (GDP) in the Republic of Croatia and selected European countries in 2016 is shown in graph 3. Due to relatively higher consumption relative to the GDP, transition countries (especially the Republic of Croatia) have higher shares of retail turnover in GDP from economically and commercially developed European countries

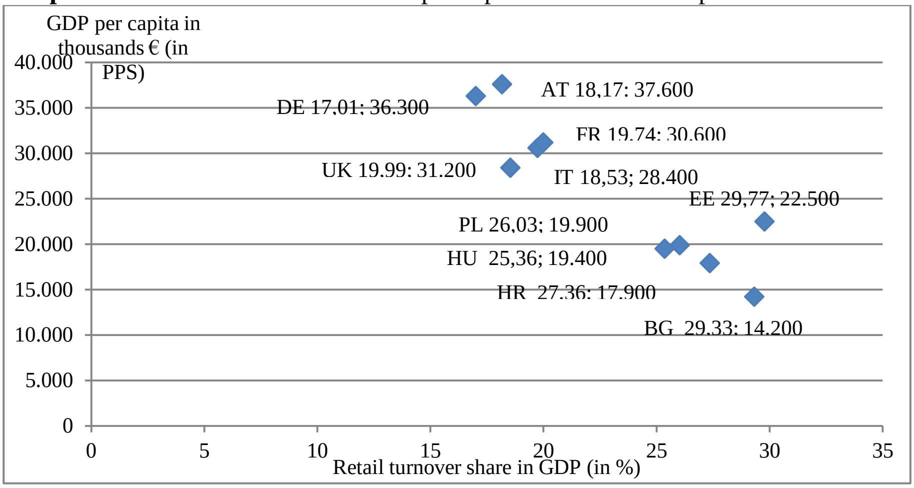
Graph 3. Retail turnover share in GDP in selected European Countries 2016



Annotation: * provisional
Source: (a) GDP and main components (output, expenditure and income), Eurostat, 2019.
(b) Annual detailed enterprise statistics for trade (NACE Rev2G), Eurostat, 2019.

Graph 4 shows retail turnover in % of GDP given the level of economic development (GDP per capita in Purchasing Power Standards) in 2016 in selected European countries. The observed transition countries (Estonia, the Republic of Croatia, Hungary, Poland and Bulgaria) have relatively lower GDP per capita, but also higher shares of retail turnover in GDP than other observed developed countries.

Graph 4. Retail turnover share in GDP per capita in selected European countries 2016

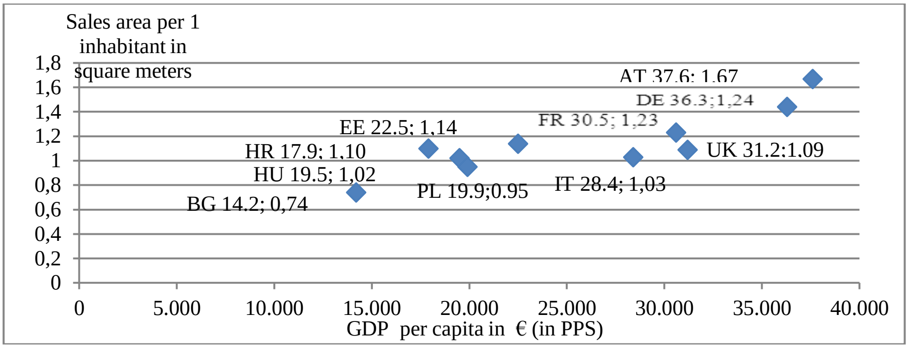


Annotations: PPS – Purchases Power Standard
Sources: (a) Main GDP aggregates per capita, Eurostat, 2019.
(b) GDP and main components (output, expenditure and income), Eurostat, 2019.
(c) Annual detailed enterprise statistics for trade (NACE Rev2G), Eurostat, 2019.

4.2. Retail development

Quantitative development of retail in the Republic of Croatia has been evaluated based on sales area per 1 inhabitant indicator. Graphs 5 and 6 show sales area per 1 inhabitant and GDP per capita in selected European countries in 2016 and 2017. Countries with higher GDP per capita also have a larger sales area. However, the Republic of Croatia has the most unfavourable ratio of all observed countries between GDP per capita and sales area per 1 inhabitant in 2016 and 2017 – the lowest GDP per unit sales area. This indicates a certain mismatch in the development of retail capacities (in quantitative terms) and the level of the overall economic development in the Republic of Croatia.

Graph 5. Sales area per 1 inhabitant and GDP per capita in selected European countries in 2016

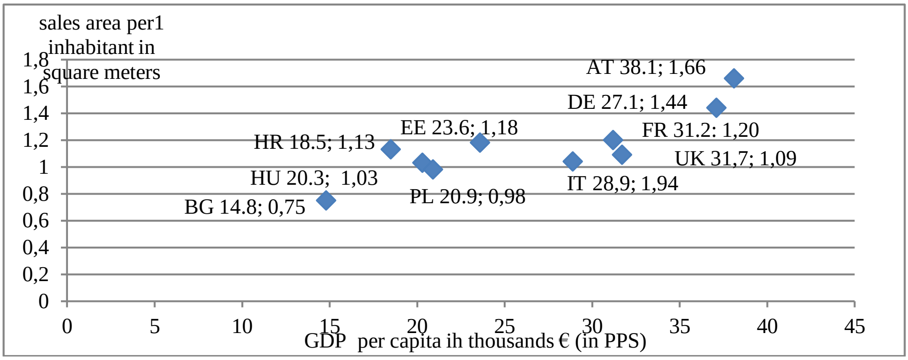


Annotation: PPS – Purchases Power Standard

Source: (a) European Retail in 2017, GfK study on key retail indicators 2016 review and 2017 forecast (2017), Eurostat, 2019.

(b) Main GDP aggregates per capita, Eurostat, 2019.

Graph 6. Sales area per 1 inhabitant and GDP per capita in selected European countries in 2017



Annotation: PPS = Purchases Power Standard

Source: (a) European Retail in 2018, GfK study on key retail indicators 2017 review and 2018 forecast (2018)

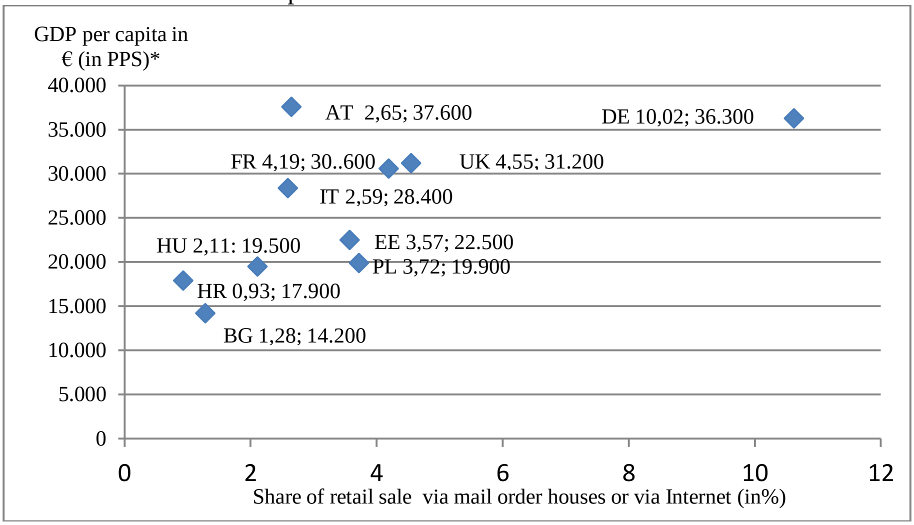
(b) Main GDP aggregates per capita, Eurostat, 2019.

In contemporary development processes, sales areas are shrinking in some countries (European Retail in 2019). The reasons for that include the spread of e-retail, earlier saturation of sales areas, population migration and others (Die Verkaufsflächedichte: Nivelierungstendenzen in Europa, 2018). The process of sales area downsizing is particularly evident in contemporary cities, given the many interdependencies in the development of retail and the city (Kreutz, 2016). There are numerous analyses of retail development in terms of urban locations and architecture, especially known for German cities (e.g. Sperle, 2012). However, the problems of managing such free spaces, i.e. empty sites, also arose in the Republic of Croatia (Segetlija, 2017).

According to the latest sources (European Retail in 2019, GfK), the sales area per 1 inhabitant in the Republic of Croatia has continued to grow and in 2019 there were 1.16 m^2 per 1 inhabitant (it fell to 1.62 m^2 in Austria). The main reason for the increase in the Republic of Croatia may be the decrease in the number of inhabitants (migration of population).

Since there are interdependencies between the level of retail development and the level of overall economic development of a country, it is necessary to consider retail development in qualitative terms as well, in relation to contemporary retail formats in the retail structure. Essentials are shares of retail via mail and via the Internet. The share of retail via mail and via the Internet in total retail sales other than retail trade in motor vehicles and motorcycles (G-47) in selected European countries in 2016 is shown in Graph 7. One can see a relatively small share of retail via mail and Internet (G-47) in the Republic of Croatia (lowest among observed countries).

Graph 7. Share of retail sale via mail order houses or via the Internet in the retail trade* in the selected European countries in 2016



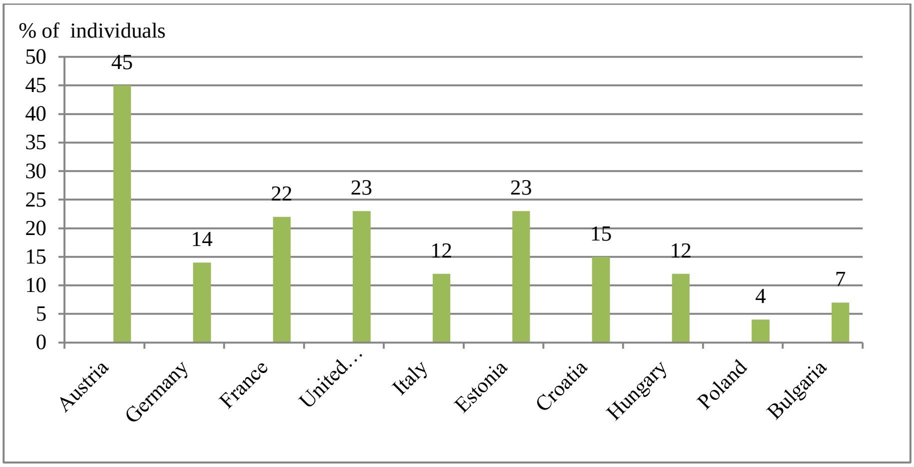
Annotation: *G-47 – retail trade except of motor and motorcycles; PPS=Purchasing Power Standard.

Source. (a) Annual detailed enterprise statistics for trade (NACE Rev. 2G), Eurostat, 2019.

(b) Main GDP aggregates per capita, Eurostat, 2019.

However, if the online retail of foreign suppliers is also considered, this share in the Republic of Croatia could be much higher (see: Onlinehandel: Das Europe der zwei Geschwindigkeiten, April 24, 2017). Therefore, graph 8 shows the percentages of consumers buying online from providers from other EU countries (who purchased or ordered in the last 12 months) in 2016.

Graph 8. Individuals* using the Internet ordering goods or services from other EU countries



Annotation: * % of individuals aged 16 to 74
Source: Individuals using the Internet for ordering goods or services from other EU countries, Eurostat, 2019.

Graph 8 shows that % of people who bought online from other EU countries in 2016 were 15 % in the Republic of Croatia, while 12 % in Hungary, 4 % in Poland and 7 % in Bulgaria.

4.3. The importance of retail logistics

Online retail development in a particular country mostly depends on the following factors: purchasing power, expertise and quality of supply, the degree of concentration of retail and, in particular, the quality of logistics (especially retail logistics).

Particularly important is the degree of concentration, as large online retailers continue to expand internationally. Thus, e.g., Amazon.com Inc. holds 50 % of the online trade market in Germany (Gärtner, 2019). The same retailer had an average revenue growth rate of 18 % between 2012 and 2017 (Global Powers of Retailing 2019).

Logistics quality is in the function of the economic development and competitiveness of each country. It can be expressed by the Logistic Performance Index (LPI). Logistics services are known to be the main support of international trade. Trade logistics is also important in this context, as large retail companies operate internationally. Of course, the quality of logistics in a particular country is also important for its overall competitiveness, for its Global Competitiveness Index.

The importance of the LPI arises from the fact that in today's era of high automation and robotization of manufacturing processes, when productivity growth potentials in the production sphere have been used to their maximum, the area of competitive advantage creation should be sought in the sphere of space and time transformation, in logistics (Zekić et al., 2017). This index is also important in assessing the development of trade logistics in a particular country.

Table 1 shows the LPI for selected European countries in 2007 and 2018. The Republic of Croatia has significantly improved its position in 2018 compared to 2007, although the quality of logistics services is still not satisfactory. Only Bulgaria has a lower index than the Republic of Croatia. This has an impact on both the development of contemporary retail formats and the level of overall economic development.

Table 1. Logistic Performance Index (LPI) in selected European countries 2018 and 2007

Country	2018		2007	
	LPI Score	LPI Rank	LPI Score	LPI Rank
Germany	4,20	1.	4,10	3.
Austria	4,03	4.	4,05	5.
United Kingdom	3,99	9.	3,99	9.
France	3,84	16	3,76	18.
Italy	3,74	19.	3,58	22.
Poland	3,54	28.	3,04	40.
Hungary	3,41	31.	3,15	35.
Estonia	3,31	36.	2,91	51.
Croatia	3,10	49.	2,71	63.
Bulgaria	3,03	52.	2,87	55.

Source: Global Rankings 2018, The World Bank, Washington, 2019.

5. CONCLUSION

The importance of trade, especially retail, and trade logistics in the economy was emphasized in this paper. The role of trade logistics should be highlighted in the functioning of retail formats. In today's context, supply chain management has evolved with the development of logistics.

In contemporary business models, which are developed by individual retail formats, business processes and thus the overall value chains are being improved. This makes trade logistics particularly important in new models of distribution channels.

As a complex logistics system, in many cases a multi-level logistics system, contemporary trade logistics is a concept of supply chain management. It is important to emphasize that certain types of retail formats also differ in what logistical tasks they need to perform.

For assessing the importance of trade logistics, the starting point is the importance of trade itself and, especially the importance of retail in the national economy.

Within the contemporary development processes in the economy, the industrial, agrarian and digital revolution, as well as the trade and logistics revolution, are essential. However, the digital revolution as the third industrial revolution is mostly highlighted. The fourth industrial revolution (Industry 4.0) refers to individualization, i.e. the hybridization of customers and the integration of customers and business partners in business processes. The fourth retail revolution (Retail 4.0) means the further development of digitalization (Digitization 3.0) and the exploitation of information on customer needs and behaviour in the function of creating value chains and new business models. Under these conditions, logistics will be developed using the services of specialized delivery companies and autonomous deliveries by other routes. Within the Logistics 4.0. it is important to network and connect products, facilities, partners (suppliers, wholesalers, retailers and logistics service providers) and customers based on information and communication technology (ICT) with decentralized decision-making structures.

The importance of trade and retail in the Republic of Croatia and in selected European countries in this paper have been evaluated according to their shares in the creation of gross value added (2016). Total trade, and retail as well, in the Republic of Croatia and in other transition countries are more important than in more developed countries. Therefore, in transition countries where GDP per capita is lower, the share of retail turnover in GDP is higher.

Quantitative retail development in the Republic of Croatia has been analysed based on sales area per 1 inhabitant (in 2016 and 2017). Although in quantitative terms retail in the Republic of Croatia is more developed than in Hungary, Poland and Bulgaria, it generates less GDP per unit of sales area, which indicates a mismatch in the development of retail capacities (in quantitative terms) with the level of general economic development.

In the Republic of Croatia (2016), there is a relatively small share (0.93%) of retail sales via mail or Internet (G-47) by domestic suppliers, the smallest among the observed countries. The share increases if the online retail of foreign suppliers is also considered. This means that contemporary retail formats are relatively underdeveloped and are not drivers of economic development. Specifically, retailers running their supply chains could also be drivers of new production.

Finally, it can be concluded that the quality of logistics services, i.e. trade logistics in Croatia is not satisfactory. Only Bulgaria has a lower LPI than the Republic of Croatia in 2018. This is also reflected in the overall processes of economic development through the international integration and development of contemporary retail formats.

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THE IMPACT OF STANDARD LOGISTICS LABELS ON DISTRIBUTION EFFICIENCY IN THE SUPPLY CHAIN

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Abstract

Efficiency of distribution processes is one of the key factors influencing the optimization of the entire supply chain. For this reason, both research and business practice initiatives point to the need for continuous search for solutions that will improve distribution efficiency both at the operational level and in terms of the entire supply chain. An effective way to optimize distribution processes is to use a standard logistics labels, which enables the integration of information flow between business partners. Institute of Logistics and Warehousing together with GS1 Poland for over 10 years has been researching the level of use and practical implementations of standard logistics labels GS1 in companies. As part of its research work, the Poznan School of Logistics conducts analyses of the scope of evaluation of the distribution process efficiency as key components in the aspect of intelligent supply chains. Cooperation between these institutions allows to achieve the synergy effect, which Authors wish to present within the framework of this paper. The aim of the paper is to analyze the level of use of logistic labels and to analyze the impact of their use on the supply chain efficiency. Scientific and practical research was carried out in 2017-2018 and provides a research basis for further analysis of the impact of logistical labels on the digitisation of supply chains.

Key words: distribution efficiency, supply chain efficiency, logistics label

1. INTRODUCTION

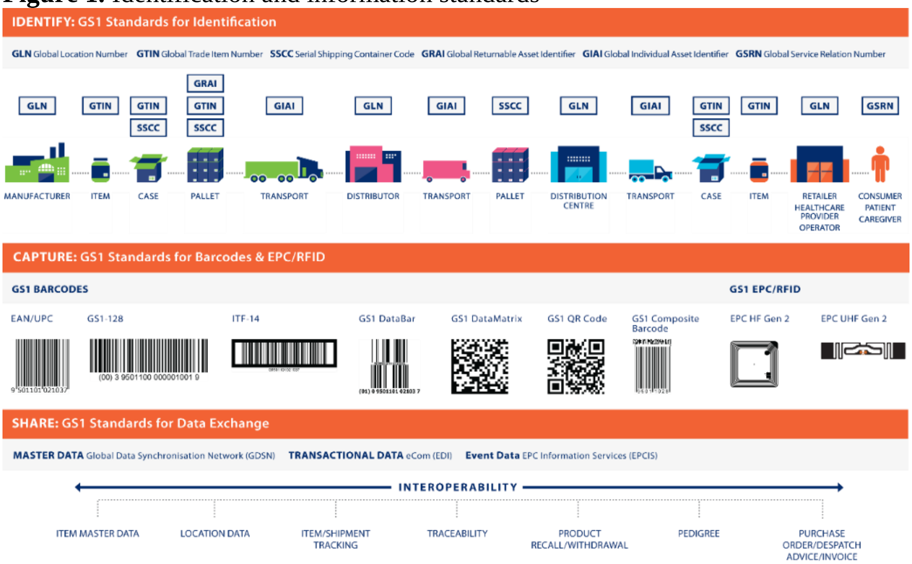
The changes taking place in the surrounding reality significantly affect the development of the modern economy. The challenges include, among others, demographic changes or a change in the approach to eliminating the greatest barriers to development and an increasing trend towards basing development on knowledge, digitisation and innovation. Digitalisation of processes, taking place in individual companies or in the whole economy, and being their integral part, shall contribute to the improvement of their functioning, shorten the time of service and reduce the costs of economic activity. In order to fully implement them, it is necessary to digitise the processes taking place in enterprises.

This issue of the use of logistic labels is extremely important for the supply chain efficiency, mainly due to the possibility of monitoring the logistics process and identification of the delivered goods. The use of logistic labels reduces the risk of errors not only at the stage of delivery acceptance, but also at the stage of delivery advice. In terms of operational distribution efficiency, this allows for effective preparation of the warehousing process, e.g. for dedicated delivery conditions or the exact delivery time, taking into account the application of SSCC (Serial Shipping Container Code) number in the DESADV (Dispatch Advice) message. The identified research goal that the Authors are trying to solve in this paper is the impact of standard solutions on the increase in supply chain efficiency. The aim of the paper is to analyze the level of use of logistic labels and to analyze the impact of their use on the supply chain efficiency.

A very important aspect to which particular attention should be paid is the evolution of traditional supply chains into an integrated, shared, smart, digital and highly efficient ecosystem. The correctness of events occurring in it will depend on many key technologies:

- integrated planning and execution systems,
- visualization of logistic processes,
- intelligent supply and storage,
- use of identification and information standards (Fig. 1.).

Figure 1. Identification and information standards



Source: GS1 Materials

Such approach will allow companies to react quickly to any disruptions in the supply chain, or even anticipate them, so that they can fully model them, thus creating real-time scenarios and processes. This will allow companies to have a flexible approach to managing their business, thereby increasing the competitiveness of their products or services.

2. IDENTIFICATION STANDARDS IN LOGISTIC PROCESSES

The efficiency of information flow in the company directly affects the accuracy of decisions made by the management. The specificity of the information flow process hinders the already complex issue of efficiency. The concept of efficiency has not yet been clearly defined. The literature on the subject offers various interpretations and approaches to the efficiency of processes occurring both in enterprises (Rummler, Brache, 1995) and supply chains (Mishra 2012; Lichocik and Sadowski 2013; Geunes et al. 2016; Brandenburg 2016; Sohrabpour et al. 2016). The presented definitions and approaches to efficiency do not, as a rule, exclude one other, but they constitute a complementary whole and supplement or take into account another analytical aspect. This causes not only a research issue, but also a problem in terms of economic practice. IT tools supporting enterprise and supply chain management come in handy; however, the efficiency of application depends on the process approach upon the creation of the enterprise information system. Integration of information in the supply chain generates a number of additional problems related to the transmission of reliable information along the chain in real time (Bottani, et. al., 2010; Liu, et al., 2016a), which has a direct impact on the implementation of logistics processes (Silva, Carvalho, 2013; Maiga, et al., 2015). One of the key information problems is the integration of the production and logistics system with partners in the supply chain (Golinska, et al., 2011; Adamczak, et al., 2016, Varela, et al., 2017; Trojanowska, et al., 2017), also taking into account the aspect of a sustainable supply chain (Cyplik, et al., 2014). The following considerations confirm the research conducted by the Authors concerning, among others, the identification of key functionality necessary for a comprehensive analysis of the efficiency of logistics processes (Bigaj, Koliński, 2017). These practical and theoretical considerations lead to further research on identification standards in logistic processes. Literature research based on both theoretical analyses (Ross, 2011; Shi, Chan, 2007; Ramos, Lazaro, Girbau, Villarino, 2016) as well as research and development analyses (Nakatani, Chuang, Zhou, 2006; Śliwczyński, Hajdul, Golińska, 2012; Dujak, Zdziarska, Koliński, 2017) proves that there is a great fragmentation of possibilities to implement various identification standards in economic practice, especially the logistic label used by companies in the TL industry (Transport&Logistics Industry).

These theoretical considerations are only a general overview of the research problem. The lack of a detailed delineation of the research scope results from the fact that the identification of the use of standard logistic labels is the result of preliminary scientific research in this area. The empirical studies conducted so far in Poland should be considered as partial and unrepresentative.

For this reason, research was undertaken to diagnose the current degree of use of logistic labels in the implementation of logistic processes by the Polish operators of the TL industry; attention was also drawn to the effect of its use in the processes of data exchange on the basis of research conducted on a specific company. Thanks to a thorough analysis of the issue, measurable benefits of differentiating logistic labels in the supply chain were identified.

3. RESEARCH METHODOLOGY

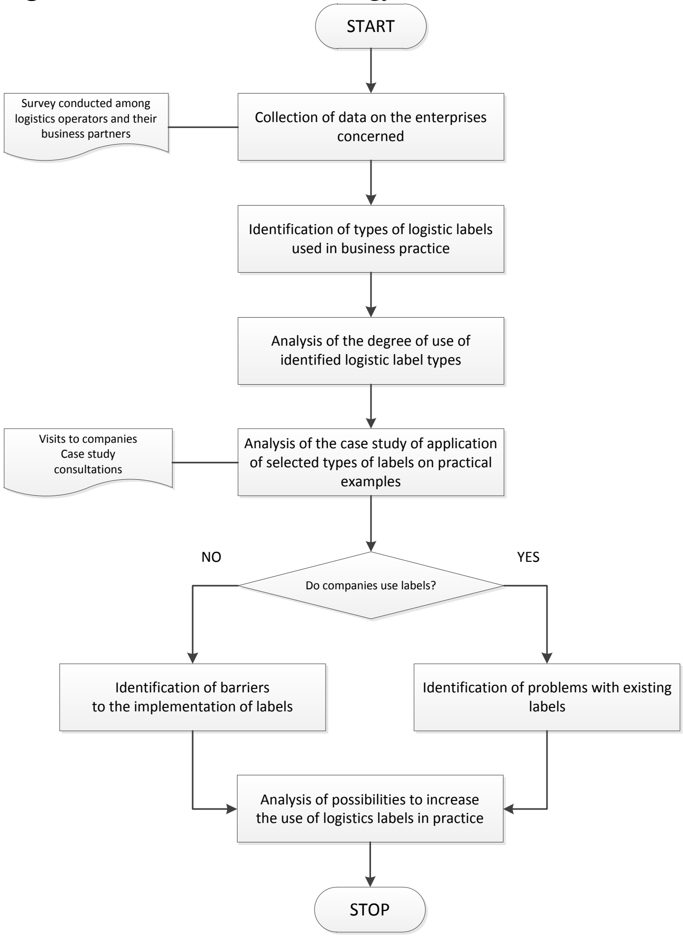
Taking into account the nature of this publication, the main purpose of which is to determine the degree of use of logistic labels by 50 TOP logistics operators in Poland, its authors decided to divide the research work into three aspects:

- a theoretical one, identifying both the definition problem of the concept and the possibilities of its application in logistic processes,
- a conceptual one, identifying the basic operational scope of the application of assumptions in logistic processes of different characteristics,
- a practical one, presenting the possibilities of using solutions resulting from international research and development projects as a proposal to implement particular key areas of application of the concept.

The process of scientific research presented in this article results from the logic of structural analysis of the identified research problem. The adopted methodology of research work aims to systematize the procedure based on scientific research principles. The logic of solving a research problem has been presented in Fig. 2.

Therefore, this research methodology assumes both theoretical research and verification of its assumptions in business practice. In the Authors' opinion, both aspects, supplemented by the conceptual scope, aimed not only at confronting research and practical considerations, but also at organizing the existing knowledge on the analysed topic, cannot be carried out separately. The specificity of the research problem requires complex research on every plane.

Figure 2. The research methodology



Source: own study

The proposed methodology assumed both surveys and direct research. In the opinion of the project team, only such research approach can guarantee both the reliability of the obtained data and the representativeness, which impacts the generalisation of conclusions.

4. THE ANALYSIS OF DEGREE OF USE OF LOGISTIC LABELS

The conducted research was based on the research logic taking into account:

- identification of the types of logistic labels used in practice,
- analysis of the degree and place of use of both standard GS1 logistics labels and proprietary labels,

- identification of barriers to the implementation of standard GS1 logistic labels,
- identification of problems with the effective use of already implemented standard logistic labels.

Proprietary label is understood as a logistic label whose structure was developed by the company exclusively for internal needs. A standard GS1 label, on the other hand, is characterized by a unified structure (in accordance with GS1 standards), which enables error-free reading of the label content by IT systems of business partners in the supply chain.

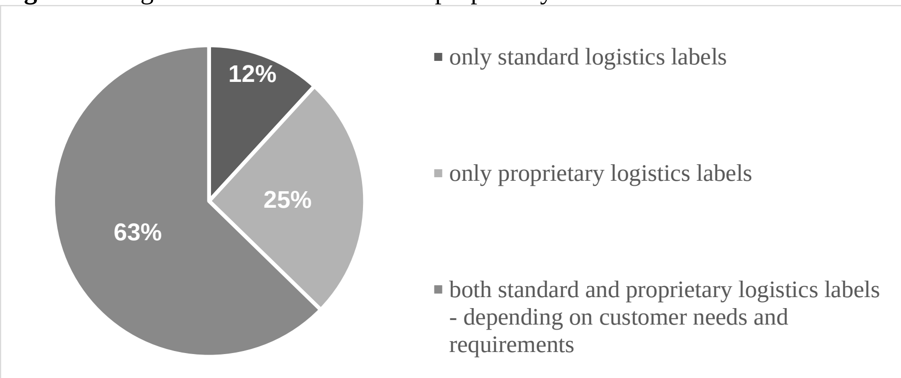
The research was conducted in 2018. The research involved 50 logistics operators and distributors representing various industries, which conduct their logistic activity in Poland. Due to the perspective of using logistic labels, the industry in which the company is functioning was not a decisive factor. The research was conducted in the form of direct consultations at company offices, telephone and e-mail consultations, as well as supplementary surveys.

Identification of label types used in the TL industry

The first stage of the research was to identify the types of logistic labels used, distinguishing between standard and proprietary labels.

As a whole, the degree of use of proprietary and standard labels has been shown in Fig. 3.

Figure 3. Degree of use of standard and proprietary labels



Source: own research

The vast majority of researched companies use both standard logistic labels and their proprietary labels, depending on the process in which they are used and whether the partner in the supply chain uses a standard or a proprietary label. It is also worth noting that companies using only proprietary logistic label are statistically more numerous than companies using only standard labels.

This situation has a direct impact on the distribution efficiency due to the risk of error in the information flow on deliveries and the need to manually check the content of the logistics label. This has a negative impact not only on the operational activities in the distribution process, but can also cascade the efficiency of the whole supply chain.

From a quantitative point of view, it should be stated that:

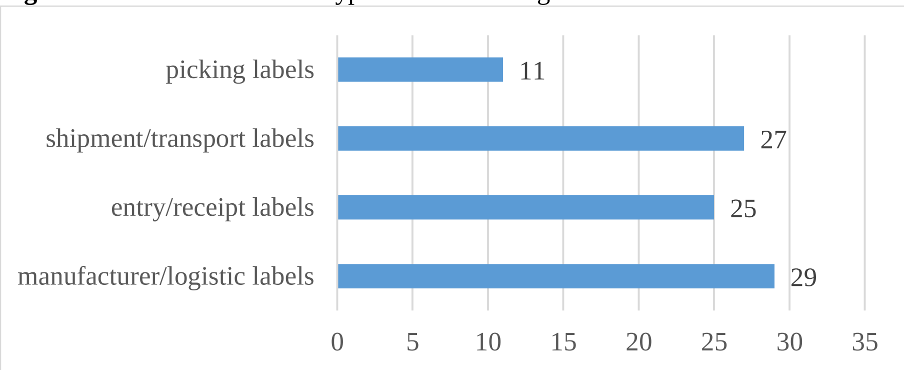
- 37 researched companies (72%) use at least partially standard logistic labels,
- 48 researched companies (94%) use at least partially proprietary logistic labels.

The first step in a detailed analysis of the use of logistics labels was to identify the types of standard logistics labels in business practice. This stage of research concerned those companies that used only standard logistics labels in their processes, as well as those that used standard labels in conjunction with proprietary labels. Figure 4 shows the general trend in the use of different types of standard logistics labels.

The following types of labels were distinguished and researched in the framework of the analyses:

- manufacturer/logistic labels (logistic unit content data),
- entry/receipt labels (identification of the logistic unit at the time of receipt),
- shipment/transport labels (consignment designation, route codes, logistic parameters of the unit - weight, dimensions),
- picking labels.

Figure 4. Identification of the types of standard logistic labels used



Source: own research

The conducted analysis indicates that the standard manufacturer's label is most frequently used in business practice - in 29 researched enterprises (76% of 37 researched enterprises). At the adoption stage, 25 companies (65%) indicated the use of a standard label, which meant that 4 companies, despite having received standard labels, did not use them at this stage. 27 companies (71%) used standard labels to organize shipping and transportation, which indicated that two additional operators, in addition to those using standard labels at the receipt, identified the goods with standard labels during the shipping process. In the case of picking processes, only 11 of the researched companies indicated the use of standard logistic labels, which may mean that the remaining 14 companies (out of 25 using standard labels at the receipt) carried out picking without standard labels, mainly using their proprietary labels.

The lowest level of use was made of picking labels, which also had an impact on their use in terms of IT system functionality, what is important for the supply chain efficiency. From the point of view of the analysis of IT systems functionality it also follows that the greatest information demand of companies concerns data concerning the content of logistic units, their identification during receipts, as well as data concerning the identification of consignment, route and parameters of the unit during dispatch/transport.

Identification of processes in which logistic labels are used

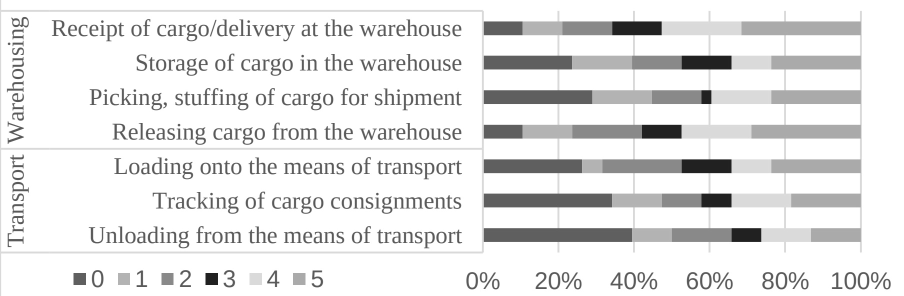
The next stage of the research was to identify processes in which companies use standard and proprietary logistic labels. It was decided not only to identify the place of application, but also the degree of use of standard and proprietary logistic labels. From the point of view for research work on distribution efficiency at the operational level and the supply chain, at the strategic level, an extremely important aspect is the identification of those elements of the logistics process that increase the risk of information errors related to deliveries. The more processes identified that use their proprietary logistics labels, the greater the negative impact on efficiency. The added value of this research is to indicate to which extent standard logistic labels are used, especially when companies declare the use of both proprietary and standard logistic labels.

In the examination of the degree of use of both standard and proprietary logistic labels, a uniform division into stages of the logistic process was adopted, taking into account separately storage and transport, in accordance with the following logical process:

- receipt of cargo/delivery at the warehouse,
- storage of cargo in the warehouse,
- picking, stuffing of cargo for shipment,
- the release of the cargo from the warehouse,
- loading onto the means of transport,
- tracking of cargo consignments,
- unloading from the means of transport.

Figure 5 shows the statistical results presenting the overall use of GS1 standard logistics labels among 37 researched enterprises.

Figure 5. The degree of use of standard logistic labels



Source: own research

Due to an attempt at data generalization, a 5-level Likert scale was adopted, extended by a zero level, in which:

- 5 - meant that a given enterprise always used standard labels in a given process (equivalent to 90-100%),
- 4 - meant that a given enterprise very often used standard labels in a given process (at least 70-80%),
- 3 - meant that a given enterprise often used standard labels in a given process (at least 50- 60%),
- 2 - meant that a given enterprise seldom used standard labels in a given process (approx. 30-40%),
- 1 - meant that a given enterprise very rarely used standard labels in a given process (up to approx. 20%),
- 0 - meant that a given enterprise never used standard labels in a given process (0%).

This list should be interpreted as the percentage of enterprises that use the standard label to a specific extent, e.g.:

- more than 50% of companies (20 companies out of 37 declaring at least partial use of the standard labels) use the standard label in at least 70% of their warehouse receipts,
- almost 60% of companies (22 companies out of 37) use the standard label in at least 50% of releases from the warehouse.

Table 1. Degree of use of standard logistic labels - the analysis of general data

Scope	Process	Degree of utilisation						Weighted average
		0	1	2	3	4	5	
Warehousing	Receipt of cargo/delivery at the warehouse	3	4	5	5	8	12	3.18
	Storage of cargo in the warehouse	8	6	5	5	4	9	2.42
	Picking, stuffing of cargo for shipment	10	6	5	1	6	9	2.32
	Releasing cargo from the warehouse	3	5	7	4	7	11	3.00
Transport	Loading onto the means of transport	9	2	8	5	4	9	2.47
	Tracking of cargo consignments	12	5	4	3	6	7	2.13
	Unloading from the means of transport	14	4	6	3	5	5	1.84

Source: own research

When analysing global data it should be stated that greater use of standard logistics labels is found in warehouse processes. This is also evidenced by the weighted average results determined for individual processes.

When analysing the numerical data from a statistical perspective, it should be stated that all identified warehouse processes use standard logistic labels in the range of at least 60% (2.73), as was the case of transport processes (2.15).

The research points to the need for further dissemination and implementation of standard logistics labels, both in warehousing and transport processes.

By analysing the degree to which standard logistics labels are used in individual companies, the degree to which standard logistics labels are used throughout the supply chain can be deduced.

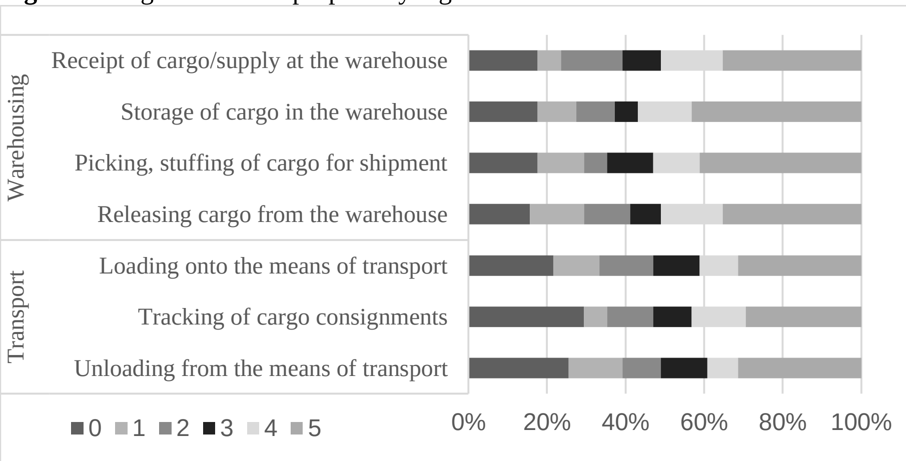
Statistically, the use of a standard logistic label throughout the supply chain oscillates around 35%. In the case of 20 enterprises (out of 37 enterprises using standard labels), it was identified that some of the standard labels underwent through all the processes in the supply chain, which accounted for 54% of companies which declared that they used standard logistics labels.

The next stage of research was to verify the degree of use of proprietary logistic labels in the same warehouse and transport processes as in the case of standard logistic labels.

Similarly, as in the case of the analysis of the degree of use of standard logistic labels, a 5-level Likert scale was adopted, extended by the zero level, in which:

- 5 - meant that a given enterprise always used proprietary labels in a given process (equivalent to 90-100%),
- 4 - meant that a given enterprise very often used proprietary labels in a given process (at least 70-80%),
- 3 - meant that a given enterprise often used proprietary labels in a given process (at least 50-60%),
- 2 - meant that a given enterprise seldom used proprietary labels in a given process (approx. 30-40%),
- 1 - meant that a given enterprise very rarely used proprietary labels in a given process (up to approx. 20%),
- 0 - meant that a given enterprise never used proprietary labels in a given process (0%).

Figure 6. Degree of use of proprietary logistic labels



Source: own research

Proprietary logistics labels were used by 48 companies, which had been taken into account when analysing the degree of label use. This list should be interpreted as the percentage of enterprises that use the proprietary label to a specific extent, e.g.:

- over 50% of companies (26 companies out of 48 declaring at least partial use of the proprietary labels) use the proprietary label in at least 70% of their warehouse receipts,
- almost 60% of companies (28 companies out of 48) use the proprietary label in at least 50% of releases from the warehouse.

When analysing global data it should be stated that greater use of proprietary logistics labels is found in warehouse processes. This is also evidenced by the weighted average results determined for individual processes.

Table 2. Degree of use of proprietary logistic labels - the analysis of general data

Scope	Process	Degree of utilisation						Weighted average
		0	1	2	3	4	5	
Warehousing	Receipt of cargo/delivery at the warehouse	9	3	8	4	8	16	3.06
	Storage of cargo in the warehouse	9	5	5	3	7	19	3.18
	Picking, stuffing of cargo for shipment	9	6	3	6	6	18	3.12
	Releasing cargo from the warehouse	7	7	6	4	7	17	3.00
Transport	Loading onto the means of transport	11	6	7	5	5	14	2.71
	Tracking of cargo consignments	15	3	6	5	6	13	2.61
	Unloading from the means of transport	13	7	4	5	4	14	2.57

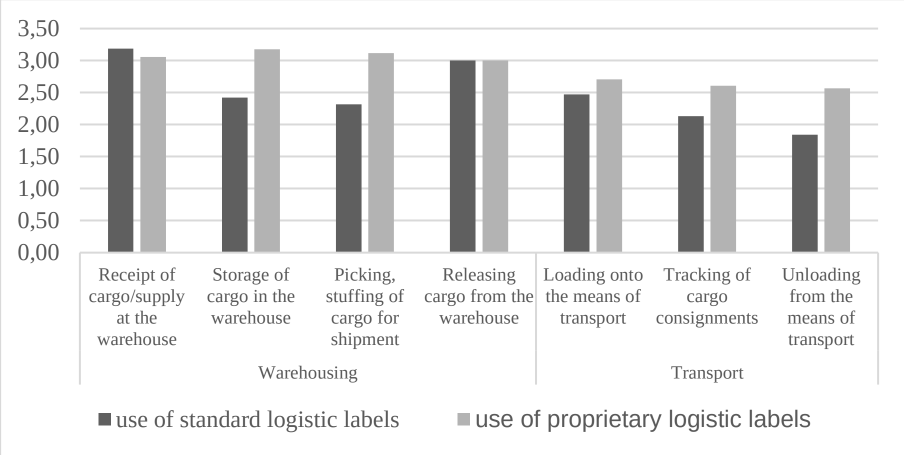
Source: own research

When analysing the numerical data from a statistical perspective, it should be stated that all identified warehouse processes use proprietary logistic labels in the range of at least 60% (3.09). In case of transport processes, the use of proprietary logistic labels exceeds 50% (2.63).

Statistically, the use of a standard logistic label throughout the supply chain oscillates around 48%. In the case of 36 enterprises (out of 48 enterprises using proprietary labels), it was identified that some of the standard labels underwent through all the processes in the supply chain, which accounted for 75% of companies which declared that they used proprietary logistics labels.

Fig. 7 shows a comparison of the average value of the degree of use of standard and proprietary labels in individual warehousing and transport processes.

Figure 7. Comparison of the use of standard and proprietary logistic labels



Source: own research

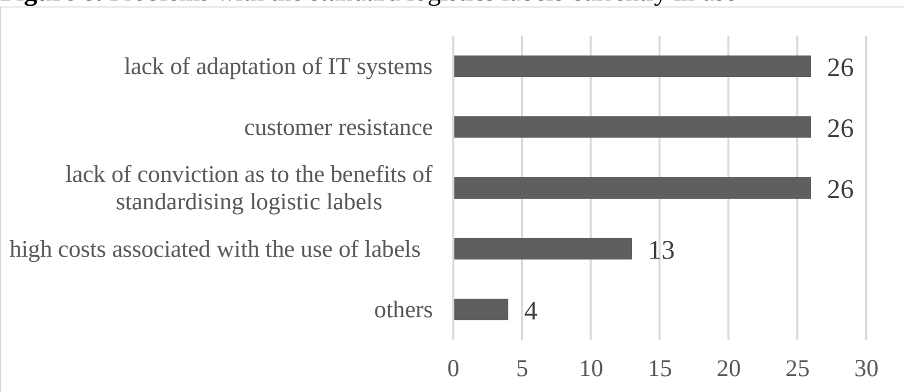
When comparing the degree of use of standard and proprietary logistic labels, relatively similar values could be noted - e.g. in case of cargo release from the warehouse, both standard and proprietary labels are used at the level of 50-60%.

It should be noted that the use of standard labels in the global context should increase and should become more prevalent in business practice. However, this conclusion should be confirmed by repeated research in this area in the future.

Identification of barriers to implementation and problems with the use of logistic labels in business practice

A separate element of the research was the identification of barriers related to the implementation of standard logistic labels and problems with their use after their implementation. Figure 8 shows statistical results showing the identification of problems with the use of logistics labels in business practice.

Figure 8. Problems with the standard logistics labels currently in use



Source: own research

When analysing the results from the general perspective it should be noted that the main problems with an even greater use of the already implemented standard logistics labels are as follows:

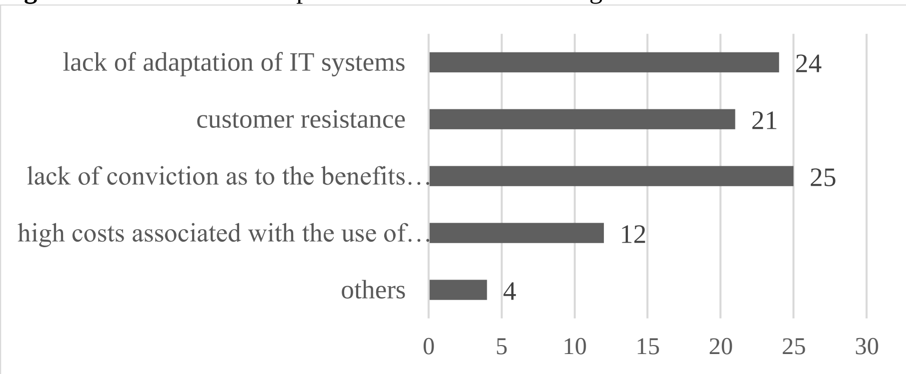
- lack of adaptation of IT systems of the counterparties to the available functionality (51%),
- customer resistance (51%),
- lack of conviction as to the benefits of standardising logistic labels (51%).

Other problems identified in particular enterprises during the research were as follows:

- incomplete data generated by our customers,
- operators using proprietary labels, lack of expectations and lack of use of labels by most customers,
- different labels for different customers,
- the type of label which was imposed by the customers (vehicle manufacturers).

Figure 9 shows the statistical results presenting the general trend in the scope of barriers to the implementation of standard logistics labels in new processes or with new counterparties. This identification also included those companies that had already used standard labels but had had difficulties in their dissemination among other business partners.

Figure 9. Barriers to the implementation of standard logistics labels



Source: own research

As in the case of problems with the use of standard logistic labels, the barriers identified at the implementation stage are related to the same issues. The basic barriers to the implementation of standard logistic labels are as follows:

- lack of adaptation of IT systems of the counterparties to the available functionality (47.1%),
- customer resistance (41.2%),
- lack of confidence in the benefits of standardising logistic labels (49%).

Other barriers identified in particular enterprises during the research were as follows:

- proprietary system,

- incorrect data on the label,
- the requirement of the World Postal Union for the identification of cross-border consignments,
- relying on customers' logistic labels.

5. THE ANALYSIS OF THE IMPACT OF LOGISTIC LABELS ON DISTRIBUTION AND SUPPLY CHAIN EFFICIENCY

This part of research presents the result of analysis concerning the impact of use of logistic labels on the efficiency of warehouse processes as one of the elements of the supply chain. Due to the fact that one of the key issues of effective implementation of a standard logistic label is to convince manufacturers/distributors to benefits that can be obtained from its use, we have decided to present in this case study an example of a company manufacturing and distributing wiring harnesses for the automotive industry. This case study concerns EL-CAB, a company whose beginnings date back to 1996, when it started its business activity from the production of cable harnesses for buses of NEOPLAN Polska. At that time, the company employed 22 persons. Currently, employment has increased several times and the company provides cable harnesses to various companies, such as: SOLARIS BUS, IFE-CR a.s, BAVARIA, JELCZ, VOLKSWAGEN PL, etc.

The manner of identification of goods, locations and cargo units

On the basis of the conducted analysis it can be concluded from the submitted data on the labels on the packagings under deliveries that the labels on the transport units are:

- variable, depending on the supplier's labelling system,
- incomplete, since they do not contain all pieces of information
- recorded using in various code symbols, difficult to read by owned ADC devices.

For this reason, EL-CAB now labels all transport units with internal labels, an example of which is shown in Figure 10, after the delivery inspections have been carried out.

Figure 10. Example of an applied internal label of a transport unit

Source: own study

The following data are included in the sample label:

- "1010-008282-00"- goods index,

- "4250"- quantity in units of measurement,
- "51965430" - number of the cargo unit in the delivery.

Selection of the target goods identification system

In order to be able to streamline the entire logistic process, EL-CAB will require that the Supplies should include the following data on the label:

- EL-CAB internal index of goods,
- Quantity on/in the transport unit,
- EL-CAB order no.,
- EL-CAB customer no.,
- Transport unit number/resource number.

As a result of the analysis of data on domestic suppliers of EL-CAB in cooperation with the GS1 Polska Foundation, it was confirmed that about 21% of domestic suppliers were participants of the GS1 system. Moreover, it was assumed that among foreign suppliers there were also suppliers participating in the GS1 system.

Therefore, an internal solution based on the GS1 identification standards was proposed. Companies participating in the GS1 system will mark transport units in accordance with the standards on the basis of the number pools assigned to them, and companies not participating in the system will mark them with internal numbers in accordance with the guidelines and information provided by EL-CAB.

Effects of logistic label implementation at EL-CAB

Estimation of the effects of implementing a logistics label was carried out on the basis of the methodology applied by the Institute of Logistics and Warehousing for diagnosing warehousing processes. On the basis of the course of the identified current warehousing process, its assumed modification, average size of deliveries to the warehouse and average times of execution of particular activities in the process of receipt of deliveries given by EL-CAB, the labour intensity of the process was determined by comparing the situation before and after the implementation of the label. While determining the labour intensity of the process of handling deliveries with the use of a logistic label, it was assumed that only 50% of suppliers will identify the transport units sent to EL-CAB with labels. A comparison of the labour intensity of the delivery process with and without a logistic label is presented in table 3.

Table 3. Labour intensity of the delivery handling process before and after the implementation of the label

LABOUR INTENSITY OF THE PROCESS:	
WITHOUT LOGISTIC LABEL	WITH LOGISTIC LABEL
306.05	253.92
-	-17%

Source: study of the Institute of Logistics and Warehousing

The simulation of the effects of implementing logistic labels in the process of receiving deliveries showed the possibility of reducing labour intensity by about 17%, assuming that 50% of suppliers will identify the units in accordance with the guidelines provided.

In case of an increase to 80% of identifying suppliers, the possibility to reduce labour intensity will increase to approx. 22%.

This analysis confirms not only the need to implement logistics labels, but also to focus on the number of suppliers who use them. Implementation of a logistic label with only one supplier will not generate optimization effects of a given process. Popularization activities are necessary to encourage companies to research and implementations in this area.

6. CONCLUSION

As part of the work carried out in 2018, 51 companies from the TL sector were researched. The main conclusions of the survey concerning the degree of use of logistic labels:

- 72% of enterprises (37 researched ones) used at least partially logistic labels,
- 94% of enterprises (48 researched ones) used at least partially proprietary logistic labels,
- 76% of the researched enterprises (29 out of 37 using a standard label for some of their processes) indicated the use of standard manufacturer's/logistics labels in their processes,
- 71% of enterprises (27 out of 37) used standard labels to organize their shipment/release, of which nearly 60% (22 out of 37) used standard labels for at least 50% of their warehouse releases,
- over 50% of companies (20 companies out of 37 declaring at least partial use of the standard labels) use the standard label in at least 70% of their warehouse receipts,
- 54% of companies (20 out of 37 companies using standard labels) were identified as having a proportion of standard labels (35% on average) going through all processes in the supply chain,
- the main issues of even greater use of already implemented standard logistics labels concern the lack of adaptation of IT systems of the counterparties to the available functionality (51%), customer resistance to implementation (51%) and lack of conviction as to the benefits of standardized logistic labels (51%),
- based on the use of logistic label it is possible to generate measurable savings throughout the supply chain, as indicated by research. Only in the process of storage one can achieve savings in handling time of up to 22%, which is a significant value.

The research work in subsequent years shall be focused:

- not only on attracting new operators to implementing the standard label, but also on increasing the involvement of existing operators who already

use the standard label in their processes (increasing the percentage of customers using the standard label in cooperation with a given operator),
- on increased attracting of manufacturers/distributors to implementing standard logistics labels, due to their key role in the type of label used in the supply chain (increasing the percentage of customers using a standard label in cooperation with a given operator),
- committing IT system suppliers to applying the assumptions of the standard logistic label GS1 and other GS1 standards in their standard functionality (on a global level, not with the view to meeting specific functional expectations of customers). This measure shall encourage system users to apply standard solutions offered by GS1, which in the perspective of the next few years shall affect the unintentional increase in the use of standard logistic labels by manufacturers/distributors, in warehouse and transport processes,
- on technical support for the integration of business partners in the supply chain by means of EDI messages, not only in terms of using a standard logistic label but also in terms of the whole order to cash process. The aim of this measure is to support the integration of the companies identified above as key ones for the achievement of the basic objectives of GS1 in the scope of implementation of the logistics label,
- further popularisation /dissemination activities. Aimed at raising awareness of the benefits of using standard logistic labels (training, consultation, webinars). The aim of these measures is to indicate the possibility of standardizing the used labels in accordance with GS1 requirements and to verify their correctness afterwards.

The need for a comprehensive implementation of the logistics label throughout the supply chain, i.e. involving chain partners representing different business roles (manufacturer, carrier, distribution centre, logistics operator), should be considered as a basic premise for the implementation of these tasks. This approach will strengthen the efforts to increase the percentage of customers using standard labels in cooperation with a given operator.

The issue of the impact of the logistics labels use on the distribution and supply chain efficiency requires further research in both literature and business practice. Theoretical research works in this area are conducted at the Poznan School of Logistics, which will allow to unify the methodological scope and definition of distribution and supply chain efficiency. However, business practice research conducted by the Lukasiewicz Research Network - Institute of Logistics and Warehousing faces certain limitations that affect the results obtained. The basic limitation is the lack of knowledge about standard solutions. Companies using barcodes on logistics labels identify them as GS1 labels, which is not always true. Another serious limitation is the lack of belief in the benefits of using standard solutions. The direction of further research is therefore not only methodological but also diseminative work.

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V. URBAN, HUMANITARIAN AND GREEN LOGISTICS

THE ROLE OF URBAN LOGISTICS REAL ESTATE IN LAST MILE DELIVERIES: OPPORTUNITIES, CHALLENGES AND SUCCESS FACTORS FOR INTEGRATION

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Abstract

Rising urbanization, growing share of e-commerce sales, high-frequency and customer-specific deliveries as well as increasing urban access regulations lead to higher requirements for logistics service providers in supplying the urban last mile. Despite space scarcity, logistics service providers have to move closer to customers in order to provide high service levels in distribution. Hence, urban logistics facilities gain strategic importance. This paper aims to present the current status of urban distribution network structures and related logistics facility design, as well as current challenges and relevant success factors for developing sustainable and future-oriented last mile distribution systems. Based upon a literature-based description and assessment model, an explorative study of 38 German participants has been conducted. The main results indicate a particular lack of collaboration among all stakeholders in urban distribution working together on solutions for efficient urban logistics. This is for instance reflected in bureaucratic constraints, complicating tender and approval procedures on governmental level. Our results provide three distinct hypotheses for successfully designing and implementing urban logistics real estate into urban logistics systems. Practitioners may find new approaches for designing their own distribution structures, just as public institutions may find suggestions on how they can support urban distribution through process adaptations and thereby increase social well-being of inhabitants.

Key words: urban logistics, logistics real estate, last mile delivery

1. INTRODUCTION

Currently, more than 55 percent of the world's 7.5 billion population live in cities. Until 2050 this proportion is expected to rise up to 67 percent - from a predicted 9.3 billion population (Prange, 2018). Hence, living space, work environment and existing infrastructure needs to be adapted. More and more goods are distributed in metropolitan areas, consequently, transport volume is increasing (BIEK, 2018). In 2017, 3.35 billion single shipments were distributed in German B2C retail, corresponding to 11 million shipments per delivery day. For 2021, 4.15 billion shipments are forecasted (BIEK, 2018). Although only about 30 percent of urban traffic is commercial traffic, increasing shipment volumes from retailers or the hospitality industry lead to a heavy traffic load (Schmid, 2018), pushing the capacities of cities to their limits (Bernsmann, 2017). This results in increased noise, emission and particulate matter levels (Kiwitt, 2010).

Due to the increasing range of services, such as same-day delivery or flexible delivery points, structures and procedures of logistics service providers are reaching their limits, as the complexity of delivery increases and greater flexibility is required (PwC, 2017). The growth in delivery frequency and the small size of shipments represents a particular challenge in operations for logistics service providers on the last mile which requires alternative concepts (PwC, 2017). Despite urban space shortages, the proximity to customers is becoming essential. Urban logistics properties are gaining strategic importance to meet the demand for environmentally friendly and fast deliveries. Though, the acceptance of the logistics sector is growing, it is competing intensively with more attractive asset classes such as office or residential real estate in urban areas with limited space (Kille & Nehm, 2017).

The technical perspective in urban logistics is a frequently discussed aspect, especially regarding vehicle routing problems (e.g. Crainic et al., 2004; Taniguchi and Shimamoto, 2004; Ando and Taniguchi, 2006). Also the stakeholder perspective is explored in various studies, as the collaboration of involved parties (e.g. traders, couriers, logistics service providers) is considered as a main success factor for implementing new urban logistics solutions (Hensher and Puckett, 2005; Holguín-Veras, 2008). Stakeholder management on the one hand can be structured to involve the opinions of key stakeholders (Bourne, 2008; Statopoulos et al., 2012), on the other hand project owners can actively influence the attitude of stakeholders towards such projects, heightening the acceptance of urban logistics solutions (Dablanc et al., 2011). This can be done in a progressive approach, heightening the complexity of collaboration, starting from data sharing up to a commonly used urban distribution center (Pinto et al., 2015). A key challenge regarding urban logistics is the role of public authorities, as their actions are affecting urban logistics projects with legislation and structural interventions (Statopoulos et al., 2012), but often they do not fully understand the urban logistics issues, as they are complex in nature and involve conflicting stakeholder interests (Ballantyne et al., 2013).

To the best of our knowledge the topic of urban logistics assets as part of the urban distribution network and the associated involvement of stakeholder is not specifically covered in scientific literature. Due to this gap and the increased relevance of new logistics structures, the aim of this paper is to outline the role of urban logistics real estate as well as the interaction of involved stakeholders. Focusing on the urban network configuration of parcel service providers (CEP) to supply the last mile to end customers, the following research questions arise:

RQ I: How and why do which urban stakeholders interact in urban logistics real estate projects?

RQ II: Which success factors need to be considered in order to improve urban distribution networks?

In order to answer the above mentioned research questions in a structured way, the remainder of this paper is structured as follows: In the following section, the theoretical and conceptual foundation of urban logistics networks is outlined. Next, the methodology applied is described. Afterwards, the findings gathered are presented, guided by dimensions emerged from the data. These will be amalgamated in the following chapter and condensed into three hypotheses regarding urban logistics real estate projects. Finally, we continue to discuss open research gaps.

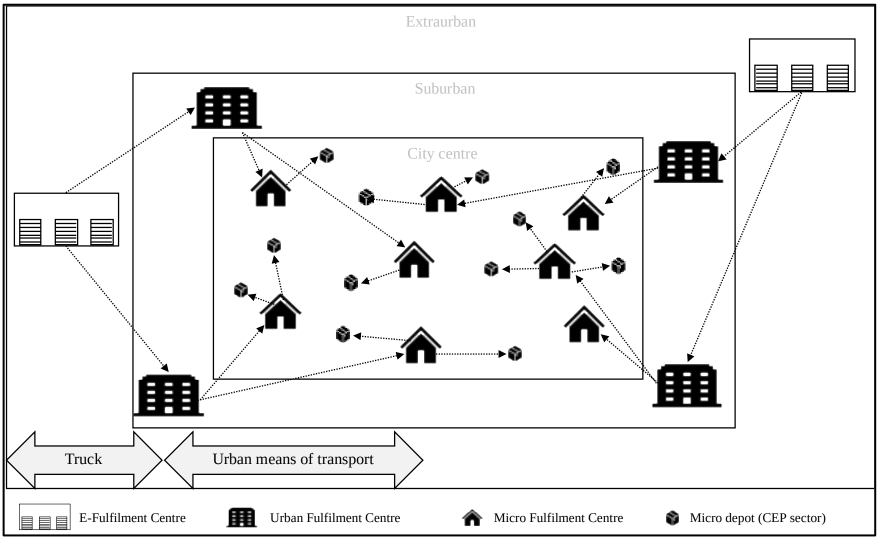
2. THEORETICAL FOUNDATION

2.1. Overview of urban network structures

Logistics is responsible for the spatial-temporal transformation of goods within the entire value chain through storage and movement processes. For this purpose, it uses function-specific subsystems that ensure the core task of efficient goods distribution through systemic interaction. Logistics systems are efficient when the highest possible delivery service can be achieved at the lowest possible cost. Storage and movement processes take place in logistics network structures that connect the source of a shipment with its final destination. Additional network nodes can be integrated between the two, which temporarily receive goods in order to tranship, consolidate, separate and transfer them to another network path. The transport between the nodes takes place via transport edges in the network (Pfohl, 2016; 2018).

As part of the urban logistics network, logistics real estate plays an important role. However, the shortage of urban space makes the construction of pure logistics real estate more difficult. Urban logistics requires multi-level, flexible and dynamic distribution and warehousing structures in the form of larger logistics properties outside the city and (flexible) smaller micro depots (PwC, 2017) which can be found in a cascade structure (Bulwiengesa AG, 2017).

Figure 1. Cascade structure of an urban logistics network



Source: Own illustration based on Bulwiengesa AG, 2017; Bu et al., 2012.

2.2. Urban distribution center concepts

In the cascade-shaped urban network structures, it is possible to differentiate between four different types of distribution centres based on their location, size, number of employees and functionality.

- Large, extra-urban transhipment centres, **E-Fulfilment Centres**, are used by (online) retail companies for standard dispatch. These have an area of between 25,000 and 150,000 m² on which between 500 and 1,000 employees work. They supply a radius between 100 and 250 km (Bulwiengesa AG, 2017).
- **Urban Fulfilment Centres** enable direct delivery of (online) orders in a radius of 10 km. An operations area between 4,000-6,000 m² require approximately 30-250 employees (Bulwiengesa AG, 2017).
- The urban **Micro Fulfilment Centres** serve the direct delivery of orders from online retail companies to customer. These logistics properties require between 30-50 employees in 1,000-3,000 m² and serve a radius of 1-5 km (Bulwiengesa AG, 2017). Regional depots, e.g. Urban Consolidation Centre (UCC), are located outside and inside the city and are responsible for standard shipping in the CEP sector, retail logistics as well as for internal deliveries. Between 100 and 200 employees work on approximately 15,000 m^2, covering an area of 50-70 km. Due to the direct customer delivery they still belong to Micro Fulfilment Centres (Lehmacher, 2015).
- Urban **micro depots** are often relatively small (15-25 m² CEP area / 200-500 m² retail), therefore, they are quite easy to operate. Accordingly, the

number of employees is low (2-5 CEP / 15-20 retail) and they can supply only a small radius (1 km CEP / 2-4 km retail) (Bulwiengesa AG, 2017).

2.3. Transport systems in urban logistics

Smaller shipment sizes present challenges in terms of a higher volume of shipments and the associated increased volume of traffic, which needs to be integrated into existing traffic (Kille & Nehm, 2017). Particularly on the last mile, the focus is on the use of environmentally friendly transport technologies to make more efficient use of infrastructure (Deckert, 2016). Urban access restrictions for conventional, diesel-powered delivery vehicles in city centres can be circumvented with **electric vehicles**. The use of **load bicycles** is another way to use other transport routes (Kloeckner, 2017), especially for relatively light, non-bulky shipments from nearby depots in the city centre (Johanning, 2017).

2.4. Actors in urban logistic networks

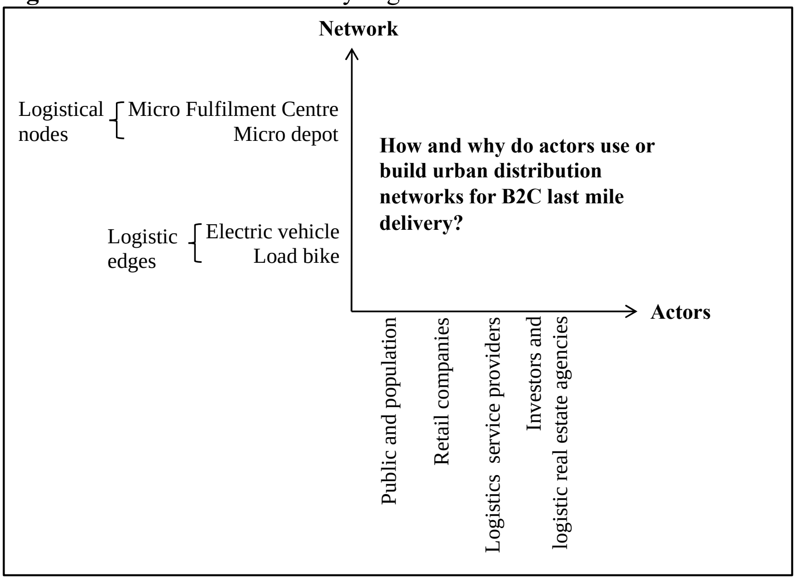
Different actors influence urban logistics networks:

- The **public** basically pursues the increase of local economic power without restricting the quality of inhabitants' life (Veres-Homm & Weber, 2017).
- The demands of the **local population** on the economic system are influenced by the perceived quality of life, in terms of the availability of adequate jobs, the satisfactory supply of goods and the involvement in political decisions (Veres-Homm & Weber, 2017).
- In the context of logistics, **urban planners** are more and more involved in the planning of logistics areas in order to meet the demands of both, citizens and business, which often leads to a tension between the urbanisation of cities and the globalisation of retail (LogReal World GmbH, 2018).
- **Retail companies**, as clients, often seek and award supply contracts to logistics service providers and thus influence urban supply.
- **Logistics service providers** demand a long-term development perspective from cities with regard to sufficient regional staff with appropriate qualifications and the opportunity to grow in terms of area. Good infrastructural connections and support for municipal policy are also important (Veres-Homm & Weber, 2017).
- **Investors** act as lenders and are usually only interested in a (logistics) real estate if it is profitable (Bulwiengesa AG, 2017).
- As operational extension, **logistics real estate agents and developer** provide the location, the capital and the concept in a defined period of time and realize logistics real estate projects. In addition to initiating new projects, they also develop, modernise or revitalise existing areas and act as intermediaries for the various players (Rottke, 2017).

3. METHODOLOGY

As the role of urban logistics assets is scarcely covered in academic literature, an exploratory study needs to be conducted. We used a grounded theory inspired research approach, in which we inductively gathered insights about the urban logistics real estate by interviewing 38 experts in the field. Interviewing experts is a common method for data collection, as they have valuable insight in a research topic and provide information about actual processes and structures (Creswell, 2012). After reviewing grounded theories in literature, we followed the action and processes-oriented Strauss and Corbin approach (Corbin & Strauss, 2008) because it allowed us more flexibility and procedural guidance. Moreover, it allows us to adopt a conceptual framework from theory, developed within a preliminary study and consists of the determinants of networks and actors (Yahşi, 2017). The above described urban logistics network in combination with the changing requirements of urban environment lead to the following framework.

Figure 2. A framework for analysing urban real estate



Source: Own figure

3.1 Data Collection

In order to determine the role and function of actors in urban distribution, a total of 38 interviews with different backgrounds were conducted. The experience of practitioners is a relevant source of data in research, as they are well informed about current practices and future challenges (Flynn et al., 1990; Trautrims et al., 2012). Due to the distance between interviewer and interviewee, as well as the high quantity of interviews, only four interviews were conducted face-to-face, the rest was conducted by phone. In terms of the interview structure, semi-standardised interviews were selected for the previously little explored subject of urban logistics space, so that individual problems could be examined in greater depth, but at the same time the interviewee was given the opportunity to speak freely (Lindlof & Taylor, 2011). An interview guideline including open and closed questions as well as the likert scale as a scale instrument (Raab-Steiner & Benesch, 2015) was used to conduct the semi-structured interviews, which had been tested several times and continuously developed and adapted beforehand. The interview questionnaire was splitted into three main categories: Urban logistics and delivery concepts, challenges in the integration of logistics real estates in urban areas and possibilities and fields of action for the integration of urban logistics real estates.

The attendees of the survey were split into different groups: 20 largest German cities, representatives of research institutions (2) and chambers of industry and commerce (3), lawyers with focus on logistical real assets (2), CEP providers (3), companies with logistics focus (6), logistics real estate developer (4), logistics real estate broker (3).

Figure 3. Categorization of interview partner

Category	Interview number
Logistics real estate developer	16, 22, 23, 26
Logistics real estate broker	1, 28, 37
Company with logistics focus	2, 4, 18, 31, 34, 35
City representative	3, 5, 6, 9, 10, 11, 12, 13, 15, 17, 19, 20, 21, 25, 27, 29, 33
Logistics Service Provider	7, 14, 30
Lawyer	8, 38
Research Institution	24, 32
Chambers of industry and commerce	36

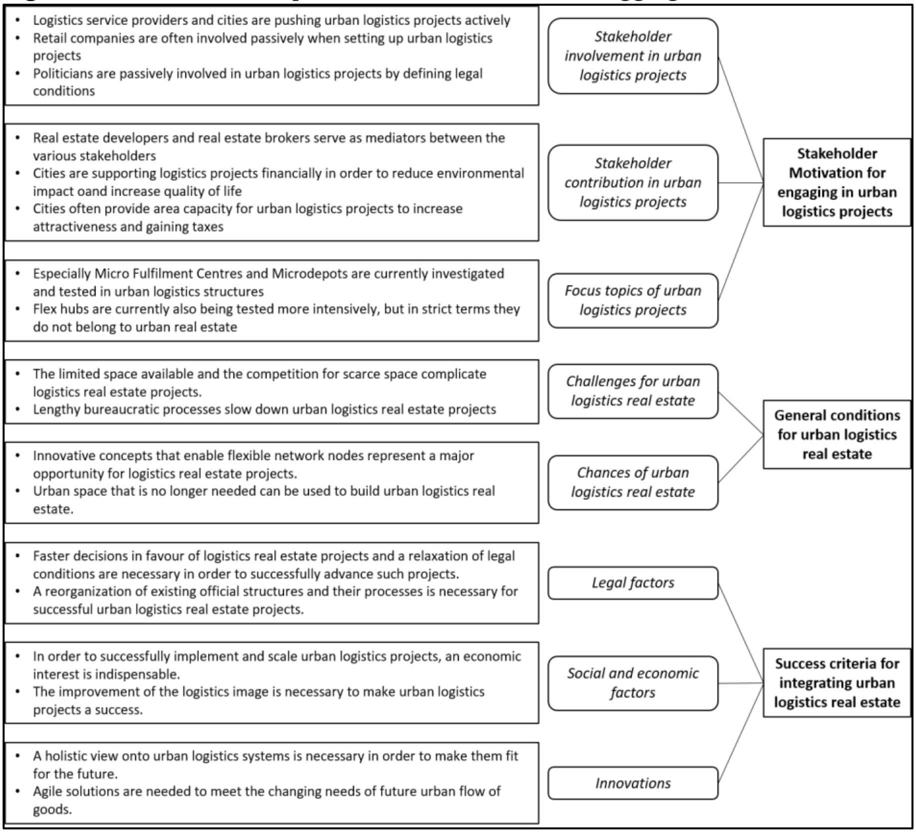
Source: Own figure

3.2 Data Analysis

We used a grounded-theory inspired, qualitative research approach to create a data-based theory, as there is not enough theoretical material available to formulate a theory. Accordingly, we used an interpretative research approach based on interviews with experts from the field. Our task as researchers is to gain deeper theories by interpreting the results obtained (Bryman & Bell, 2011). We followed the procedures recommended by Corbin and Strauss (2008).

Each interview was documented in writing and then coded according to core statements. Based on underlying similarities among them, we were able to create 18 relevant first order concepts. We then searched for connections between the individual concepts in order to create 8 second-order themes at a higher level. Finally, we classified these into 3 aggregated dimensions that define the structure of our framework. Figure 4 shows the data structure and our first order concepts, second order themes and the aggregated dimensions.

Figure 4: First order concepts, second order themes and aggregated dimensions



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4. RESULTS

In this section, the role of different stakeholders in urban logistics real estate projects is outlined, based on our empirical findings gathered. The aim is to find out, how and why stakeholders engage in urban logistics real estate projects. In addition, we want to determine which challenges have to be considered when integrating urban logistics real estate, and which opportunities are available to drive such projects. Ultimately, success criteria should be examined which have to be considered when designing and implementing urban logistics real estate projects. We use the structure explored in section 3 as guideline for presenting our findings. First, the stakeholder motivation for engaging in urban logistics projects is analysed. Following, main conditions for integrating urban logistics real estate in urban network structures are examined. Lastly, success factors for integrating urban logistics real estates in urban network structures are investigated.

4.1. Motivation for urban logistics projects

4.1.1. Stakeholder involvement in urban logistics projects

The different stakeholders of urban logistics projects have either an active or passive influence. Due to their position as infrastructure users and providers, logistics service providers and cities are actively involved in such projects and consistently drive their further development.

Retail companies that require logistics space are passively involved (28, 30). Their role is that of demanders of logistics performance, whereby they define specific logistical performance requirements. In addition, they themselves compete for space in urban regions.

As further passive parties, politics can be identified which define the legal framework conditions of infrastructure and can thus either accelerate or hamper logistics projects (13, 14).

4.1.2. Stakeholder contribution in urban logistics projects

Different actors contribute in different ways to the development of urban logistics real estate projects. Cities in particular play a major role here, as they support projects financially and with resources. Due to their elevated position as land owners and infrastructure providers, they often taking the lead in project management. Logistics real estate developer and logistics real estate broker act as mediators between logistics service provider and cities in projects (22, 26, 28). Nevertheless, logistics service provider and cities are in a general exchange (7, 14).

The survey shows that projects are actively promoted or financially supported by various specialist groups on the part of the cities (20, 25). Financial support usually aims at two goals. On the one hand, cities want to reduce the environmental impact of logistics processes. On the other hand, the quality of life in cities should be improved by a properly operating infrastructure (12).

In addition to financial support, cities also provide support in the form of areas for urban logistics real estate projects. This is not always completely voluntary, as land use plans by higher authorities force cities to act. However, there is also a self-interest, since such projects increase both the attractiveness for investors and can increase tax revenues (27, 33).

4.1.3. Focus topics of urban logistics projects

Stakeholders in urban logistics projects are involved in alternative transport or innovative network concepts. Regarding the mode of transport, the interview partners generally see electric vehicles and load bicycles as major options in urban areas (7, 14, 19, 24, 27) and are willing to support these. Reasons for this are traffic reduction (18, 20, 28, 29, 30, 35-37) and the integration into cities by using low-emission and quiet logistics (12, 13, 16, 21, 24, 25, 38).

In the area of logistic nodes, both Micro Fulfilment Centre and micro depot projects are ongoing or carried out. Micro Fulfilment Centres can be used in new mixed-use properties through the use of brownfields. This can be used to revitalize existing areas that are currently underutilized. At the moment, urban retail spaces are interesting, which are less needed due to increasing online commerce (Bulwiengesa AG, 2017; Kille and Nehm, 2017). The conversion of (future) unused areas, as vacant commercial properties in the city centre, also plays an important role in the area of micro depots (BIEK, 2017b).

Flex hubs are actually not real estates because they consist of mobile units such as containers. In the area of Micro Fulfilment Centres, projects were primarily mentioned in the area of new construction and conversion as e.g. sorting centres such as DPDHL's MechZB (6, 11, 16, 28, 29, 37). In the area of micro depots, flex hub solutions such as the GLS and DPD project in Nuremberg (21, 25), the flex hub project KoMoDo in Berlin (12, 14) and the UPS project in Hamburg (14, 18) were mentioned.

4.2. Conditions for the integration of urban logistics real estates

4.2.1. Challenges for urban logistics real estate

The greatest challenges for urban logistics networks can be found in the scarcity of space and complex approval procedures. Competition is fierce for scarce urban space. The low image of logistics among the general population reduces the chances of a land contract, as more prestigious projects are often awarded the tender (7, 8, 14, 19, 20, 26, 31, 37). In addition, the shortage of space increases investment and rental costs, which means that logistics projects can often no longer pay off on the cost side (2, 5, 8, 12, 14-17, 20-22, 26, 27, 29, 33, 36).

Bureaucratic processes slow down the implementation of urban logistics projects, although these are included in urban land-use plans (20, 31). In addition to mandatory approval procedures, regulations such as territorial compatibility or a large number of noise protection requirements in urban areas pose challenges (1, 8, 38). Although regulatory laws make the operational business of logistics service providers more difficult, they are also seen as an opportunity to develop innovative logistics concepts (14, 24, 32, 34).

4.2.2. Chances for urban logistics real estate

New concepts for urban logistics networks are a key opportunity for last mile delivery. Flexible network nodes in the form of micro depots as well as new approaches to land utilisation need to be differentiated.

In the CEP sector in particular, Micro depots above-ground and underground parking areas can act as a supplement to night-time transhipment. This is especially the case with decreasing numbers of private vehicles in the future (3, 18, 24, 27). Multi-storey car parks pose challenges, due to low ceiling height and safety considerations (3, 5-7, 16, 17, 21) as well as high requirements in terms of fire protection (20, 25). Therefore, containers as flex hubs provide a temporary solution for exploiting fluctuation times and testing processes (4, 9, 18, 21, 23, 37). However, lengthy approval procedures, high costs and the integration into existing cityscape aggravate the usage of flex hubs (8, 20, 22, 25, 32).

In addition to new concepts, the efficient use of space is of great importance. Depending on the land use plan, cost-intensive measures (e.g. land revitalisation, fire protection regulations, conversion measures, rents) and profitability must be taken into account (6, 12, 14, 17, 20, 26). By defining logistical areas in the land-use plan, cities can simplify the process of finding areas and also regulate the rent level, resolving potential conflicts (10, 23, 24, 26, 28, 38). In the area of new space solutions, new logistics properties can be built in height or depth due to automation, enabling plots to be equipped with adaptable logistics properties (11, 20). To justify the high construction costs, it must be ensured that traffic savings and process improvements can be generated (7, 12, 18, 20, 24, 26, 30, 32, 34).

4.3. Success criteria for the integration of urban logistics real estates

4.3.1. Legal factors

Bureaucratic processes were cited as a major challenge for the success of urban logistics real estate projects. The interview partners identified the relaxation of complex legal bases as a major success factor. A simpler approval procedure for urban areas is explicitly required, as is a simpler approval procedure for multi-storey logistics properties. This is associated with simpler approval procedures for testing innovative logistics concepts.

The overall requirement is that there should be a reorganisation of governmental structures and associated processes to accelerate and improve cooperation. The land use plans used so far must be adapted to the new requirements of urban logistics. In addition, it is proposed to review the overall legal framework, for example in order to allow longer delivery times in urban regions (18, 21).

4.3.2. Social and economic factors

To lead urban logistics real estate projects to success, it is indispensable that the economic viability is clearly recognizable from the very beginning. This is necessary to find fitting investors, in favour of support projects financially. Corresponding projects must meet the requirements of logistical efficiency, as they must also be scalable in large quantities.

The interviews show that the improvement of the logistics' image coupled with the increasing necessity and innovative strength of logistics service providers may be an important aspect in convincing politicians and citizens (33, 37). So far, despite regular exchanges between stakeholders, the promotion of logistics space has hardly been actively pursued. This can be explained by the fact that urban areas are scarce and the need for urban logistics real estate projects is apparently not yet acute.

4.3.3. Innovations

Innovative, but also holistically thought-out concepts are core prerequisites for the success of urban real estate projects. Electromobility has often been mentioned as an example; although it is innovative, it cannot be used without a suitable charging infrastructure. Accordingly, such infrastructure must be created at an early stage (6, 20, 22, 23). Applied to urban logistics projects, this means that the existing logistics system needs to be rethought. Several concepts are to be interlinked here in order to be viable for the future as a whole. This includes the multi-use of existing areas as well as the integration of smaller micro depots (13, 31, 36, 38). The interviewees see the combination of both kind of logistical nodes in a cascade system (9, 20, 21, 24, 25, 29, 30, 34) which includes small customized solution (5, 8, 30, 33, 38) in urban areas. In addition, new and more flexible framework solutions need to be created, such as delivery periods, e.g. in connection with preferential treatment for electric vehicles or the systematic organisation of delivery zones (8, 11, 15).

Although the infrastructures in cities can usually only be further developed over a period of 20 - 30 years, cities are constantly evolving and need to become more agile in their adaptability (31, 35). Regarding the urban network delivery infrastructure, rising parcel volume can be mastered with the help of innovative and mass-produced concepts (14). Individual characteristics of the area as legal restrictions, parcel volume, typography and population density need to be taken into account (14, 20, 34, 37).

5. HYPOTHESES FOR URBAN LOGISTICS REAL ESTATE PROJECTS

Our empirical results gathered illustrate three dimensions of urban logistics projects: a) the motivation of involved stakeholders to participate in urban logistics projects, b) the challenges and chances of urban logistics real estate projects, and c) success criteria to be considered when realizing urban logistics real estate projects. In the following, the core statements for each dimension are summarized and associated hypotheses are derived.

a) Motivations and objectives of stakeholders in urban logistics projects

A large number of players are actively and passively involved in urban logistics real estate projects. Logistics service providers and cities have a symbiotic connection to actively promote such projects. Retail companies are passively involved by defining logistical requirements and demanders of urban space. Politicians are responsible for creating legal framework conditions for such projects. The different actors participate in urban logistics real estate projects in order to enable faster delivery, enabling future viable infrastructure and at the same time improving quality of life in cities. To this purpose, cities in particular provide financial and resource-based support. Both are used in innovative warehousing and transport concepts, which are developed in particular by logistics service providers. Following hypothesis is derived in this dimension:

H1: In order to enable sustainable urban logistics real estate projects, several stakeholders need to work together, with cities in particular playing a central role as infrastructure providers and coordinators.

b) Opportunities and challenges of urban logistics real estate projects

The shortage of space in urban regions is the biggest challenge for urban logistics real estate projects, as they have to compete with many more prestigious projects. In addition, lengthy bureaucratic processes hamper the implementation of projects that have already been decided. These challenges are countered with innovative concepts that can use declining urban areas for logistics processes with small, flexibly adaptable solutions. This makes it possible to conquer urban areas without major competition by intelligently revitalizing areas of future declining business models. In order to achieve this, adaptations to the legal framework need to be realised. This leads to the following hypothesis:

H2: Innovative logistics concepts can help with the revitalization of areas of future declining business model, although this will require the reduction of bureaucratic obstacles.

c) Success Criteria for urban logistics real estate projects

In order to successfully implement urban logistics real estate projects, several key factors have to be considered and adjusted. First of all, legal regulations, bureaucratic structures and their processes need to be adapted. The aim here must be to accelerate and simplify the approval procedures, especially in order to be able to test innovative concepts. In addition to this factor, economic and social aspects must also be taken into account. A clear profitability statement of urban logistics real estate projects is necessary. Measures to improve the logistics image are also needed to illustrate the necessity of such projects. As a final success factor, innovations can be mentioned that are needed in any case in order to set up future-capable urban logistics concepts. It is important to consider that these are developed and implemented as part of a holistic overall concept. Likewise, both the overall framework and each innovation concept must be created under the premise of adaptability in order to enable increased agility of urban infrastructure as a whole.

P3: A holistic view and conception regarding legal framework conditions, economic efficiency and innovative concept proposals is necessary to establish sustainable urban logistics systems, with urban logistics real estate as one important component of it.

6. CONCLUSION

Increasing urbanisation of cities and the associated gains in parcel volumes, urban distribution concepts gain strategic importance. High customer requirements regarding delivery services, as well as increasing eCommerce sending volumes lead to complex logistics structures and processes, ultimately resulting in urban infrastructure reaching its capacity limits. Hence, business models and associated logistics network structures must be adapted at high cost. Cost-intensive urban logistics areas, enabling fast delivery to customers while simultaneously reducing transport costs and emissions, occupy a key position in the logistics network. This paper aimed to examine the role of urban logistics real estate in Germany, identify the stakeholders involved, as well as their motivations for engaging in those. Moreover, challenges, chances and success criteria for integrating urban logistics real estate were examined. For this we used an empirical approach by interviewing 38 experts in the field.

Our main findings can be summarized as follows: A variety of stakeholders is involved in urban logistics real estate projects, with cities in particular playing a central role as infrastructure providers and coordinators. It is important to involve all parties concerned in projects at an early stage in order to achieve quick results. The biggest hurdle here is the bureaucratic effort that hampers and slows down approval procedures. Likewise, urban logistics real estate projects have to compete with more prestigious projects for the scarce space. In order to improve this situation, innovative concepts rely on the use of less popular areas, which are currently still occupied by declining business models, such as large retail space or multi-storey car park. For successful implementation of such concepts, it is necessary to adapt the legal framework conditions. In addition, it is important that the economic viability consideration is addressed from the outset. All in all, sustainable urban logistics require a holistic approach consisting of interlocking concepts, with flexible and adaptable logistics real estate playing a central role.

There are some limitations of our research, allowing further investigations in the future. We only used insights of German experts. Hence, the geographical component limits the research expressiveness. Other urban areas with different conditions may have other stakeholders involved, as well as different procedures regarding urban logistics real estate projects. This is especially in less developed regions with other urbanization rates and different governmental structures and bureaucratic processes. Moreover, we used a qualitative research approach focusing on motivations and behaviour of urban stakeholders. Quantitative models focusing on profitability and efficiency of urban logistics real estate projects are available as a research field for further studies. Furthermore, we find that a common understanding of urban logistics and its objectives is necessary. The clear definition of urban logistics properties and areas as well as their characteristics is necessary in order to achieve a common understanding and possibly to classify previously unused areas. Depending on the city, the individual stakeholders can take on a different role. Based on experience, a definition of "fixed" project stakeholders and their expectations for an efficiently procedure should be done.

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RESEARCH METHODS IN HUMANITARIAN LOGISTICS – CURRENT APPROACHES AND FUTURE TRENDS

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Abstract

The article sums up contemporary use of operational research, modelling, and simulation (OR/MS) methods and approaches in the field of humanitarian and emergency logistic, based on the records in international research databases World of Science (WoS) and SCOPUS. In both databases were analysed more than 500 articles published in the period of 2014 until 2018. The keywords and content analysis with subsequent literary research was as a main research approach processed by the Python programming language Pandas Library. Main research goal was focused on the identification of the areas and methods used by the scientific community in the examination within humanitarian logistics, published in journals and proceedings indexed in WoS and SCOPUS databases. The stochastic optimization was identified as a most common methods used to solve humanitarian logistics tasks. The research results show that the use of simulation methods in the field of humanitarian logistics are marginal and these methods are not widespread. Further research into the use of dynamic simulations for humanitarian logistics has the potential to enrich scientific knowledge and contribute to the application of scientific methods to the practice of humanitarian logistics.

Key words: Humanitarian logistics, dynamic simulation, operation research, modelling and simulation, methods.

1. INTRODUCTION

Despite the development, humankind achieved in last 2000 year, we still have not even a limited control over natural powers, such as earthquakes, fires and floods. It is reported that an increasing number of disasters have led to overwhelming losses in recent years (Xiong, 2017). Higher density of population contributes to increasing consequences of such disasters. As confirmed by Damon Coppola, there are following global trends in disasters (Coppola, 2011):

1. the number of people affected by disasters is rising;
2. disasters are becoming less deadly;
3. disasters are becoming more costly;
4. poor countries are disproportionately affected by disaster consequences;
5. the number of disasters is increasing each year.

During a crisis, high requirements on relief distribution appear, especially in the phase of first response (within 72 hours), when it is necessary to distribute urgent humanitarian aid. The recent large scale disasters and relief efforts (e.g. 2004 Asian tsunami, 2005 Pakistan earthquake, 2010 Haiti earthquake) highlight the need for improved logistics in the field (Huang, 2012). During the first three days, when significant uncertainty appear, distribution system is formed and set including setting necessary contracts and securing sustainability of such logistics system for previously determined time (Campbell, 2011). Based on the severity and impact of natural disasters, loss of life, health and property may occur. Simultaneously critical infrastructure of the region is usually damaged, including transportation and communication networks (Urban, 2017).

Capabilities for distribution are therefore substantially constrained and it is often necessary to secure alternative means of distribution usable at least until former means are restored. Because of complex nature of natural disasters, their potential impact and concurrent demand for securing distribution of humanitarian relief and provisions, it is important to study function of logistics system in conditions of high uncertainty and variability (Senovsky, 2013).

2. LOGISTICS IN COMMERCIAL AND HUMANITARIAN FIELD

In terms of the globalization of distribution chains, the civilian sector has long faced potential disruption risks (Senovsky, 2013). The Business Continuity Institute (BCI) studies are available for long-term analysis of the causes and impacts of disruption of distribution chains in terms of scale, impact and losses (Alcantara, 2017). By comparing the available studies in 2011 and 2018, it is possible to identify a shift in the perception of the main sources of disruption to distribution chains. In 2011, natural disasters were the main cause of the disruption of logistics chains, in 2018 this was an unplanned disruption to the communication and information systems functionality (BCI, 2018).

Logistics and disasters are entangled in two ways. First is the impact of disasters on logistics infrastructure. Second lies in the fact, that logistics is important part of all operations that are related to humanitarian aid. As Kunz stated: „*From this perspective, disaster management and relief aid require complex logistical activities, as the resources they need are rarely available at the location of the disaster*“ (Kunz, 2014).

The urgency of humanitarian relief distribution is also highlighted in the Council of Supply Chain Management Professionals (CSCMP) definition of logistics as: *the* *process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements* (Council of Supply Chain Management Professionals, 2013). Similarly definition from Thomas a Mizushima define humanitarian logistics as the process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from point of consumption for the purpose of meeting the end beneficiary's requirements "(Thomas, 2005). Both definitions are virtually identical.

From this perspective, disaster management and relief aid require complex logistical activities, as the resources they need are rarely available at the location of the disaster or in close surroundings (Zajíček, 2015). These logistical activities are generally referred as humanitarian logistics (Kunz, 2014), and for both forms of disasters with natural and/or man-made disasters sources, with slow or fast onset, as depicted in table 1.

Table 1. Examples of disaster forms.

	natural	man-made
sudden-onset	earthquake hurricane tornadoes	terrorist attack coup d´Etat chemical leak
slow-onset	famine drought poverty	political crisis refugee crisis

Source: Wassenhove-Van, 2006

From the point of view of logistical support, the methods and approaches of business logistics are becoming more prominent in humanitarian logistics (Foltin, 2015). The primary reason for this is to speed up the process of distributing humanitarian aid, while at the same time trying to optimize overall logistical costs.

As concerns the application of civil approaches in humanitarian logistics, in 2017, Gavidia introduces the Enterprise Resource planning (ERP) model for Humanitarian Supply Chain Management (SCM) (Gavidia, 2017), while in 2009 Huifen describes the rapid implementation of the ERP system in the Sichuan earthquake (Huifen, 2009). In the commercial sector, the OR/MS methods are usually applied only when they are converted into easy-to-use software that can be used after appropriate training.

Even now, the expansion of decision support systems in commercial applications is relatively lower, but is considered one of the key technological challenges of the past 5 years (Panneta, 2018). Even the current wave of mobile applications often uses rather complicated mathematical procedures, but these are hidden from the end user and the device or application "just works". Simulation has the potential to become a similar application.

3. CURRENT STATE OF RESEARCH METHODS IN HUMANITARIAN LOGISTICS

Humanitarian and business logistics setting aside some specifics can benefit from the same methods and approaches, which is implied in the definition of humanitarian as well as logistics in general, which are very similar.

Implications arising are that researchers have studied more immediate responses than preparation and/or prevention events, and that preparation and prevention activities, which include a supply chain perspective, have been neglected by the relevant authorities due to the fact that there are few studies which analyse preventive actions to deal with such disasters (Coppola, 2011).

Using operational research methods that seek to find the most appropriate solution, the question arises of how to evaluate whether the solution found is the most appropriate or available solution to compare. In commercial terms, the maximization of profit is usually the evaluation criterion. In humanitarian logistics, this scale cannot be easily applied (Fikar, 2016). It is necessary to ensure that humanitarian aid is fairly distributed so as to minimize the impact on the disabled. All this while deploying resources that are not sufficient. The specificities of humanitarian logistics are the main reason why methods and procedures from commercial logistics cannot be automatically adopted without further investigation.

Supply chain design and processes management takes into account specifics humanitarian logistics, especially donor issues, last mile problems. There are two distinguished approaches in specific humanitarian logistics information systems development. These are specific software tools for humanitarian operations, e.g., SUMA, LSS, UniTrack, Helios, LogistiX or Sahana. On the other hand, there are in practical use commercial software solutions, e.g., Orion-PI, Enterprise One, mySAP SCM (Blecken, 2008).

Literature revise are an essential part of all kinds of research, especially as concerns the content and frequency analysis (Kotzab, 2005). While in the social sciences and humanities a large number of disaster management articles are represented, less attention is paid to this issue in the field of operational research (Altay, 2006). The use of advanced analytical tools in humanitarian operations can be seen as an important tool to optimize the use of scarce resources in crisis conditions, i.e. with uncertainty and uncertainty. While in the social sciences and the humanities there is an abundance of disaster management articles, the operational research community has yet to create a critical mass of publications (Altay, 2006). However, as noted Van Wassenh, approximately 15 years of delay in the use of advanced logistics analysis tools for humanitarian organizations can be identified, as opposed to the approaches used by the private sector who realized the importance of using efficient supply chains, particularly due to given increasing opportunities to “go global” (Wassenhove-Van, 2006).

As early as 2006, Van Wassenhove set out possible directions in which operational research can contribute his expertise and transfer knowledge to the field of humanitarian logistics. This is mainly deals with (Wassenhove-Van, 2006):

- supply chain design and management (donor issues, last mile supply issues, mutual transfer of experience between the private sector, military and humanitarian organizations);
- system and technology (disaster management information systems, knowledge management);
- project management;
- risk management;
- coordination and strategic alliances;
- performance management;
- standardization of processes (e.g., Total Quality Management, Six Sigma, training).

The authors of follow-up studies and monographs often criticize, the focus of published articles, such as Coppola, states that researchers focus more on the issue of immediate response than on preparatory and preventive activities (Coppola, 2011). Chiappet et al. in their analysis of literature between 2007 and 2016 report that most of the articles included in the study were theoretical and as a consequence rarely touched on a particular disaster, its type, the humanitarian aid phase and the type of humanitarian organization (Chiappetta Jabbour, 2017).

There are many areas where OR academics can offer their expertise and transfer their knowledge to have a positive impact. On one hand, simulations are used to train-practice surgical procedures but are limited in practice to support disaster decision making. On the other hand, several approaches appear, e.g. scenario-based two-stage stochastic programming (Alem, 2016). These conditions and wider circumstances leads authors for formulate the one working hypothesis, which is as follows:

Hypothesis:

H: Methods of OR/MS and DES are explored in humanitarian logistics significantly frequently.

Analysis is focused to the difficulty to grasp conceptual models, without practical implications, as it is discussed in final part the article.

Based on the literature research and declaration of methodological approach, next part of the article is focused to find out whether there is visible change in trend over the past five years and what operational research methods are being focused and published.

4. KEYWORDS ANALYSIS

The analytical effort is laid to identify and review articles, their focus on the description of theoretical approaches, and their possible relation to other aspects of disaster, phases of disaster relief, type of humanitarian organization and/or humanitarian logistics and relief distribution. In order to find out which methods for dealing with humanitarian logistics are being investigated and what problems are being addressed in the research of reviewed articles, an analysis of the occurrence of keywords was conducted on a sample of articles available in the international SCOPUS scientific work database and World of Science (WoS) database. For analysis purposes, articles containing the keyword "*humanitarian logistics*" or topics for WoS were selected and the selection was limited to 2014 to 2018.

When searching in SCOPUS, more than 500 articles are searched for logistics and simulation, while after adding a humanitarian keyword, the number of articles decreases to just 9. A similar situation is in software in general.

A database of individual keywords was processed from the keywords using the Python programming language Pandas library. Identified text strings have been cleared of invisible characters. The source code for the transformation is shown in Figure 1.

Figure 1. Source code of keyword transformation from export from SCOPUS database.

```
import pandas as pd
scopus = pd.read_csv("scopus (6).csv")
scopus['Author Keywords'] = scopus['Author Keywords'].astype('str')
scopus['Author Keywords'] = scopus['Author Keywords'].str.split(';').tolist()
keywords = scopus['Author Keywords'].sum()
kw = pd.DataFrame({'keyword':keywords})
kw['keyword'] = kw['keyword'].str.strip()

kw.to_excel('keywords.xlsx')
```

Source: Authors’ analysis

Based on the use of keywords in SCOPUS, 378 relevant articles were identified, 1807 keywords were further analysed. From the WoS database was possible to retrieve 820 records, with 1977 unique keywords. For the purpose of our analysis only author keywords were selected, as World of Science Keyword plus are usually only one-word keywords and preliminary results were incomparable to SCOPUS keywords.

Subsequently, the frequency of occurrence of keywords was determined and categorized. Keywords were divided into three groups according to their meaning, as follows:

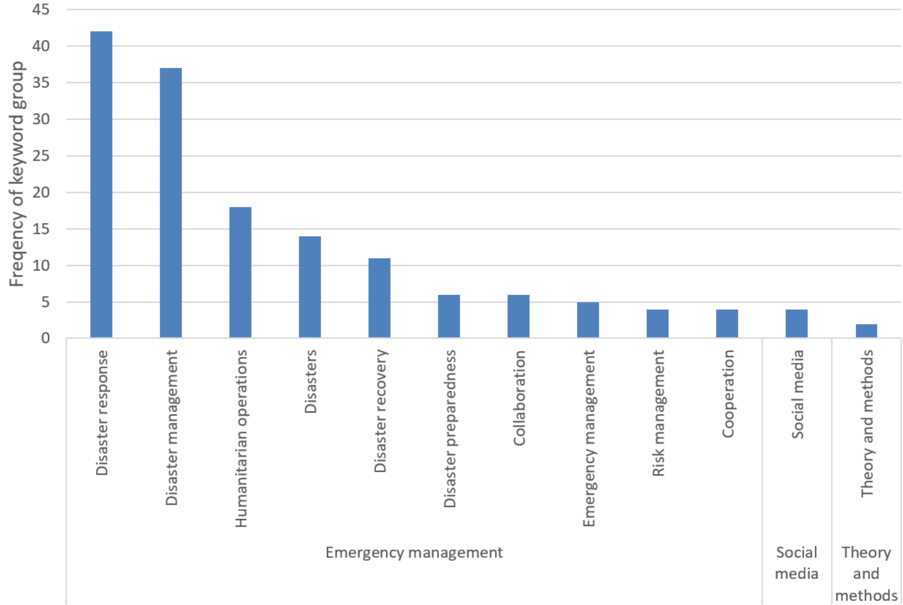
- research area;
- methods;
- tasks.

In these groups, the keywords identified were categorized and grouped for further analysis.

Research Area

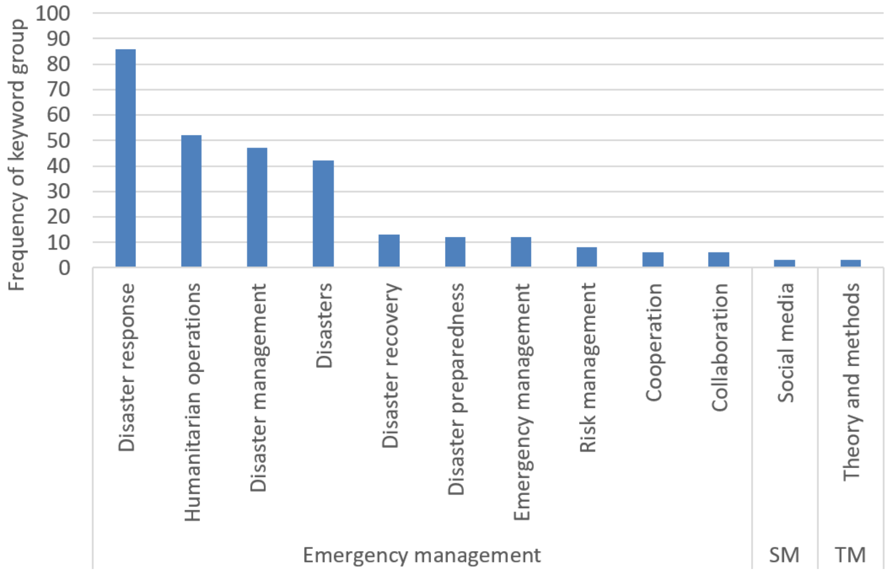
Two levels of categories were selected in the "Research Area" group. The categorization has made it possible to clarify the described research area, and to remove the found duplicate keywords identifying the same research areas. The resulting frequencies for the categories are shown in Figure 2.

Figure 2. Key words frequency in humanitarian logistics research SCOPUS



Source: Authors' analysis.

Figure 3. Key words frequency in humanitarian logistics research WoS



Source: Authors' analysis

Research areas show that there is still a strong focus on disaster response methods. The "Disaster response" category is most common. The "Disaster

Management" category contains only the word "Disaster Management", which is considered synonymous with "Emergency Management". It is therefore a general term that logically relates to the field of humanitarian logistics.

Disregarding the general keywords, it was possible to rank the various phases of crisis management as follows:

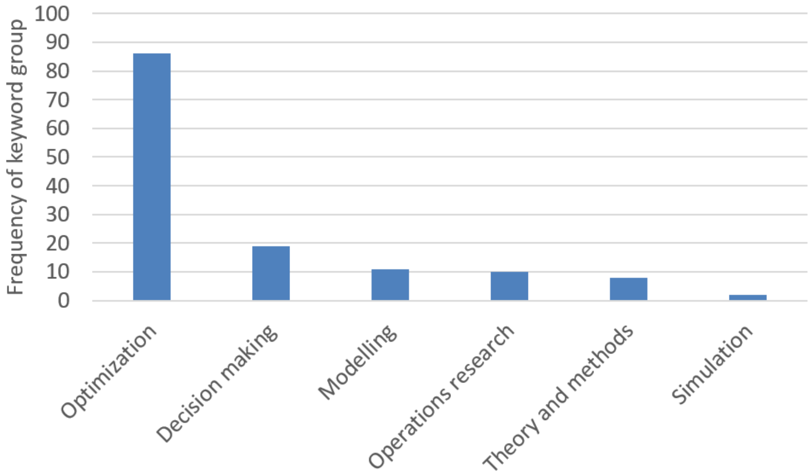
- disaster response (i.e. a response to a crisis event);
- disaster recovery (i.e. recovery after a crisis event);
- disaster preparedness (i.e. preparing for a crisis event).

Ranking of keyword groups is similar in both SCOPUS and WoS databases. The "disaster prevention" area does not fall into the field of humanitarian logistics and therefore this phase does not appear in the keyword survey.

Methods Examined

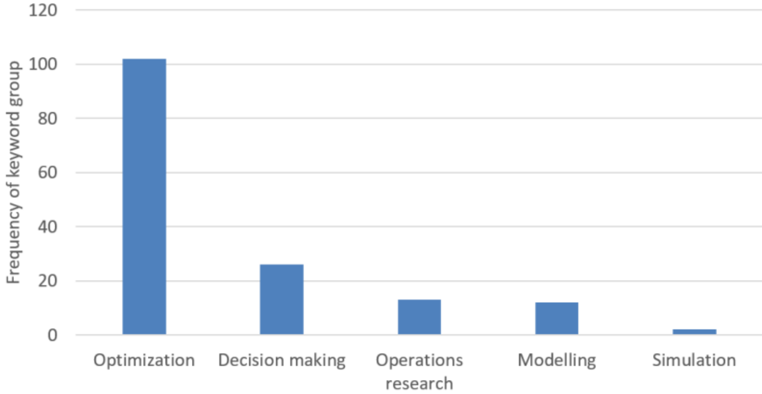
In the field of applied methods, the division into two levels was performed. Figure 4 shows the first level distribution of method's groups found in SCOPUS, which refers to the most commonly reported method, namely "optimization". The frequency of other methods is considerably lower, i.e. optimization methods are significantly prevalent. The simulation approach is examined only marginally and in all cases it is sort of "agent simulation".

Figure 4. Key words frequency – used research methods SCOPUS.



Source: Authors' analysis

Figure 5. Key words frequency – used research methods WoS.



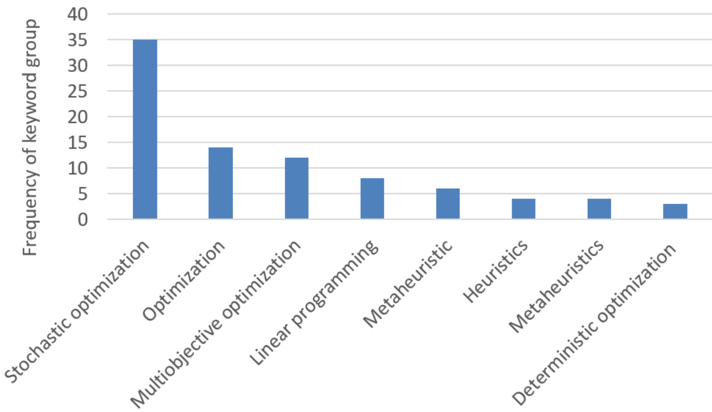
Source: Authors' analysis

As can be seen on both figure 4 and figure 5 the frequencies and ranking of keyword groups in this case are also similar with different ranking of simulation which has higher ranking in SCOPUS than in WoS database.

In the second level of classification, there is a significant division of the optimization methods shown in Figure 6. In the group of optimization methods, the most significant part was identified as stochastic optimization, e.g., stochastic programming. The occurrence of a generic term optimization can be explained by the fact that keywords often include both general and detailed differentiation of the methods used.

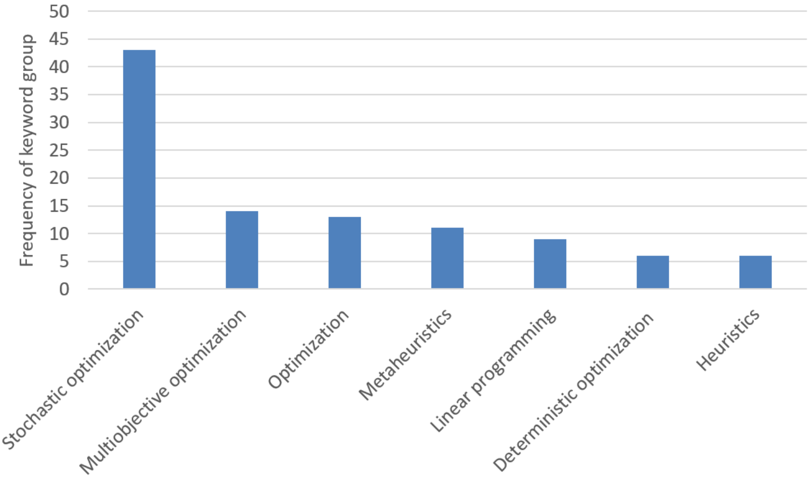
Similar distribution of frequency among the optimization methods was found in WoS database keywords. The differences in being the ranking of generic term "optimization and the ranking of the long-tail of less common keywords like Linear programming, Heuristics, Metaheuristics and Deterministic optimization.

Figure 6. Key words frequency – detailed view of types of optimization methods SCOPUS



Source: Authors' analysis

Figure 7. Key words frequency – detailed view of types of optimization methods WoS



Source: Authors' analysis

Greater attention is paid to stochastic optimization methods in 2014-2018, as practice points to the appropriateness of using deterministic optimization methods to solve random input problems. The main reason is the possibility of simplifying the problem, which is often at the expense of accuracy and precision. Nevertheless, linear programming methods (i.e., deterministic) are examined and presented relatively frequently in the articles published in both Scopus and WoS database.

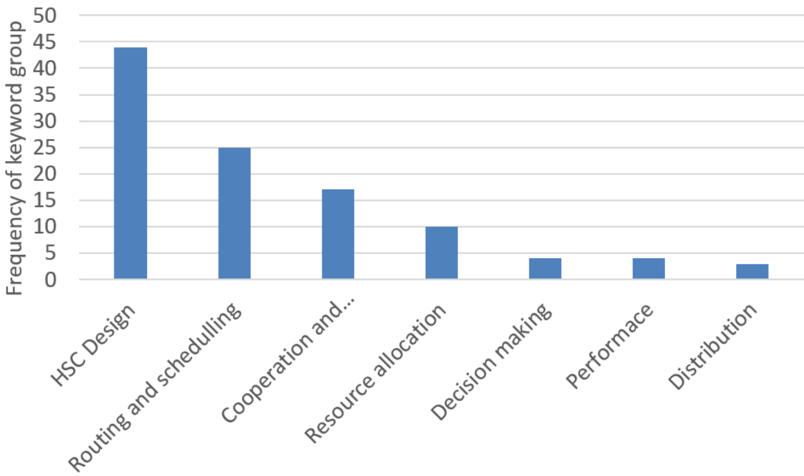
Humanitarian Logistics Tasks

In the group of humanitarian logistics tasks depicted in Figure 8 and 9, there are important tasks related to the design of humanitarian supply chains (HSC), i.e., "HSC design". It is a relatively broad category including the placement of temporary shelters, the management and allocation of stocks and the location of their warehouses. At first glance, it is surprising that this category prevails. It appears to be in direct contradiction to the low frequency of "Disaster preparedness" mentioned in Chapter 3.1. The explanation is hidden in detail when a significant portion of the keywords in this category deal with the operational deployment of resources in a disaster situation.

The second important part is the "Routing and scheduling" category, which includes the different types of delivery problem (e.g. Vehicle Routiong Problem - VRP), which is related to the distribution of humanitarian aid in the affected area. The second part is the task of scheduling work for humanitarian workers.

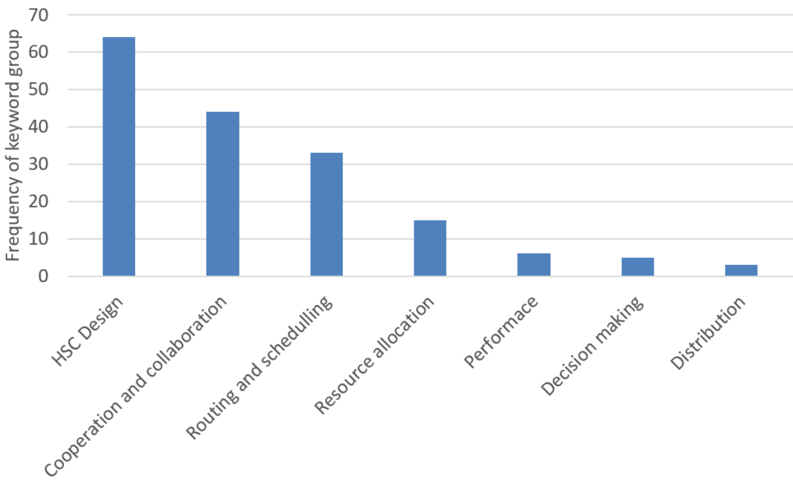
Cooperation and collaboration category is covered more in WoS database and this is both in absolute as well as relative numbers.

Figure 8. Solved tasks in humanitarian logistics – key words frequency SCOPUS.



Source: Authors' analysis

Figure 9. Solved tasks in humanitarian logistics – key words frequency WoS.



Source: Authors' analysis

4. APPLICATION OF OPERATIONAL RESEARCH METHODS TO PRACTICE

In the commercial sector, the OR/MS methods are applied only when they are converted into easy-to-use software that can be used after appropriate training. ERP systems are now widespread in the commercial sector. When applying advanced methods of operational research (OR/MS methods), it is the basis on which to build and integrate other software that uses advanced data processing methods that are recorded in ERP systems.

User-friendliness and productivity are a prerequisite for extending OR/MS methods. An example is the expansion of mobile applications, many of which use advanced methods and algorithms. Their use would not be possible without the complexity of the solution being hidden from the user, and the program enabled user-friendly applications and uses.

There are other complications in the field of humanitarian logistics, which may limit the extension of modern methods. For example:

- limited communication options (unavailable internet connection);
- obsolete hardware;
- unavailability of electricity.

In the field of humanitarian supply chain management, logistics management systems have begun to emerge since 1992 (Blecken, 2013):

- SUMA later LSS developed in 1992 by Pan American Health Organization;
- the Helios system, developed in 2001 at the Fritz Institute;
- LogistiX system used by the MSF since 2006;
- Sahana system developed by Sahana foundation in 2004.

The use of commercial ERP systems is not excluded either. E.g. Huifen describes the rapid implementation of the ERP system in the 2009 Sichuan earthquake (Gavidia, 2017). The basis for applying advanced methods to practice is therefore available and it is possible to work on the application of theoretical knowledge, methods and models in the field of humanitarian logistics.

5. DISCUSSION

The analysis showed that the trends in the scientific research of humanitarian logistics have not changed much. Coppla's conclusions in 2011 confirm the focus on the immediate response and neglect of the planning phase. The current state of research is focused on the transfer of know-how in the field of optimization methods. The focus is on methods that take into account the stochasticity of modelled processes, which is very important in the field of humanitarian logistics.

Dynamic simulation is a method that is examined only marginally. It is possible to formulate the question to what extent this fact is related to the focus on immediate reaction, where until recently the longer time for creation and higher computational complexity of simulation models did not allow to use dynamic simulations to support real-time decision making. Recently, there has been a shift trend in simulation conferences to support immediate decision-making, whether through the rapid verification of decisions, or by using a combination of heuristics and simulation (called sim-heuristics). Still, in the area of humanitarian logistics, the potential of better planning and testing of practices that cannot be verified in the real world remains to be exploited. Humanitarian disasters are inherently times when there is no time and space to test new approaches. The simulation methods give us the opportunity to test the news in advance in a computerized environment and enter into more crises with better preparation.

For further and more detailed research, it would be appropriate to extend the research to other sources, both academic and practical. It is hard to imagine that humanitarian organizations do not improve their functioning on the basis of knowledge acquired in disaster management. Humanitarian Logistics Management Systems show that humanitarian organizations are not waiting for the benefits of scientific research, but are forced to implement solutions that may not be optimal but bring immediate effects, or eliminate the significant weaknesses identified in the past crisis.

Based on the analysis outputs, both for Scopus and WoS databases, is possible to state, that working hypothesis is not confirmed. Outputs of the analysis of both databases presents lower frequency in use of OR/MS and discrete event simulation (DES) in the field of humanitarian logistics, in comparison of the other analytical approaches to support decision making and analytical approaches in humanitarian logistics optimization.

6. CONCLUSION

The concept of humanitarian logistics is one of the key aspects of reducing the negative impacts of crisis events. A key aspect of humanitarian logistics is the rapid distribution of material supplies and humanitarian aid in the first 72 hours, immediately after the crisis. Advanced analytical approaches and tools commonly used in civilian supply chain conditions can be used to design and manage the system for the subsequent distribution of humanitarian aid.

In the framework of the realized research, the analysis of key words and subsequent literary research was carried out with the aim to find out what tasks in what areas and by what methods are examined by the scientific community. Based on the analysis of articles available in the international Scopus database, the focus of the current professional community has been identified primarily to support decision-making, in the immediate disaster response phase. The most common methods used to solve humanitarian logistics tasks are optimization, especially stochastic optimization.

Another of the objectives of the research was to identify how and to what extent dynamic discrete simulation is used. The results show that the use of simulation methods in the field of humanitarian logistics is marginal and these methods are not widespread. At the same time, the areas in which dynamic simulation has the potential to contribute to solving tasks (i.e. designing, planning and validating new processes) are only marginally studied in the literature. Research into the use of dynamic simulations for humanitarian logistics has the potential to enrich scientific knowledge and contribute to the application of scientific methods to the practice of humanitarian logistics.

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OPTIMISATION OF REVERSE LOGISTICS WITH METHODS OF OPERATIONAL RESEARCH

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Abstract

Optimisation of routes and searching for the shortest journey is currently an inevitable action during the management of logistic processes which significantly affect the production activity of businesses. There in a market environment it is necessary for businesses to plan transport routes effectively. This represents a key to achieve savings, and a fast and quality customers' satisfaction; last but not least the effectively set transport processes affect the environment protection, too. Thus the optimisation of transport routes represents one of very important aspects of all logistic systems. The protection of the environment is directly related to another important part of a logistic system - reverse logistics. This term includes handling of waste, its management, recycling and disposal. For waste producers, households and businesses, the concerns with waste end with its throwing into containers intended for it; for waste processors, however, this represents the beginning of the whole cycle of processing. The first important part of processing the waste is the waste collection and haulage to its further processing. Optimisation of this part is therefore significant for the economy of the entire waste processing. The article deals with the optimisation of collection and haulage of a selected type of sorted waste. For the sake of a general illustration the optimisation will be performed with heuristic algorithms in a real street network of a selected town. The aim of the article is to determine reserves of the current system of waste collection in a company, to evaluate the options to eliminate these reserves to an essential minimum, to choose appropriate optimisation tools and subsequently to use these tools, and to make the system of waste collection and haulage more effective.

Key words: Route optimisation, transportation networks, reverse logistics, waste sorting, waste disposal.

1. INTRODUCTION

Environmental burdens arise due to problems in the industrial production and waste economy (Abramovic, 2012). Such an arisen toxic source may be removed (eliminated) or it represents a threat for the future. One of important logistics activities is the reverse logistics which aims to remove and dispose a waste material, arising in the process of production, goods distribution and packaging (Lizbetin, 2018). Mostly it comprises activities such as ensuring a temporary storage of these materials, their subsequent haulage to a disposal site, processing, re-using or recycling. Optimisation of this part is therefore significant for the economy of the entire waste processing.

Currently there increases a general interest in recycling and re-using of materials very much, and thus a considerable attention is paid to this issue (Janíčková, 2012). It is especially true for Europe where with respect to a limited number of dumping sites there exist some relatively very strict restrictions regarding removing packaging material and outdated products (Skrucany, 2018; Dolinayova, 2015).

The aim of the article is to optimise collection and haulage of a selected type of sorted waste of the enterprise Městské služby Písek, s.r.o. The main goal is to determine reserves of the current system of waste collection in the company, to evaluate the options to eliminate these reserves to an essential minimum, to choose appropriate optimisation tools and subsequently to use these tools, and to make the system of waste collection and haulage more effective. Based on the analysis of the current state of sorted waste in the monitored area it was found out that a weak point in the waste haulage is the frequency and routing of vehicles in case of haulage of glass in two different containers. In the conclusion of the article there is a comparison of routes of the current state and the state after optimisation.

2. METHODOLOGY OF THE SOLVED PROBLEM

To address the observed problem there will be a scientific methodology used in the paper. The methodology is divided into several parts, and its primary goal is the optimisation of a multi-circuit, capacitive limited haulage/distribution issue. Specifically it is the haulage of sorted municipal waste by the enterprise Městské služby Písek, s.r.o. The first part of the methodology describes the observed problem; it provides information required for the optimisation of routes and explains some terms from the area of a reverse logistics, mainly of waste haulage. Collected information, complexity and depth of examined indicators were the basis for creating a research plan which exactly identified individual phases, methods and procedures. The following part of the methodology evaluates the effectiveness of the current haulage logistics in Písek, identifies weak points and reserves of sorted waste haulage, describes options to reduce the weak points, and in the final part of the methodology there is the determination of optimisation tools for streamlining the system of waste haulage in the monitored area. Optimisation tools used to eliminate weak points of the reverse logistics are represented with a Clarke-Wright Method intended to solve circular routes, and the Nearest Neighbour Method.

The Clarke-Wright Method is probably the most known heuristic method, solving a circular transport problem. The authors introduced their method as early as in 1964; thanks to its attributes and simplicity the method has been applied up to now (Stopka, 2015; Hansut, 2017). It is mainly used to solve multi-circuit transport problems where it is necessary to count on driven kilometres as well as other restricting conditions which divide the whole concept into more sub-circuits. The method improves existing solutions up to the moment when it is not possible to achieve any better solutions (it would lead to breaking of conditions of capacity, time, etc.) (Clarke G, 1964).

The Nearest Neighbour Method represents a very simple heuristic approach which applies principles of so called greedy algorithms and is sequentially progressive (Jablonský, 2007). It means that for a current peak the best option is chosen; in case of a route optimisation it is the nearest peak from the point of view of distance. For this peak there is the search for the nearest, so far not operated peak applied again. The process continues this way until all operation peaks are completely run out of. It is appropriate to apply this procedure so that all the peaks of the operation network are taken as the initial peak which creates a plenty of routes with their count equal to the count of individual peaks. Afterwards the distance (in kilometres) among individual peaks of all computed routes is computed; the choice falls on that route which has the least driven kilometres (Fiala, 2010).

The results of optimisation will be compared to the current state of specific waste (glass) haulage, and in the final part of the methodology they will be evaluated from the economics point of view. The methodology represents a sequence of steps to ensure the effectiveness of the concept of sorted waste haulage in Písek.

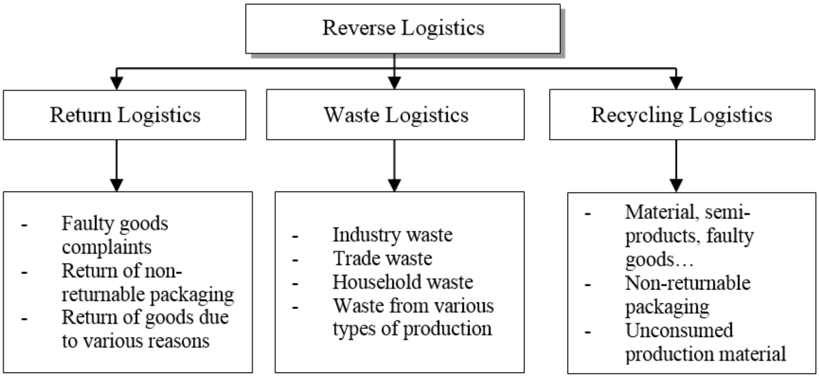
3. REVERSE (BACKWARDS) LOGISTICS

The term “backwards logistics” is synonymous to the term “reverse logistics” (Cudzilo, 2018). It can be used to denominate a backward physical motion in backward oriented distributional contract flows which are provided with the following logistics (Tomková, 2015):

- return logistics,
- waste logistics,
- backward logistics,
- recycling logistics.

All terms above are correct because they indicate specific logistic subsystems which are usually part of a certain integrated logistic system. For the sake of solving the aim of waste haulage optimisation the term “reverse logistics” will be used in the article. The following Figure 1 shows a scheme of division of the reverse logistics.

Figure 1. Division of Reverse Logistics



Source: Tomková, 2015

Currently there exist two perspectives on the reverse logistics, which differ in the subject of interest of the reverse logistics (Jeřábek, 2012):

- the American notion of the reverse logistics - the subject of interest is returned goods (goods under complaint, unsold stocks, etc.); from this point of view the reverse logistics deals with complaints, unneeded and redundant goods,
- the European notion of the reverse logistics - the subject of interest is the option to recycle municipal and industrial waste with regard to increasing ecology requirements which are evoked mainly with the pressure of ecology groups, and legislation.

The reverse logistics is a flow of used products, packaging and other materials which come from a consumer. Mostly these are flows of already consumed products, i.e. waste, and empty packaging as well as goods under complaint. The main content of the reverse logistics is the collection, sorting, dismantlement and processing of used products, components, side products, redundant stocks and packaging material where the main aim is to find their new use or material valorisation in a way that is environment-friendly and economically interesting. The importance of the reverse logistics differs by industry. Generally speaking, the reverse logistics plays a significant role in industries with a high value of goods or with a high share of returned products. Enterprises in these industries devote big efforts to improve the process of backward material flows.

3.1. Importance of the Reverse Logistics

Logistics plays a big role in the waste processing. At the beginning of the 90s the waste logistics was considered only as a way how to reduce costs or handle complaints. In the following years the complexity of the reverse logistics was developed; this happened not only with regard to enterprise's costs but also with regard to the environment. The reverse logistics even defines a duty to sort waste in certain enterprises. Its main content is the collection, sorting, and processing of used products, side products, and redundant stocks where the main aim is to find their new use.

The reverse logistics works with two communication strategies (Pazourková, 2015). Specifically, these are the Push strategy and the Pull strategy. The Push strategy is grounded mainly on the Environment Protection Act, ecology directives, but also on protests of civil initiatives, or ecological behaviour of competitors. The Pull strategy is governed with wishes of customers and ecologically aware consumers.

3.2. Logistics of Municipal Waste

The logistics of municipal waste deals with the issue of placing the waste on the site of its origin, with the following transport into the site of processing and then with the waste processing itself. From the point of view of the municipal waste haulage it is mainly the mapping of the haulage route and its optimisation; the output is the most economic route. At the same time this route should be economic from the point of view of time as well as from the point of view of costs on transport. For the sake of optimisation it is required to know the location of collection sites. To achieve optimisation, it is also necessary to know the quality of land communications, availability of collection sites, and rush hours, too, (Zefreh, 2018).

Optimisation is solved with two typical problems - the Chinese Postman Problem, and the Travelling Salesman Problem. Each of these problems can be solved using several methods, and each problem fits another type of waste.

The Chinese Postman Problem can be applied to the haulage of mixed municipal waste. The main reason is because there in case of the mixed municipal waste haulage entire streets - edges must be operated. On the other hand, the Travelling Salesman Problem can be applied to the haulage of sorted waste, where individual locations of collecting containers are represented with individual peaks of the chart - here the peaks of the chart must be operated.

4. PROCESSING OF MUNICIPAL WASTE

Mixed municipal waste is stored in containers, so called rubbish bins/litter baskets. This is all the waste which households get rid of without any sorting or placing into a facility for further processing. Mixed municipal waste cannot be recycled. It can, however, be energetically utilised through its direct burning without any previous treatment (provided a minimum energetic efficiency of facilities is met), or it can be processed using a mechanic-biological adjustment.

Biodegradable municipal waste is a biodegradable waste which arises exclusively in a municipal sphere - it belongs to municipal waste.

In order to determine the volume of biodegradable municipal waste production it is necessary to come out from the volumes of arisen municipal waste as well as from the composition of municipal waste. However, the composition of municipal waste must be understood as a ratio of individual components/fractions in municipal waste, i.e. potential volumes which can be separated out of the municipal waste.

Plastic is placed into yellow containers. On average it takes the most space out of all wastes and therefore its sorting as well as pressing or compressing is of a greater importance than throwing away. The majority of plastic waste which arises in households comprises packaging of food and consumables. After plastic is hauled into centres intended for a further processing this plastic is further processed. This is a very important step because some undesirable foreign substances are removed through final sorting, and it leads to dividing plastic to basic groups by material. Each of these materials is further processed separately (Jaktridit.cz, 2016).

Glass is thrown into a green or white container. If both are available, it is important to sort glass by colour, too: coloured glass belongs to a green container, transparent glass belongs to a white container. If there is only one container for glass, it is placed in regardless of its colour. Since there follows a further final-sorting, it is not necessary to break glass. The purpose of the final sort is to perfectly remove everything which is not made of glass. The final sort must be thorough; otherwise it could result in deterioration of the entire batch of glass products. In the first stage of sorting there are large impurities, such as porcelain, pottery, metals and another mess removed. Afterwards glass is crushed and modified on a vibration network. Finally it is cleaned using optoelectronic sensors (Jaktridit.cz, 2016). Thanks to its properties glass waste can be recycled over and over again.

Paper is placed into blue containers. Its production by households is the biggest out of all types of sorted waste. Its placement into a container for paper represents the easiest way how to get rid of this waste. An alternative is to place it into collection centres of sorted waste where they pay for it, so sorting also brings a small economic benefit for households.

Paper can be placed in any way, however, it should not be dirty or wet. Cartons, cardboards, paper packaging, newspaper as well as books can be placed there. Paper clips or envelopes with plastic boxes are not an obstacle either. Before any further processing paper is manually final-sorted according to needs of individual purchasers of raw materials. Undesirable foreign substances are also removed with manual sorting. Sorted paper is then pressed and taken to a further processing.

Besides waste which can be sorted into colour containers there in households arises waste which is also required to be sorted. This category includes metals, large-volume waste, hazardous waste, biowaste, outdated electrical appliances and batteries. Generally there are no containers to sort these types of waste (in some towns there are containers for electrical waste and biowaste); scrapyards and collection sites serve for passing it on a further processing.

5. ANALYSIS OF THE CURRENT STATE OF WASTE COLLECTION IN PÍSEK

Increasing legislative requirements of the government for handling with packaging, waste and dangerous products represent one of main factors which cause a bigger interest of enterprises in the reverse logistics. Enterprises are required to take responsibility for the environment not only by the government, but they are also expected to do so by their customers.

5.1. Characteristics of the Enterprise Městské služby Písek, s.r.o.

Městské služby Písek, s.r.o., is a company with a wide coverage of services provided to town citizens. Besides others these services include all maintenance of communications (altogether 74 km), road signs on communications, maintenance of urban green areas, maintenance of a playground, market hall, animal cemetery, public fountains, paid parking areas, public toilets, and last but not least concerns about waste.

The enterprise Městské služby Písek is a haulage company of all household refuse. The haulage frequency in the town is set to a weekly haulage. The enterprise Městské služby Písek provides containers with the volume of 110 l and 1,100 l for town citizens who are engaged in the waste system of the town; 110 l containers are mostly intended for family houses and some flats, 1,100 l containers then serve for inhabitants of residential areas as common containers for an entire block of flats. Distribution, number and type of containers are determined by the Environment department and Municipal office. Inhabitants of Písek may also utilise 7 scrapyards which serve for placing bulky and sorted waste.

Moreover, there are 130 facilities for placing sorted waste in the town. The number of containers within these facilities is different for individual locations; it always depends on the need of the given site. 80 of these facilities contain a container for glass, other ones contain only containers for paper and plastic. Some of them are classic - above the ground, and in the historical centre of the town there are underground containers. This waste is processed and meant for a further application. Only persons, namely inhabitants of Písek, may place the waste into scrapyards. Specifically, the following waste can be placed there: old furniture, wood, carpets, PVC, old clothes, rags, appliances, and all secondary raw materials. Then also hazardous waste, such as accumulators, oil filters, oils, fabrics stained with harmful substances, brake fluid, waste containing mercury (fluorescent lamps, gas tubes), paints, varnishes, old medications, galvanic cells, etc. In the region of the town there are 2,000 containers for biowaste distributed, too. Citizens put waste suitable for composting into these containers. The containers are specifically designed for such a kind of waste.

Regularly there happens the collection and haulage of litter bins which are located mostly in parks and busy sites. During the bins installation peripheries of the town were not forgotten either. Altogether there are 240 litter bins positioned. (Městské služby Písek, s.r.o., 2014)

5.2. Frequency of Waste Collection in Písek

Currently the separated waste is hauled once or twice a week depending on the type of the waste. In case of paper it is twice a week, every Monday and Thursday; plastic is also hauled twice a week, every Tuesday and Friday. Glass is hauled once a week, every Wednesday, due to its smaller volume.

There are 3 hauling vehicles used for the haulage. That one which is intended for collection of paper and plastic, enables to compact the waste with a linear compacting machine which allows for serving a bigger number of sites in one haulage cycle (from the volume weight of approx. 20 kg/1,000 l the following volume weight of approx. 250 kg/1,000 l may be achieved through compacting). The second vehicle equipped with a hydraulic arm is intended for haulage of waste from underground containers. This vehicle is used to haul all kinds of sorted waste; moreover in case of hauling glass from underground containers it is also used for the haulage from containers of a "bell" type. The third vehicle serves for haulage of glass waste from plastic dumping containers for glass, when there happens no waste compacting.

For all kinds of sorted waste the routes of hauling vehicles are basically the same. In case of glass due to a smaller number of sites intended for glass placing these routes are different. Since majority of sites which are intended for collection of paper and plastic only, are located on a route intended for glass, too, a bigger number of such sites does not have a big impact on driven kilometres. There exists only a difference from the time point of view, when a bigger number of containers for paper and plastic requires a longer operation time.

The optimisation of sorted waste haulage in Písek will be focused on changing the frequency of haulage, and changing routes of glass haulage (plastic containers and containers of a "bell" type) with a subsequent proposal of new routes, taking into account the capacity of hauling vehicles. In case of glass haulage it was found out that the filling level of all containers is small; in all observed cases it even did not reach half of the container's capacity. The frequency of glass haulage is not set optimally.

5.3. Current Concept of Glass Haulage

Current glass haulages are performed once a week, on Wednesdays, with two transport vehicles. One is intended for haulage from plastic containers, and another one from other containers. Routes of individual vehicles were part of the analysis (Table 2).

Total costs on haulage consist of several items. They include costs on vehicles (driven kilometres, amortisation), costs on staff (wages), and other costs. For the sake of frequency and routes optimisation, only the costs on hauling vehicles will be taken into account (Table 1).

Table 1. Costs by Container Type

Type of container	Annual costs (€)
Plastic containers	2, 294.87
Bells	4, 689.04
Total	6, 983.9

Source: Koraba, 2016

Table 2. Vehicles Intended for Waste Haulage

Type of vehicle	Useful volume (l)	Load capacity (kg)	Operation costs (CZK/km)
Vehicles with an arm for containers of a bell type	16,000	7,000	1.21
Vehicle for dumping of plastic containers	16,000	6,000	1.21

Source: Koraba, 2016

The optimisation calculates with 10 % capacity reserve in case of fluctuations in waste volume (Table 3).

Table 3. Existing Routes of Glass Haulage

Route for containers of a bell type	Route length (m)	Waste volume (l)	Costs on route (€)
DEPOT – 39 – 14 – 5 – 71 – 6 – 3 – 1 – 2 – 66 – 67 – 76 – 8 – 21 – 19 – 13 – 30 – 31 – 41 – 42 – 53 – 54 – 55 – 56 – 60 – 62 – 4 – 51 – DUMPING SITE – DEPOT	34,200	7,210	40.98
Route for plastic containers			
DEPOT – 22 – 37 – 35 – 36 – 38 – 24 – 23 – 25 – 26 – 27 – 28 – 79 – 78 – 77 – 73 – 74 – 75 – 15 – 16 – 9 – 10 – 12 – 11 – 17 – 18 – 20 – 7 – 72 – 69 – 68 – 70 – 64 – 63 – 40 – 59 – 61 – 57 – 58 – 52 – DUMPING SITE	33,500	13,750	40.14
DUMPING SITE – 33 – 29 – 32 – 34 – 43 – 80 – 44 – 46 – 47 – 45 – 48 – 49 – 50 – DUMPING SITE – DEPOT	36,380	3,960	43.59
Total	104,080	24,920	124.74

Source: Koraba, 2016

6. OPTIMISATION OF GLASS HAULAGE IN PÍSEK

In case of sorted waste haulage by the enterprise Městské služby Písek the weakest point seems to be the glass haulage. The frequency of haulage does not correspond to facts - containers for glass are filled only to a small extent in case of a weekly haulage, and thus it is necessary to adjust the haulage frequency. The adjustment of glass haulage frequency will also bring a change in existing routes of glass haulage (due to capacity possibilities of vehicles).

The optimisation of haulage of glass placed in plastic containers and containers of a "bell" type will be implemented using the Clarke-Wright Method and the Nearest Neighbour Method. The goals of optimisation of haulage of glass in plastic containers and containers of a "bell" type will be as follows:

- change in haulage frequency,
- reduction of driven kilometres.

6.1. Procedure of Optimisation of Haulage of Plastic Containers with Glass (Clarke-Wright Method)

Since the adjustment from a weekly haulage to a biweekly one would lead to exceeding of capacity options of a hauling vehicle, it is necessary to choose such a method which will divide a drive of one vehicle into several drives. Individual drives must respect the capacity of the vehicle and at the same time the number of driven kilometres must be as smallest as possible. It seems that the most effective method is the Clarke-Wright Method; it is a heuristic, solving a multi-circuit, capacitive limited circular problem.

Clark and Wright (1964) condensed the method into the following steps:

1) For a given transport network S = (V, H) a matrix of distance D = {d(i, j)} is created, where i, j = 0, 1, …, n; n = |V|. Furthermore, the following values are given:
   i. capacity of a vehicle,
   ii. amount of transported elements,
   iii. maximum time of the vehicle motion away from the starting peak V0,
   iv. other parameters.

2) There is created an initial solution, i.e. a set of so called elementary routes (V0 – Vi – V0) for all peaks of the network i = 1, ..., n. The routes are logged into a table and information about individual routes (route length, amount of load, time, etc.) is added.

3) The matrix D is used to calculate a profitability matrix with the most profitable coefficients Z = {z_{ij}}, where i, j = 1, …, n. The calculation is performed using the formula zij = d0i + d0j – dij.

4) There in the matrix Z is the most positive element z_{ij} found and, if possible, routes (V0 – Vi – V0) and (V0 – VJ – V0) are joined into a route (V0 – Vi – VJ – V0). If there is no element z_{ij} available anymore or if the capacity of all vehicles is fulfilled (all processed peaks), the algorithm has reached its end and the actual set of circular routes is the result of the optimisation. Otherwise the step 5 follows.

5) In case there arises an acceptable route after joining the routes: the value of the given element z_{ij} is set to 0, and the step 6 follows. If for any reason it is not possible to join the routes (development of a cycle, exceeding the capacity of a vehicle), the value of z_{ij} is set to 0 and the step 4 follows).

6) If after joining the routes there arise some peaks, which are not marginal ones, the most profitable route is updated. Furthermore, the table of routes must be updated with a newly created route. Elementary routes as well as routes created with a previous joining process may be joined. Then the step 4 follows.

Since the depot site of vehicles and the dumping site are in different locations, it is required to adjust the matrix of distances. This drive is acceptable only in case of an empty car, i.e. in the direction from a dumping site do a depot. The modification is performed as follows: for all connections from network peaks to the depot there is set a value which is greater than the length of the connection from the dumping site do the depot. This ensures that this edge will be included in one of resultant drives. This drive will then be divided into a technological part of the containers operation and the return to the depot.

After adjusting the matrix of distances there is the profitability matrix Z = {zij} formed, where i, j = 1, ..., n according to the formula zij = d0i + d0j – DIJ. At the same time the table of elementary routes must be created. This table contains all initially solved problems and thus the connection from V0 to individual peaks V_i and back to V0. It is also necessary to state individual observed quantities into the table so it is clear whether any of the conditions was broken or not.

6.2. Procedure of Optimisation of Haulage of a Container of a "Bell" Type with Glass (the Nearest Neighbour Method)

With respect to the number of waste containers of a "bell" type and underground containers the vehicle capacity was not exceeded even in case of the proposal of a biweekly waste haulage. It even did not happen in case of including a reserve which is needed for a potential coverage of an above-average volume of hauled waste. For this reason the Nearest Neighbour Method was chosen; it is a heuristic method looking for the shortest one-circuit circular drive.

This method is simple and does not require any complex calculations. Data source is represented with the matrix of distances among individual peaks which is progressively searched for.

In the beginning of the whole procedure an initial peak is chosen. In the distance matrix for the given peak there is the nearest, not operated peak found, and this connection is logged into the concurrent solution of the route. This procedure is applied to all peaks step by step; after finding the last peak there happens its linking to the initial peak. This way the entire route can be found. We do also recommend performing a reduction of the distance matrix after each finding a route peak. This step mainly serves to make the matrix well arranged for a subsequent procedure. This reduction lies in a removal of a column which determines the distance to the given peak from the other ones because there leads no route to this peak.

Since the connection between the dumping site and the depot is mandatory, it is necessary to modify the distance matrix through setting the distance between these peaks to zero (or shorter than the shortest distance between the depot and the nearest point, and the dumping site and the nearest point). This ensures that this edge will always be part of the resultant route. Zeroes in the diagonal indicating the route from a peak to the same peak are ignored during the calculation. In the first place it is necessary to create a distance matrix.

The following Figure 2 represents the process of searching for the shortest route for the initial peak V10. There in the first row of the table is the sequence of operations - order of columns being removed. There in the first column is the sequence of peaks for which the nearest neighbour is searched for. Cells indicating the nearest neighbour and the distance from this neighbour are highlighted in yellow. The procedure for other points is not mentioned here since it is the same repeated procedure. In the figure there are only the resultant routes represented.

Figure 2. Procedure of Searching for the Shortest Route

		26	16	15	14	8	6	13	24	2	1	3	4	28		5
		V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15
26	V1	x	2760	2570	2490	2330	1630	2370	2030	1400	1100	1560	1680	2100	2700	1200
16	V2	2760	x	190	510	950	1130	390	1790	1960	1660	2120	2240	3800	4100	2000
15	V3	2570	190	x	320	760	940	200	1600	1770	1470	1930	2050	3610	3910	1810
14	V4	2490	510	320	x	680	860	120	1520	1690	1390	1850	1970	3530	3830	1730
8	V5	2330	950	760	680	x	700	560	1360	1530	1230	1690	1810	3370	3670	1570
6	V6	1630	1130	940	860	700	x	740	1300	830	530	990	1110	2670	2970	870
13	V7	2370	390	200	120	560	740	x	1400	1570	1270	1730	1850	3410	3710	1610
24	V8	2030	1790	1600	1520	1360	1300	1400	x	1230	930	1240	1100	3070	3370	1270
2	V9	1400	1960	1770	1690	1530	830	1570	1230	x	300	160	300	2440	2740	640
1	V10	1100	1660	1470	1390	1230	530	1270	930	300	x	460	580	2140	2440	340
3	V11	1560	2120	1930	1850	1690	990	1730	1240	160	460	x	140	2600	2900	800
4	V12	1680	2240	2050	1970	1810	1110	1850	1100	300	580	140	x	2720	3020	920
28	V13	2100	3800	3610	3530	3370	2670	3410	3070	2440	2140	2600	2720	x	600	1800
	V14	2700	4100	3910	3830	3670	2970	3710	3370	2740	2440	2900	3020	600	x	2100
5	V15	1200	2000	1810	1730	1570	870	1610	1270	640	340	800	920	1800	2100	x
17	V16	3150	1770	1580	1500	820	1520	1380	2180	2350	2050	2510	2630	4190	4490	2390
18	V17	3470	2090	1900	1820	1140	1840	1700	2500	2670	2370	2830	2950	4510	4810	2710
23	V18	5270	3890	3700	3620	2940	3640	3500	4300	4470	4170	4630	4750	6310	6610	4510
19	V19	3710	2330	2140	2060	1570	2080	1940	2740	2910	2610	3070	3190	4750	5050	2950
20	V20	3550	2170	1980	1900	1410	1920	1780	2580	2750	2450	2910	3030	4590	4890	2790
21	V21	3370	1990	1800	1720	1230	1740	1600	2400	2570	2270	2730	2850	4410	4710	2610
22	V22	3230	1850	1660	1580	1090	1600	1460	2260	2430	2130	2590	2710	4270	4570	2470
10	V23	2690	1310	1120	1040	550	1060	920	1720	1890	1590	2050	2170	3730	4030	1930
9	V24	2490	1110	920	840	350	860	720	1520	1690	1390	1850	1970	3530	3830	1730
11	V25	2540	1160	970	890	710	910	770	1570	1740	1440	1900	2020	3580	3880	1780
12	V26	2720	1340	1150	1070	890	1090	950	1750	1920	1620	2080	2200	3760	4060	1960
7	V27	2070	690	500	420	260	440	300	1100	1270	970	1430	1550	3110	3410	1310
25	V28	2850	2360	2170	2090	1910	2110	1970	820	2050	1750	2060	1920	3890	4190	2090
27	V29	0	6730	6540	6460	5970	6480	6340	7140	7310	7010	7470	7590	9150	9450	7350

		17	18	23	19	20	21	22	10	9	11	12	7	25	27
		V16	V17	V18	V19	V20	V21	V22	V23	V24	V25	V26	V27	V28	V29
26	V1	3150	3470	5270	3710	3550	3370	3230	2690	2490	2540	2720	2070	2850	0
16	V2	1770	2090	3890	2330	2170	1990	1850	1310	1110	1160	1340	690	2360	6730
15	V3	1580	1900	3700	2140	1980	1800	1660	1120	920	970	1150	500	2170	6540
14	V4	1500	1820	3620	2060	1900	1720	1580	1040	840	890	1070	420	2090	6460
8	V5	820	1140	2940	1570	1410	1230	1090	550	350	710	890	260	1910	5970
6	V6	1520	1840	3640	2080	1920	1740	1600	1060	860	910	1090	440	2110	6480
13	V7	1380	1700	3500	1940	1780	1600	1460	920	720	770	950	300	1970	6340
24	V8	2180	2500	4300	2740	2580	2400	2260	1720	1520	1570	1750	1100	820	7140
2	V9	2350	2670	4470	2910	2750	2570	2430	1890	1690	1740	1920	1270	2050	7310
1	V10	2050	2370	4170	2610	2450	2270	2130	1590	1390	1440	1620	970	1750	7010
3	V11	2510	2830	4630	3070	2910	2730	2590	2050	1850	1900	2080	1430	2060	7470
4	V12	2630	2950	4750	3190	3030	2850	2710	2170	1970	2020	2200	1550	1920	7590
28	V13	4190	4510	6310	4750	4590	4410	4270	3730	3530	3580	3760	3110	3890	9150
	V14	4490	4810	6610	5050	4890	4710	4570	4030	3830	3880	4060	3410	4190	9450
5	V15	2390	2710	4510	2950	2790	2610	2470	1930	1730	1780	1960	1310	2090	7350
17	V16	x	320	2120	880	840	660	520	1090	890	1250	1430	1080	2450	5280
18	V17	320	x	1800	560	820	980	840	1410	1210	1570	1750	1400	2770	4960
23	V18	2120	1800	x	1600	1860	2040	2080	3020	2820	3180	3360	3200	4380	4300
19	V19	880	560	1600	x	260	440	480	1420	1220	1580	1760	1640	2780	4400
20	V20	840	820	1860	260	x	180	320	1260	1060	1420	1600	1480	2620	4660
21	V21	660	980	2040	440	180	x	140	1080	880	1240	1420	1300	2440	4840
22	V22	520	840	2080	480	320	140	x	940	740	1100	1280	1160	2300	4880
10	V23	1090	1410	3020	1420	1260	1080	940	x	200	550	730	620	1750	5820
9	V24	890	1210	2820	1220	1060	880	740	200	x	360	540	420	1560	5620
11	V25	1250	1570	3180	1580	1420	1240	1100	550	360	x	180	470	1200	5980
12	V26	1430	1750	3360	1760	1600	1420	1280	730	540	180	x	650	1380	6160
7	V27	1080	1400	3200	1640	1480	1300	1160	620	420	470	650	x	1670	6040
25	V28	2450	2770	4380	2780	2620	2440	2300	1750	1560	1200	1380	1670	x	7180
27	V29	5280	4960	4300	4400	4660	4840	4880	5820	5620	5980	6160	6040	7180	x

Source: Koraba, 2016

The following route was found using a progressive search with the origin in the peak V10:

V10 – V9 – V11 – V12 – V15 – V6 – V27 – V5 – V24 – V23 – V25 – V26 – V7 – V4 – V3 – V2 – V16 – V17 – V19 – V20 – V21 – V22 – V18 – V8 – V28 – V1 – V29 – V13 – V14 – V10 (Figure 2).

The length of V29 – V1, which was replaced with 0 during the adjustment of distance matrix, must be added to the total route length, which arose from the algorithm. The total length of this route is 39,520 m.

6.3. Result of Waste Haulage Optimisation

The evaluation of effectiveness is realised per a period of one distribution cycle of a newly proposed route which represents 1 haulage/14 days. Costs on 1 km are 1.21 €.

A: Result of Optimisation of Haulage of Plastic Containers with Glass

Table 4. Resultant Routes

Route	Volume of waste (l)	Route length (m)	Driving time (min.)	Operation time t (min.)	Total time t (min.)
DEPOT – 7 – 11 – 10 – 12 – 48 – 49 – 50 – 46 – 47 – 45 – 44 – 43 – 80 – 52 – DUMPING SITE	9,020	24,590	98.36	14	112.36
DUMPING SITE – 15 – 16 – 9 – 17 – 18 – 20 – 24 –	14,300	27,280	109.12	21	130.12

23 – 25 – 26 – 27 – 28 – 22 – 37 – 36 – 38 – 35 – 33 – 29 – 32 – 34 – DUMPING SITE					
DUMPING SITE – 58 – 57 – 40 – 63 – 59 – 61 – 65 – 64 – 70 – 69 – 68 – 72 – 73 – 74 – 75 – 77 – 78 – 79 – DUMPING SITE	12,100	21,020	84.08	18	102.08
DUMPING SITE – DEPOT		8,100			

Source: Koraba, 2016

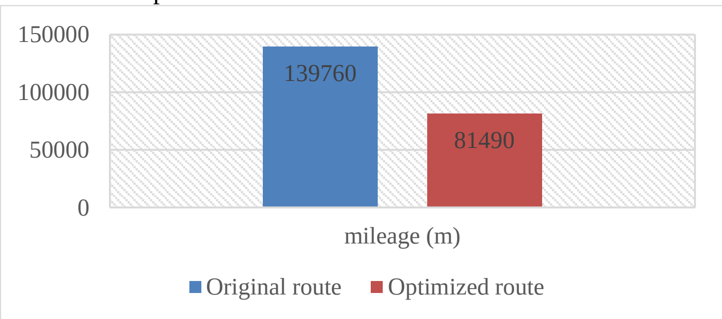
Table 5. Routes Comparison

Routes	Total route length (m)	Costs on haulage (€)	Saving in distances (m)	Percentage saving in costs (%)
Original	139,760	168.85	-	-
Optimised	81,490	98.44	58,270	41.7

Source: Koraba, 2016

The table makes it clear that thanks to the frequency change there has happened a 41.7 % saving in costs, which represents 70.4 € for 14 days. The optimisation has also brought a saving in kilometres: 58.27 km.

Chart 1. Comparison of a Run Distance



Source: Koraba, 2016

B: Result of Optimisation of Haulage of Containers of a "Bell" Type with Glass

Table 6. Resultant Route

Route	Route length (m)
DEPOT – 31 – 30 – 76 – 8 – 39 – 21 – 19 – 13 – 14 – 5 – 67 – 66 – 60 – 62 – 1 – 2 – 3 – 6 – 71 – 4 – 42 – 41 – 56 – 55 – 54 – 53 – 51 – DUMPING SITE – DEPOT	28,700

Source: Koraba, 2016

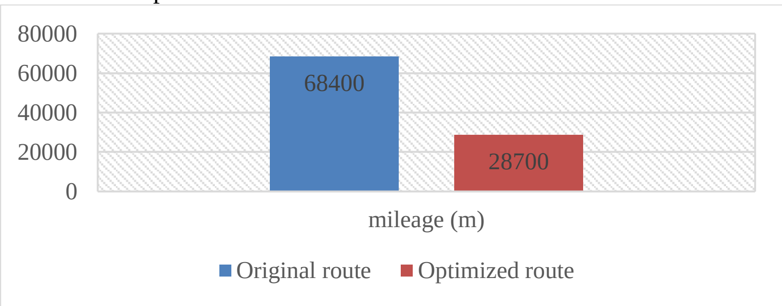
Table 7. Routes Comparison

Route	Total route length (m)	Costs on haulage (€)	Saving in distances (m)	Percentage saving in costs (%)
Original	68,400	82.64	-	-
Optimised	28,700	34.69	39,700	58

Source: Koraba, 2016

During the haulage of containers of a "bell" type the change did not happen only due to the haulage frequency change but mostly due to the improvement of existing haulage routes. For this reason the saving in original route is almost 60 %.

Chart 2. Comparison of Run Distance



Source: Koraba, 2016

6.4. Total Benefit of Glass Haulage Optimisation

Table 8. Routes Comparison

Routes	Total route length (m)	Costs on haulage (€)	Costs on haulage (m)	Percentage saving in costs (%)
Original	208,160	251.49	-	-
Optimised	110,190	133.13	97,970	47

Source: Koraba, 2016

Table 9. Annual Comparison of Routes

Routes	Total route length (km)	Costs on haulage (€)	Costs on haulage (km)	Percentage saving in costs (%)
Original	5,828.48	7,041.7	-	-
Optimised	3,085.32	3,727.5	2,743.16	47

Source: Koraba, 2016

Total saving achieved through the optimisation of haulage of plastic containers and containers of a "bell" type is 47 %. Total saving in costs is 3,314.16 €**.**

7. CONCLUSION

No mature society or household can exist without producing waste which arises in production, usage or consumption. The main source of waste is the industry (machine, building industry, etc.). The waste production, however, must be reduced and the arisen waste must be treated with properly. A way how to properly handle the waste is to recycle and separate it and also to use secondary raw materials for newly emerging products, (Junga, 2015).

Despite the reverse logistics has started to appear as a separate part of a logistic chain only in recent years, the role of its application in businesses is undeniable, (Caban, 2018) and (Segetlija, 2014). The reverse logistics is applied mostly in the European notion of this term (environmental point of view) which sees the reverse logistics as a means for a further utilisation of wastes arisen in previous components of a logistics chain. So there exists a way to utilise services in the waste economy when an enterprise will take care of arisen wastes, their transport and subsequent disposal or re-usage. For the recycling it is also interesting that the reverse logistics may serve as an instrument to obtain input raw materials, and this way to contribute to saving sources which enter the production process.

Important tasks of the current society include the reduction of waste which happens also thanks to returnable packaging, separation and sorting of waste, (Pazourková, 2015). Many of us, whether citizens, or businesses, realise it is time to start protecting the environment in order to preserve the nature (Torok, 2017).

The change of frequency has introduced a need for change in current circuits of vehicles. The glass haulage on current routes would not be possible due to an increase in the volume of hauled waste. For plastic containers whose occurrence is the highest within the town, the Clarke-Wright Method for solving a circular transport problem was chosen. Based on the information from available literature resources its application represents one of the most effective ways how to optimise capacitive limited circular drives. Using the method 3 routes were found; the entire volume of the hauled waste including a 10 % reserve for potential fluctuations in waste volume was divided among them.

Thanks to the optimisation there arose a 41.7 % saving in costs on the haulage, expressed in money: 1,806.50 CZK for 14 days.

For the second type of containers the optimisation through the Nearest Neighbour Method was chosen. This method was chosen due to the fact that even in case of a double waste volume and including the reserve the capacity of the vehicle was not fulfilled. The method improved the existing haulage route, thus the optimisation brought an even bigger percentage saving. In case of haulage of containers of a "bell" type there arose a 58 % saving, i.e. 1,230.50 CZK for 14 days.

Totally there were achieved annual savings of 85,038,- CZK, which is approximately 47 % of costs when compared to the original concept of the waste haulage. However, the money saving which only includes costs on the haulage itself (costs on vehicles) is not the only benefit brought with the optimisation. The haulage frequency change has led to a saving in labour forces. Haulage workers who currently perform the haulage once a week, may be utilised for other working needs, since a 50 % saving in working capacity of these workers has occurred there.

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MODELLING AND SIMULATION IN THE ENVIRONMENT OF LOGISTICS OF HUMANITARIAN OPERATIONS

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Abstract

The article deals with the use of modelling and simulation as a tool for planning humanitarian operations. The aim of the article is to outline the possibilities of using simulation for the need of humanitarian logistics in the context of a fiction scenario. The model situation is the state in which the distribution of humanitarian aid, more precisely the flood situation in the Czech Republic, is planned. The introductory part of the article focuses on a brief introduction to the general problems of both humanitarian logistics and modeling and simulation. Subsequently, this model situation is presented with an example of the simulation model creation process. The conclusion of the article summarizes the lessons learned about the use of simulation for this crisis situation, together with the generalization of results for wider use in humanitarian logistics.

Key words: Humanitarian logistics, modelling, simulation, distribution, complex processes

1. INTRODUCTION

Humanitarian logistics is a specific logistics part. Its main task, which at the same time distinguishes it from commercial logistics, is to ensure the timely delivery of humanitarian aid to sites affected by natural or man-made disasters or to places affected by war (Kovacs, 2007). However, a number of challenges and obstacles arise during this clearly defined task that make it difficult for the arrangement of humanitarian aid. In addition, some of them cannot be predicted in advance at all or only with a certain degree of probability. Ultimately, these phenomena can completely or at least partially alter the execution of a scheduled operation and affect its outcome. Given that this results in ensuring the health and safety of the population, the risks that could affect the humanitarian operation must be minimized.

Like management in the business sector, the logistics management of humanitarian aid organizations is struggling with the issue how to plan all sub-processes to ensure the smooth running of any logistics operations.

One of the possibilities how to check the feasibility of the set plan, check its weak and strong points and the optimal amount of resources involved is modeling the problem and then simulating this model.

2. LITERATURE REVIEW

The solving of the humanitarian crisis has become very important topic and is receiving increasing attention. The reason to it is the increasing frequency of the natural or man-made disasters, such as huriccanes, floods, earthuakes or even nuclear disaster like the one in Japan in 2011caused by the massive earthuake and tsunami. Also, these disasters have increasing impact on the material damages and people´s lives. Considering the usage of modeling and simulation in this topic, several different models have been developed for relief supply chain in response to particular disasters. Bravata et al. (2006) modeled regional and local supply chain for antibiotics and medicinal supplies to estimates the mortality when anthreax bioterrorism occurs. Hupert (2002) created the model for several level of desease prevalance bioterrosim response scenarios.

Kovacs and Spens (2007) present a thorough review of the literature available. They focused on understanding and describing the specific characteristics of humanitarian logistics in disaster relief and show parallels between humanitarian and business logistics. Cozzolino (2012) brings a detailed review of the current state of knowledge and understanding of humanitarian logistic consisting the humanitarian logistics and supply chain management, the stages of that operation such as preparation, response, mitigation and reconstruction. They underline the importance of the intense cooperation among all players involved in the humanitarian operation.

We could continue with the list of already published literature or studies, but this paper aims much more to the simulation and modeling methodology in order to present what steps are very important in order to prepare appropriate model with transparency and understandable outputs.

3. MODELING AND SIMULATION

3.1. Modeling

Modeling is a method that allows a user to create a simplified idea of a particular object or phenomenon in the real world (Robinson, 2011). Models exist in different forms. For example, models of transport such as trains, cars or airplanes; cartographic models creating different map bases; models of medieval cities; human body models and countless others.

All these examples represent a more or less plausible copy of their real foundations. However, none of them can fully capture the real image of their form.

This would not even be desirable. Train simulation loses its original weight and other characteristics that are essential to real train operation, while at the very least it would be impractical in a rail model. The model depicting the appearance of the city when it is founded does not aim to capture all the houses, wells or trees in their original locations. Its essence is to allow the observer to create a coherent picture of how the city might have looked, what was its fortification, or how large a castle it was.

So the essence of the model is abstraction. Abstraction creators in terms of scientific exploration and complex systems make it possible to avoid endless work with information, data and model details that would not yield anything fundamental. The observer of the model makes it easier to concentrate, so he can focus on a substantial part of the problem and work with it.

As far as complex systems are concerned, it is necessary to pay attention not only to the part where the model is created but also to its subsequent analysis. It should bring new discoveries - for example in the form of confirmation or refutation of a certain hypothesis or finding a new approach to solving a particular issue. While simple models can be deduced from mere observation, complex systems, including humanitarian logistics processes, can be more effectively investigated through computer simulation.

3.2. Simulation

Simulation is a method of dealing with probabilistic dynamic systems that is studied through experiments in a computer model. With it, it is possible to predict system behaviour when changing internal or external conditions, as well as optimizing the processes according to specified criteria, such as profit, cost or reliability. The result of the simulation is not the exact value but only the parameter estimate. Simulation can also explore different alternatives to system changes, validate their impacts, and choose the solution that best suits your situation.

Due to these characteristics, computer simulation is often used to analyze business processes such as supply, production, or distribution.

As far as the creation of the simulation project is concerned, it can be divided into several consecutive basic phases, which are (Dlouhý, 2007):

- identifying the problem and setting goals;
- creating a conceptual model;
- data collection;
- creating a simulation model;
- model verification and validation;
- conducting experiments and analyzing results;
- model documentation;
- implementation.

The main advantages of the simulation are that (IT Release, 2019):

- allows you to work with relatively complex systems that cannot be processed by simple analytical methods;
- is less time-consuming and expensive than real-world experiments;
- some simulation programs allow animation of the system to illustrate its operation.

However, the simulation cannot be understood as a method that would solve all problems for the processor. It is merely a tool to support him in successfully solving the problem, and the responsibility for its optimal use lies with him. In modeling, it must take into account some of the disadvantages of computer simulation, which include, in particular, that (IT release, 2019):

● requires the purchase of software in the form of a simulation program, or the project of the company involved in the activity;

● studying the program is time consuming;

● the result of the simulation is not a specific value for selecting the optimum but estimating the parameter;

● interpretation of results may not always be unambiguous.

4. HUMANITARIAN LOGISTICS PROCESSES

In the context of humanitarian logistics, aid can be divided according to the moment of the crisis. During and after the disaster, the aid phases are distinguished as follows (MZV ČR, 2010):

● Immediate assistance, which applies to the first days to weeks after the disaster, and includes, in particular, elementary aid to save lives (paramedics, paramedics and medical supplies) and the primary support of survivors (food, water, emergency shelter, generators, emergency sanitation). Depending on the scale of the crisis and the functionality of the authorities of the affected country, civilian and possibly military crisis management structures are in place at this stage.

● Next one is the phase of early rehabilitation, a period of about 2 weeks - 3 months after the disaster. In particular, it covers the care of displaced persons as a result of a disaster (shelter, food, water, health and psychosocial care) and the pursuit of rapid recovery of elementary infrastructure.

● Renewal (and development) phases are under way, generally within two years of the disaster, in the context of humanitarian aid. Includes comprehensive recovery in affected areas.

In addition to timing, humanitarian logistics can be divided from the point of view of providing assistance. Specifically, we distinguish domestic and foreign operations. Domestic humanitarian logistics mainly includes transport or storage of humanitarian material such as food, medicines, medical equipment, tents, temporary shelter material, etc. The humanitarian material is mostly the distributed within the IRS - for example by the Fire Rescue Service, the State Material Reserves Administration and the Czech Army. Republic. Private actors in the form of logistics companies, retail chains and others can also be involved in the humanitarian aid process.

Foreign aid is even more challenging. Operations take place in places that are often not easily accessible, and in addition, their infrastructure does not provide a wide choice of alternatives to find the best way to help. For example, there are missing material storage facilities or other equipment to facilitate on-site work (Weberová, 2013).

5. ENGAGING SIMULATION IN THE PROCESS OF ORGANIZING HUMANITARIAN AID

Engaging modeling with simulation is possible at virtually all stages of humanitarian aid, both at home and abroad. Above all, it is a suitable method for planning processes with a high occurrence of quantities that are random phenomena. They cannot be described by a simple mathematical function and their results can be simply calculated. This results in the advantage of simulation especially in the immediate help phase. However, simulation alone does not provide process optimization, but rather creates some support for decision-making in specific situations.

5.1. The main issue and goal of its solution

As an example of involving modeling and simulation, one can imagine a crisis situation in the form of floods in the Czech Republic. Specifically, the flood in a part of the Olomouc region, see Figure 1. In such a situation, the main objective is to ensure the safety of people in the affected area as quickly as possible. This most often means their evacuation and subsequent material security. More specifically, it is about finding the most appropriate range of resources involved to deliver a specific volume of humanitarian material.

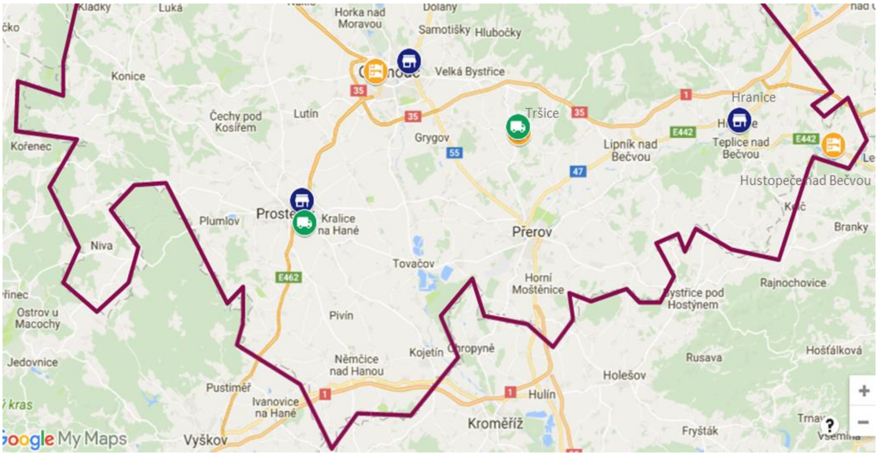
Figure 1. Floods in part of Olomouc region

Source: HF Biz (2019). Povodňový plán Olomouckého kraje

5.2. Conceptual model

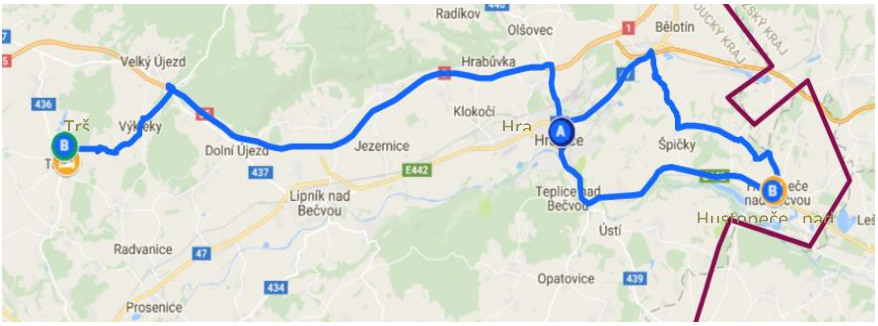
When creating the model, it is necessary to know the places for evacuation in the event of floods and their capacity, the places from which the material will be distributed, as well as the stations of the Fire Rescue Service (FRS) and, where appropriate, the location of private logistics companies, which will enter and transport the material to the destination . In summary, these locations can be called model elements. For the sake of clarity, it is appropriate to record these elements in a map background similarly to Figure 2 together with the route plan between them, see Figure 3.

Figure 2. Elements on the map background (car - fire station; shop - material store; beds - evacuation center



Source: Vogal (2017). Distribution of material stock in regions affected by natural disaster

Figure 3. Example of elements connection



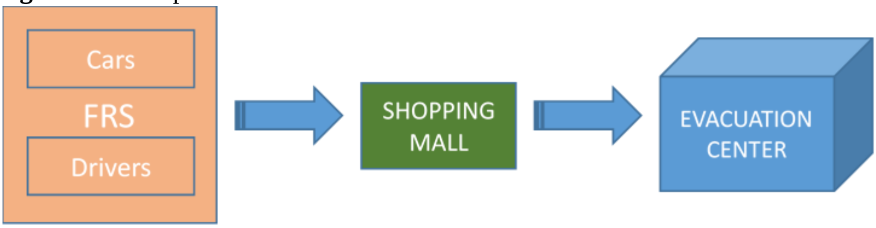
Source: Vogal (2017). Distribution of material stock in regions affected by natural disaster

5.3. Data collection

The above information is sufficient to create a conceptual model, i.e. to create a general overview of the problem and its possible solution. A simple view of the conceptual model is shown in Figure 4. For further processing, it is necessary to collect more detailed data on the individual elements and then to base them on, i.e. to modify the model to a form suitable for simulation.

The quality of the model and its capability to describe the real system as much as possible depends on the quality of available information about all elements included in the system. It consists not just the information about existing infrastructure and the real environment as the background where the humanitarian crises occurs, but the most important information about the probable behaviour of all elements in the system such a demand for the material, number of transport means, its speed and capacity and also accessibility from the depo to presumed target point. Quality of available data is crucial assumption for appropriate response from the model.

Figure 4. Conceptual model scheme



Source: Vogal (2017). Distribution of material stock in regions affected by natural disaster

5.4. Simulation model

The simulation model can be compiled using a program from a variety of products. These include ARENA, SIMUL8, SIMIO, ANYLOGIC, GPSS / H, PROMODEL, MEDMODEL, WITNESS and others. Unlike earlier simulation programming languages, these programs provide users with a comfortable visual environment (Dlouhý, 2007). You can also use the special tool Microsoft Excel to solve SOLVER decision tasks.

In the selected simulation program, we will include specifically defined elements that appear here as icons. In the example, these elements are evacuation centers, fire brigade stations, and department stores with which the State Material Reserves Administration works in similar cases. To do so, we assign the collected data representing their properties, which we can further adjust. These include, for example, the location of elements, storage capacities or the duration of some activities.

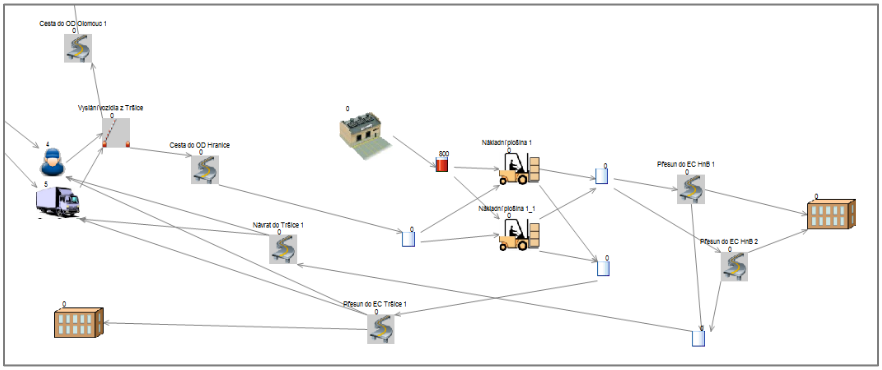
When setting up evacuation center data, it has to be assumed that even if they have a maximum capacity, their actual occupancy correlates with the extent of the flood. The location of the centers and their basic facilities are also determined.

Fire stations are defined in the program by their location, and thus by distance to evacuation centers and department stores. Also, the number of drivers per station and the amount of technique that is known to be similar to occupancy centers is known. The greater the range of floods, the smaller the amount of distribution technology available due to its involvement in the field. Drivers also have working hours, which can, however, be more adapted to the current need in a crisis situation.

Last but not least, the positions of department stores or material stores are determined. There is a time for waiting lorries for check-in and loading.

Figure 5 shows a part of a similar simulation model created in Simul8. A car with a driver is the source of a fire station, a warehouse with carts indicates where the material flows, and two houses indicate evacuation centers.

Figure 5. Parts of simulation model



Source: Vogal (2017). Distribution of material stock in regions affected by natural disaster

5.5. Verification

This model can be run in the program simulation environment to verify that it works as intended and matches the original design. This means, for example, whether the cars actually leave the fire station first to the material loading location and only then to the evacuation point and not vice versa. In this way, the simulation model is verified.

5.6. Validation

After verifying the correct function of the model, there is room for its validation, which is the biggest advantage of the simulation. The user can create a number of scenarios that may occur. It enters the data for each scenario into the verified model and observes which model element settings are most appropriate for the scenario.

5.7. Analysis of experiments

Several scenarios can be created for the course of the flood situation according to its extent. On the basis of historical data, it is possible to determine the size and course of flooding of the area for a given flood stage over time and to continue to simulate it. For example, in lower floods there is no danger of flooding the bridge, which is located on the shortest route to the evacuation center, and the transport of the material does not have to be bypassed. Firefighting units do not have to deal with a large-scale crisis, thus reducing the risk of overloading human resources. On the other hand, in the case of a more extensive flood, which is very fast, there is a risk that flooding of roads will lead to the isolation of an evacuation center within hours of the outbreak of the disaster. In this case, it is necessary to designate such a center as a priority in the model. Flood dependent variables are much more.

After running all the scenarios, the results are evaluated and a suitable range of settings for the variables for each situation is found.

6. DISCUSSION

The simulation captures the dynamic distribution model and allows it to run with different event scenarios. The result of the simulation is the basis for decision-making, containing general information about inputs, routes and other model variables, especially the range of their values for different flood conditions. Those results include, in particular, the necessary amount of human and capital resources, a number of centres providing stocks and a number of fire stations involved in the process to provide the assistance to the extent required.

The solution of the model situation shows that it is possible to use the simulation for planning the distribution of humanitarian aid in a crisis. It acts as a basis for the solver and assists him in making effective decisions. This means that the use of simulation in this case is not only appropriate but also justified. This conclusion can be generalized for domestic humanitarian logistics, as the solution of the crisis is a part of it.

In the context of foreign humanitarian logistics, this conclusion is not clear. Unlike domestic help, the data needed to create a simulation model is not so readily available. In addition, coordination of international bodies is applied. However, the use of simulations for these cases is not excluded. Further research is needed in this area.

7. CONCLUSION

Modeling and simulation have become a modern tool for solving relatively complex systems, especially in business processes. Simulation can capture dynamic processes without realization or production interruptions.

However, the simulation is not restricted to the commercial sphere. The use of this tool is quite wide. It is also justified in humanitarian logistics, as outlined in this article. Its advantages can be applied both in the planning of the distribution of humanitarian material in a crisis situation and in a number of other activities that the humanitarian logistics deals with.

The biggest challenge is foreign humanitarian logistics. There are a number of obstacles to addressing the simulation that need to be addressed. An example is the lack of information on storage options, transport routes or infrastructure. At the same time, there are a number of other factors that have an impact on foreign aid planning, such as the political or security situation in the country or a possible war conflict. Together, these obstacles make it difficult to create a simulation model. However, the assumption for this area remains the same. The suggestion for future exploration is therefore to verify this hypothesis.

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VI. PROCUREMENT

DISCRETE-EVENT SIMULATION OF PUBLIC PROCUREMENT

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Abstract

Procurement in the field of defence is a complicated and long-term process, whose success strongly depends on the corresponding legislation of the EU level, state level and internal directives of the MoD. Despite this fact, there are several possibilities for how to make public procurement within the MoD more efficient. The aim of this paper is to show the critical points of the public contracts awarding process and find out the options for its improvement by using discrete-event simulation as a technique for analysis of the current system built up the statistics data. The final experiment brings possible scenarios for decision-makers (the MoD contracting authorities) related to the adjustment of the logistical channel structure and its specific procedures timing in order to improve the system of public procurement within (not only) the MoD and its efficiency.

Key words: public procurement, discrete-event modelling and simulation, procurement efficiency

1. INTRODUCTION

The main objective of this paper will be to ask basic research questions – is it possible to make the public procurement process in the Czech MoD more efficient? Which activities or subjects significantly slow down public contracts awarding? Is it possible to speed up the logistical channel of all activities which form the above-mentioned process?

This topic is one of the crucial in the Czech public administration because public contracts awarding is really complicated and time-consuming process which can negatively influence the speed of goods and services deliveries to the end users. Based on the simulation results (part 4 Results discussion), the contracting authorities know on which phases of the awarding process to focus on in the process of their improvement. They can also be inspired by the winning scenario which suggests the optimal periods for tenders evaluation and for the whole open procedure duration and also shows how these factors can influence the number of successfuly finished public contracts.

This paper can also contribute to the science theory – the result of the literature review shows that the application of simulation software in the public contracts awarding domain is quite new so it extends the variety of posible simulation software applications.

Improvement possibilities will be based on the findings from the discrete-event simulation technique application (Simio software) and data taken from the two public procurement information systems: Journal of public contracts and NEN (National electronic tool). The MoD contracting authority is obliged to use both of these systems in order to publish the most important data related to public contracts, excluding contracts involving confidential nature of the information or dealing with the protection of the essential security interests. (Act 134/2016 Coll., of 19 April 2016 on Public Procurement, 2016, Rozkaz Ministra obrany č. 55 o úplatném nabývání majetku, služeb a stavebních prací v rezortu Ministerstva obrany, 2017).

Simulation allows a user to forecast things that have never happened before and to run some scenarios. The problem is, that one needs a good knowledge about how the system works to implement correct data in the model. Another advantage of simulation is its flexibility. It can be used for a wide range of topics. On the other hand, it also requires the researcher to have access to background information about the process. For example, informal rules, best practises etc. This information has also a huge influence on the result of the simulation.

Building a model and simulation in itself doesn't require knowledge of many data. The problem is when it comes to validation of the model. The more and more accurate data we provide in the model, the more precise results we get. Compared to real-world experimenting, the simulation doesn't consume so many resources. Still it requires time to build a model and also financial resources (Brunclík et al., 2018).

Discrete event simulation help people think introspectively about their systems and realize efficiency gains. An animated version of the system being modeled is often a major outcome of the modelling activity. These animations can provide the best available way to engage untrained people in the application of all types of operations research and systems improvement activities (Allan, 2011).

Literature review has been prepared from three points of view: simulation of logistical problems in general, application of simulation software in the field of public administration and implementation of simulation software in the field of public procurement.

Modelling and simulation is used within some main domains of man's bussiness activities such as supply chain management (Hennet, 2009), manufacturing system planning and scheduling (Merkuryeva et al., 2009 and Hadas et al., 2015). Further usage is in the transport domain (Guash et al., 2009, Uruscu et al., 2009, Eroles et al., 2009), hospital resource management (Chinea et al., 2009), fresh food supply chain (Bruzzone et al., 2009), warehouse order picking (Merkuryev et al., 2009) or material handling (Neumann, 2009). Simulation software in the field of inventory management of selected retail stores has been implemented in Germany (Trauzettel, 2014).

Transport optimization or decrease of out-of-stock ratios belong to the main aims of simulation software application in general but simulation implementation in the procurement process is missing.

The research has been conducted related to using of simulation and other visualisation methods in practice of logistical companies in Poland. The result is that only minority of them use simulations because of the lack of financial resources, human qualification and problems with reliable data (Jankowski-Guzy et al., 2018).

Bussiness and supply chain management is not the only domain, where the modelling and simulation is used in order to analyse and solve particular problems. There are even other domains in **the field of public administration**. The possibility of computer-based simulation games implementation in educational proces of bachelor and master degree students of municipal finance branch was analysed at the two Russian universities (Kutergina, 2017). It has been proved that this interactive approach of study should improve the students scores compared to traditional lectures. Multi-agent-based spatial simulation model was used for analysis of locational changes in Japanese residential areas due to aging and low birth rate (Karashima et al., 2015). This situation should influence public services appropriate deployment. Simulation software has also been applied on the metro transportation hub operation in Yekaterinburg, Russia (Zhuravskaya et al., 2018). The simulation was used in order to determine the required level of services for metro passengers and main characteristics of the system.

Concernig the **public procurement**, the usage of modelling and simulation is quite rare. I suggest that is caused due to its strong framing by the law and difficulty to predict the time consumption of all activities within this process. Application of discrete-event simulation software Stroboscope in the field of public works contracts has been used in the USA. The above mentioned software has been applied in order to prove that web based application can improve mutual cooperation among bidders and contracting autorities, resp. shorten reaction times to bidder inquiries and increase number of solved public contracts (East et al., 2009).

The term simulation based acquisition (SBA) is used for a concept of product development and manufacturing and also simulations to estimate system performance and mission effectiveness, combat training, the product modeling and manufacturing processes, simulations to support maintenance, training, logistics simulations to relate support plans and resources to readiness and simulations to address system disposal issues (National research council, 2002). The U. S. Navy LPD-17 program belongs to examples of SBA using in practice. The main factor of simulation was not the public procurement process but three-dimensional product model creation for the purpose of supporting engineering design. Thanks to simulations application the program saved 6 million dolars in design costs (Sanders, 1997).

Based on the above mentioned literature review results, it is possible to say that application of simulation and modelling in the public procurement process in the MoD is not widely common and there is a significant lack of information in this domain.

2. CREATING OPEN PROCEDURE MODEL

Methodology of a simulation project has been prepared according to a general approach consisted of four macro-stages:

1. Problem analysis.
2. Modelling and programming.
3. Validation of the model.
4. Experiments on the model (running simulations).
5. Report/ratio and conclusions (Fontanili et al., 2008).

Ad 1: All of the Czech MoD public contracts (about 150 contracts) being awarded via open procedure within the period May 2018-May 2019 were statistically analysed. The main aim of the analysis was to find out duration of each awarding procedures phases and choose the critical ones from the time point of view.

Ad 2: The model of open procedure steps (the flowchart) was created during the stage 2 according to the legislation valid in this domain and the open procedure simulation model was prepared based on the flowchart (see Figure 1 The open procedure simulation model).

Ad 3: After that first simulations were carried out to check the correct working of the model together with retrospective validation – comparing the simulation results with historical data generated by the real system (Chinea et al., 2009).

Ad 3: The dynamic behaviour of the system was tested in the stage 3. Experiment was carried out, consisting of 5 scenarios, where the time of tenders evaluation was set as the control variable. Thus, the time for tenders evaluation decreases in each scenario by 30 days. All scenarios were executed 50 times in order to obtain results on the appropriate level of statistical confidence. (Details in the part 3 Running the simulation).

Ad 4: The relevant data and a graphics package were used to explain which phases of the awarding process are the most problematic and which activities can be done more efficiently without legislation changes. (Details in the part 4 Results discussion).

The objective of the model creation and running is to show different variants/scenarios of public contracts awarding via open procedure under different conditions for the process participants.

An open procedure will be used for the model preparation as the most appropriate type of award procedure determined by the legislation of the European Union (DIRECTIVE 2014/24/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on public procurement and repealing Directive 2004/18/EC, 2014) and the Czech Republic (Act 134/2016 Coll., of 19 April 2016 on Public Procurement, 2016) as the EU member state. In this procedure, contracting authorities invite maximum number of tenderers to submit their tenders and to prove participating conditions fulfilment. Therefore the result should be the selection of the most efficient offer based on the wide spectrum of competitors (if possible). This procurement procedure cannot be used for the procurement involving defence or security aspects but despite this fact, the MoD still has to procure common and generally available products, services and public works like other „classic” contracting authorities.

All the contracting authorities in the Czech Republic have to use the NEN system in which they publish tender documentation, communicate with the potential suppliers and save awarding procedures results (Usnesení vlády ze dne 21. června 2017 č. 467 o uložení povinnosti využívat Národní elektronický nástroj při zadávání veřejných zakázek, 2017).

Preparation of the open procedure phases flowchart was essential as the basis for the simulation model creation.

Limits for the open procedure flowchart have been stated as follows:

- Focus “only” on a period which starts by tender documentation publication in the NEN system and lasts until the day of contract conclusion.
- Specification of the subject-matter of the public contract has already been prepared and approved by responsible MoD bodies.
- Future expenses from the MoD budget have been approved by the responsible persons and departments as stated in the internal MoD directives (Normativní výnos Ministerstva obrany o jednotném postupu při úplatném nabývání majetku, služeb a stavebních prací v rezortu Ministerstva obrany, 2017).

The flowchart of open procedure starts with the sending of the call for tenders to the Czech Republic Journal of public contracts. Right after the contracting authority has to publish tender documentation of a particular public contract on its profile which is in the case of the MoD the profile in the NEN system. Now, the economic operators have 30 days (minimum) for the preparation of their tenders and submitting them electronically via the NEN system. They can also ask the contracting authority for the explanation of conditions or requierement, which are not clear to them in the tender documentation. The contracting authority is then obliged to answer and publish the answer in the NEN system in order to be accessible to all of the economic operators. All operators shall be treated equally in a transparent manner according to the EU and the Czech legislation (DIRECTIVE 2014/24/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on public procurement and repealing Directive 2004/18/EC, 2014, Act 134/2016 Coll., of 19 April 2016 on Public Procurement, 2016). If after these questions is necessary to change the parameters of the tender documentation, contracting authority has to prolong the time limit for receipt of tenders. After this period, the tenders are accessible to the contracting authority for the process of their evaluation and verification if all the formal conditions have been met by the tenderer. Different situations can than occur:

- No tender is submitted (the awarding procedure is cancelled and the new awarding procedure has to begin).
- Only one tender is submitted via the NEN system (the tenderer becomes the winner if it meets all conditions stated in tender documentation).
- More than one tender is submitted (contracting authority has to evaluate all of the tenders and verify if all formal conditions have been met).
- If the tenderer does not meet the criteria crucial for tenders evaluation, it has to be excluded.

- If the tenderer does not meet the formal conditions stated in the tender documentation, it can be appealed by the contracting authority for the completion of the missing documents or for the explanation of reasons of abnormally low tender price, if necessary.

Now the winner can be chosen among the tenderers which met not only the tender criteria but also the formal conditions of the tender. Information related to the winner is then published in the NEN system but the contract cannot be concluded yet. The contracting authority has to wait for a minimum of 15 days for objections of unsuccessful suppliers against the contracting authority decision related to the selection of the most appropriate supplier. Different situations can then occur as well:

- If there are no objections, the contract can be concluded right after 15 days of waiting for objections.
- If the objection has been submitted, the contracting authority has to decide if it is reasonable or not. If it is reasonable, the contracting authority has 15 days for its settlement. If not, the contracting authority informs the tenderer about the possibility to appeal against its decision to the Office for the Protection of Competition (the Office). Maximum 10 days after the contracting authority's decision about the reasonability of the objection, the tenderer has to appeal to the Office and the Office has to deal with it. The time limits for that are not exactly determined in the Act.
- If the Office decides, that the objection is reasonable (even if the contracting authority disagrees), it can suspend the awarding procedure until both the tenderer and the contracting authority find the solution of the situation or it can even cancel the awarding procedure.
- The Office can also refuse the objection of the tenderer and the contract can be concluded.
- The Office can also impose a ban on contract conclusion until the contracting authority proves the reasons to continue with the contract performance.

If the situation with objections is solved, the contract can be signed.

Conceptual model of the MoD open procedure is based on the above-mentioned legislation: the Act on public contracts and internal MoD directives. The elements of the model are represented by the main phases and specific legal acts and relationships among them, necessary for the public contracts awarding operation. Minimum and maximum time limit of operation was assessed for each of the phase. The real-time periods were determined thanks to the analysis of data taken from the Czech Journal of public contracts and the NEN system:

Table 1. Open procedures in the Czech MoD (May 2018 - May 2019) - table excerpt

contract number	procedure publishing date in NEN	changes in tender documentation (TD)	reasons of TD changes and delays	tenders receipt till:	time for tenders receipt (days)	contract conclusion date	open procedure duration in days	objections	evaluation time in days (-15 days for objections)
1	**2**	**3**	**4**	**5**	**6 (5-2)**	**7**	**8 (7-2)**	**9**	**10 (7-5-15)**
1.	8. 2. 2019	TD changes	TD explanation 3x	3. 4. 2019	**54**	14. 5. 2019	95	0	26
2.	14. 12. 2018	TD changes, prolongued	TD explanation 3x	31. 1. 2019	**48**	29. 4. 2019	**136**	0	73
3.	12. 11. 2018	TD changes	explanation 1x	13. 12. 2018	31	16. 4. 2019	**155**	0	**109**
4.	8. 2. 2019	TD changes, prolongued	explanation 1x	26. 3. 2019	**46**	2. 5. 2019	83	0	22
5.	4. 2. 2019	TD changes, prolongued	explanation 1x	25. 3. 2019	**49**	29. 4. 2019	84	0	20
6.	14. 12. 2018	TD changes	0	17. 1. 2019	34	26. 4. 2019	133	0	84

Source: author's own based on Informační systém o veřejných zakázkách

Switching times from one phase to the other were determined as t=0 because the majority of documents are prepared in electronic form so the delays caused by e-mail or publishing documents on the particular website or database are not probable.

The simulation model will be focused on the following open procedure phases: publication of the tender documentation, tenders´ evaluation and dealing with objections. It will be interesting to discover if the change of time of some of the above-mentioned processes can significantly influence the whole public contract realization time.

Tender documentation is the monitored entity. It comes into our model prepared for publication, so we suppose that it involves all data necessary for the call for tenders announcement. The documentation is published right after its entry to the information system NEN (element „Tender documentation publishing" in the model).

Evaluation of tenders is the next phase right after the expiration of the time limit for tenders preparation (element „Tender evaluation" in our model). Random variable, the number of tenders is than generated. If the tenders´ number = 0, an open procedure is finished. If the tenders number is > 0, all of the tenders have to be evaluated by the contracting authority.

The results of the competition among the tenderers are published in the NEN system and the period of waiting for objections starts now and takes max. 15 days. This phase is involved in the model as Supplier selection. Right after the time limit for tenders receipt ends (public contract comes to the point Output@supplierselection), the existence of objections is tested.

If objections are submitted by the unsuccessful supplier, they have to be solved by the contracting authority or the Office (elements Objections - contracting authority, Objections - Office). If there are no objections, the contract can be concluded and realized.

Solving of objections operates within the time limits determined by the Act on public contracts. If the objection is solved, the contract can be signed or, if not, it is cancelled and the new awarding procedure has to be prepared.

Within the analysis of time limits determined for each phase of the process by the legislation, it was not possible to confirm the type of statistical distribution. Despite this fact, it was possible to determine data, which enable to use random numbers generators built in the simulation software. Examples of some variables generation:

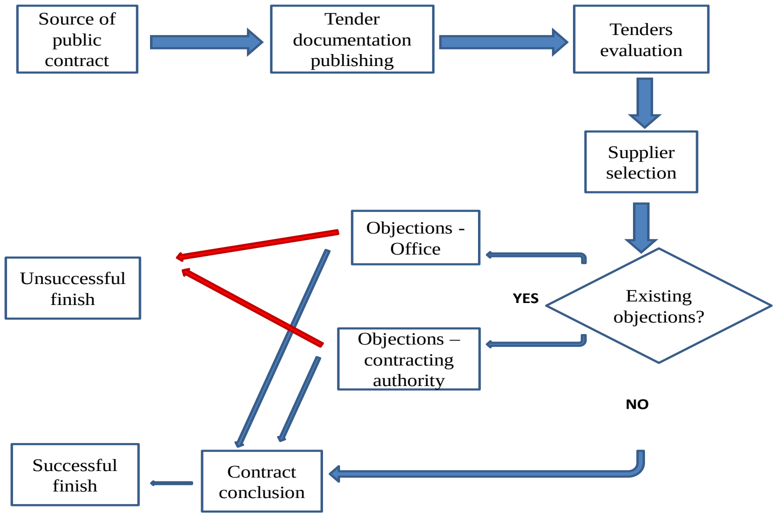
- Time period for tender documentation publishing: Triangular (23, 35, 60).
- Time period for tenders evaluation: Triangular (0, 39, 183).

Functions enabling to generate values related to the probability of existence were used for objections generation. Two situations can occur for the variable "Objections existence": 1 – objections exist, 0 – no objections. Based on the data from statistical analysis of about 150 open procedures, it can be assumed, that objections were submitted in 10% of situations. Based on this calculation, the function "Objections existence" is generated:

Random discrete (0, 0.9, 1,1).

Based on the above mentioned findings, the final model of open procedure has been created (figure 1).

Figure 1. The open procedure simulation model



Source: author's own

3. RUNNING THE SIMULATION

The complex model was tested during the first run mainly because of the procedure logic and possible mistakes in the process, variables or commands in the processes, which are defined behind specific acts. We can avoid some syntax errors found out by simulation software during the simulation process (software is able to warn us about that).

The experiment was created in order to obtain the results related to the whole open procedure duration, which lasts from the procedure announcement to the successful or unsuccessful finish. The Experiment consists of 5 scenarios, where the time of tenders evaluation is set as the control variable. Thus, the time of tenders evaluation decreases in each scenario by 30 days. All scenarios were executed 50 times in order to obtain results on the appropriate level of statistical confidence.

After the run of the experiment all necessary information has been obtained for further analysis including processing time of all involved activities within the whole process, their minimal, maximal and average values, number of evaluated tenders, the solution of the evaluation and also numbers of objections. There is plenty of another information provided from simulation, but we are focused just on the mentioned ones due to the purpose of this simulation.

4. RESULTS DISCUSSION

The simulation proposes the results of the experiment explained above. As we can see from table 2, the number of public contracts entering the system is not significantly changing and its average is aproximately 180:

Table 2. Number of public contracts entering the system

VZ - NumberCreated - Total						
Scenario	**Data Source**	**Category**	**Average**	**Half Width**	**Minimum**	**Maximum**
Scenario1	[Population]	Throughput	183,0	1,2	176,	193,
Scenario2	[Population]	Throughput	182,8	1,3	175,	192,
Scenario3	[Population]	Throughput	182,6	1,0	173,	189,
Scenario4	[Population]	Throughput	183,0	1,2	174,	194,
Scenario5	[Population]	Throughput	183,4	1,0	176,	190,

Source: author's own based on Simio simulation software

This is logically correct because it was generated by the same probability function for all scenarios, which was set by the historical data from the NEN system.

We put focus mainly on time for tenders evaluation. This is the main point in the whole process, where the time of processing up to the data from the NEN system varies in the largest scale of values (see Table 1 Open procedures in the Czech MoD (May 2018 - May 2019) - table excerpt).

Simulation results related to tenders evaluation time are involved in table 3 and the average times oscillate between 68 and 34 days:

Table 3. Time for tenders evaluation

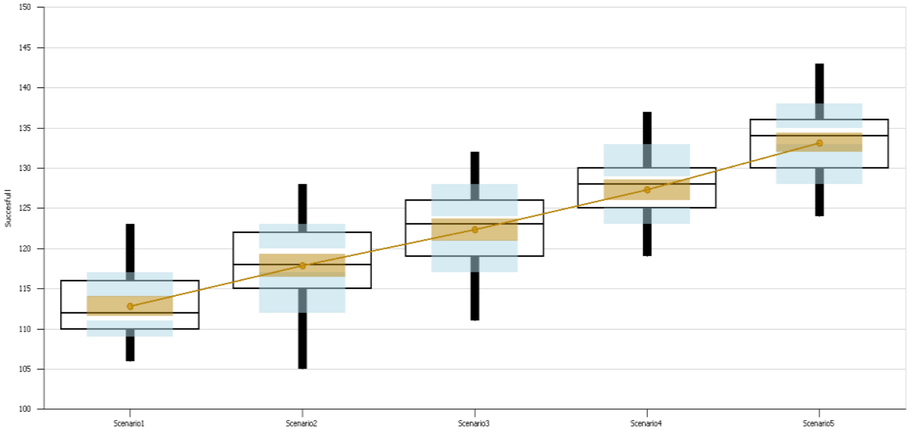
Tenders evaluation - TimeInStation - Average (Days)						
Scenario	**Data Source**	**Category**	**Average**	**Half Width**	**Minimum**	**Maximum**
Scenario1	Processing	HoldingTime	67,4	0,9	59,5	76,8
Scenario2	Processing	HoldingTime	60,5	0,8	54,3	66,1
Scenario3	Processing	HoldingTime	51,7	0,6	47,4	58,3
Scenario4	Processing	HoldingTime	42,7	0,5	38,7	46,4
Scenario5	Processing	HoldingTime	33,4	0,3	30,2	36,5

Source: author's own based on Simio simulation software

The law does not define exact time for decision-making, which means, that contracting authority can set some internal procedures in order to force its own evaluators to finish evaluating without non-eligible prolongation. Therefore, time of tender evaluation was set as the control variable, to set several scenarios in the experiment.

The difference is visible if we monitor the number of public contracts, which were solved in the course of the awarding process, no matter if the result is positive or negative (the contract has been concluded or awarding procedure has been cancelled). From the plot diagram 1 is obvious, that the number of solved public tenders grows depending on the decrease of time for tenders evaluation:

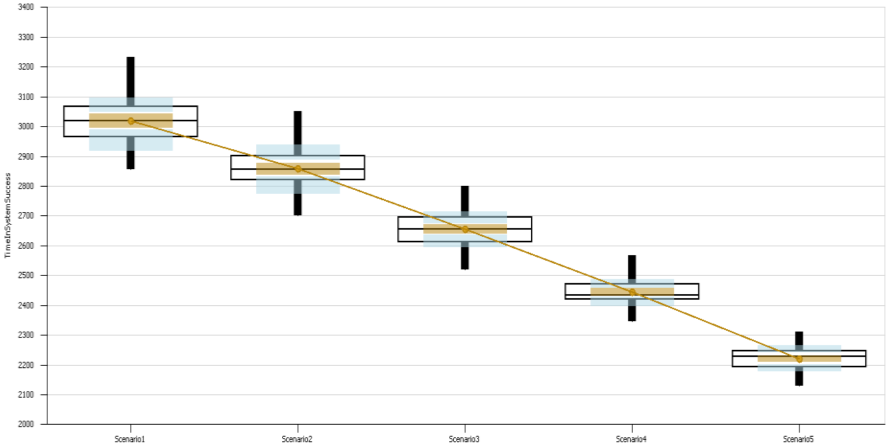
Plot diagram 1. Number of successful public contracts



Source: author's own based on Simio simulation software

We can also monitor the decrease of the whole open procedure time period (time in system, successful finish, in hours) thanks to the shortening of the tenders evaluation period:

Plot diagram 2: Duration of the open procedure



Source: author's own based on Simio simulation software

The best result based on Simio simulation application should be the scenario 5 with the shortest duration of time which all of the contracts spend in the awarding proces (plot diagram 2, time in hours) and maximum number of successful contracts finished by the contract conclusion (plot diagram 1). Time period for tenders evaluation should oscillate around 30 days. The results need to be verified by the public procurement specialists and it mainly depends on the subject-matter of a particular contract (more details in the part Conclusions).

5. CONCLUSIONS

Public procurement is the process with quite strongly defined framework, determined by the legislation and internal procedures of the contracting authorities. This framework defines the main roles and responsibilities of each element, but still propose some level of freedom during the whole process. This setting allows us to design appropriate model of this system, put it under an analysis, and run the simulation in order to see the impact of possible adjustments of several procedures. Also, some kind of legislative freedom gives the possibility to improve efficiency of the procurement process without changes in the Act on public contracts, just within the responsibility of the contracting authority as for example the MoD.

Otherwise, it is necessary to pay attention about the available data from the information systems. If there are some gaps in the information, the model could be set wrong and thus the results could be inappropriate. It means that all authorities should pay more attention to the quality and accuracy of information which they have to publish in these systems (NEN, Journal of public contracts).

Finally, this model shows the possibility of using modelling and simulation for analysis of this process in order of further adjustments before it is applied into practice. It means that the MoD can analyze the impact of prepared changes of the procurement system before their implementation. That can save a lot of worktime, energy and money instead of putting inefficient changes into life and their further corrections.

The approach suggested by the researchers is universal. All of the contracting authorities regularly procure common and generally available products through open procedures. Particular steps of each open procedure are the same for all of the contracting authorities in the Czech Republic. This type of awarding procedure also enables significant improvements especially from the point of view of time savings and mutual cooperation among contracting authorities, users, economic operators and tenderers.

Variety of public procurement aspects is still waiting for further research. It will be necessary to consider different subject-matters of public contracts. Public works contracts are definitely more time-consuming from the point of view of tender documentation preparation and tenders evaluation than office stationery contracts etc. So public contracts should be divided into groups according to their subject-matters and different periods of time should be considered for tender documentation preparation and tenders evaluation.

Another important issue to consider is the number of evaluated tenders. It would be possible to statistically evaluate numbers of tenders submitted for each public contract and than assume appropriate time period of tenders evaluation for those subject-matters of the public contracts which are mostly awarded.

Database of public contracts with all the necessary data related to time periods of each awarding proces phase and subject-matters of contracts should involve longer period of time than one year in order to obtain more reliable results based on simulation software application.

It would also be interesting to find out if the MoDs contracting authorities of other states are obliged to use similar information systems (as NEN for the Czech MoD) and which type of data they have to publish in. After that it would be possible to compare time lengths of tenders evaluation phases or time periods for tender documentation preparation (within the same subject of the contract) which belong to the most critical phases of the public contracts awarding process.

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THE ECONOMIC DIMENSION OF THE OUTSOURCING APPLICATION IN THE FIELD OF SELECTED LOGISTICS SERVICES BASED ON THE EXAMPLE OF THE EUROPEAN AUTOMOTIVE INDUSTRY

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Abstract

The aim of the article is to present the subject of economic aspects of outsourcing in the field of selected logistics services on the example of the automotive industry. The verification of the following research hypothesis was used to achieve this goal. Outsourcing in the scope of selected logistic services may lead to measurable economic benefits in the form of reduced costs of logistic services. The implementation of this task required the author to apply appropriate research methods and techniques, such as: analysis of available literature sources and internal materials, methods of induction and deduction, and interview methods (computer-assisted telephone interviewing), in order to demonstrate economic benefits from the use of outsourcing in relation to selected logistic services.

The direct recipients of the research results, apart from researchers dealing with the outsourcing and logistics of services, will also be entities from the automotive market, which at the current stage are considering the possibility of implementing the discussed concept in terms of planned organizational changes.

Key words: economic benefits, logistics, outsourcing, automotive industry.

1. INTRODUCTION

The literature on the subject emphasizes that changes in the global economy, both in the economic, organizational and legal spheres have led to the emergence of new concepts and methods of enterprise management, thus making the implementation of individual services an increasingly larger logistical challenge (Hirschheim et al. 2002; Graham 2010).

In the opinion of many representatives of economic thought, the level of complexity of modern production processes as well as constant pressure to reduce costs and the increasingly common tendency of enterprises to focus on key activities caused that more often, logistics services are entrusted to specialized external companies (outsourcing) (Zhu et al. 2017). In particular, this process is noticeable in the strategy of entities conducting manufacturing activity. As the available literature indicates, one of such sectors of the economy is the automotive industry. For example, suppliers of parts (components) for the production of motor vehicles are obliged to supply individual components in the form of pre-assembled modules and according to the sequence consistent with the order of assembly on the production line (Ciravegna et al. 2013). Therefore, proper organization of logistic processes is of key importance for the operations of these entities.

Although the concept of using outsourcing in relation to logistic services is not an innovative solution, as demonstrated by a thorough analysis of available literature, there are no literature items that would describe the benefits of using this method in the processes of managing selected logistics services in relation to the automotive industry (Becker & Zirpoli, 2003; Ciravegna et al. 2013). What makes this subject even more interesting and worth considering in order to diagnose the positive effects and rightness of the actions taken in this matter. Therefore, discussing these issues seems to be the proper identification of the research problem, covering both the aspects of modern concepts of management and logistics of services.

The approach presented above became the basis for the adoption of boundary conditions and methodes of conduct aimed at attempting to dimension the impact of outsourcing as a tool for managing logistics services on the example of the automotive industry through:

- Description of the origins of the concept of outsourcing,
- To present the essence of relations between logistics and outsourcing,
- An attempt to assess economic benefits from the use of the outsourcing concept in relation to selected logistic services based on the chosen research method.

The direct recipients of the research results, apart from researchers dealing with the outsourcing and logistics of services, will also be entities from the automotive market, which at the current stage are considering the possibility of implementing the discussed concept in terms of planned organizational changes.

2. AIM AND METODS

The purpose of the article is to verify the following research hypothesis. Outsourcing in the scope of selected logistic services leads to measurable economic benefits in the form of reduced costs of logistic services. Implementation of this task required the author to apply appropriate research methods and techniques, such as: analysis of available literature sources and internal materials, methods of induction and deduction, and interview methods (computer-assisted telephone interviewing), in order to demonstrate the real economic benefits of outsourcing in relation to selected services logistics in the automotive industry. The presented market research was conducted on two randomly chosen research samples. Interviews with the first group of enterprises were carried out in December 2017 using the computer-assisted telephone interviewing method, and with the second - in the period January 2018, also using this method. In the case of both attempts, interviews were conducted with representatives of enterprises employing from 10 to 2,000 employees (the size of the first sample N = 50 enterprises, the second N = 50 enterprises). Among them were manufacturers, sub-suppliers of car parts and components, car dealers, security system and software suppliers. No division was made due to: size of the entity, form of ownership or type of business. The respondents were: quality engineers, directors, traders, managers, department managers.

3. THE ORIGIN OF THE CONCEPT OF OUTSOURCING

The first organizational initiatives, currently referred to as outsourcing, took place in the 1960s and were associated with the separation of IT functions. The pioneer is the Electronic Data System company R.Perota, which in 1963 was the first to propose to the external company from Pennsylvani a paid implementation of tasks in the field of computer science. At that time, it was a pioneering solution consisting in transferring the entire data processing department to another entity. This service was defined then as equipment management (facilities management). Another term applied to outsourcing in the initial period of its implementation was also the term "enterprise specialization" (Hirschheim et al. 2002).

On the other hand, the concept of outsourcing was introduced to business practice by General Motors in the 1980s to define the external supply of spare parts. In the theory of organization and management, however, it gained an established position in the 1990s (Ili et all. 2010).

As the analysis of available literature suggests, outsourcing was initially treated as a simple modification of the make or buy concept, aimed at reducing the operating costs of the company (Travles & Drury, 2001). The prospect of its application included mainly the tactical level and focused on quick and immediate satisfaction of a specific economic need or solving a specific problem, often caused by increased costs (Tjader et al., 2014). Currently, the objective of this method is primarily to shape the business structures in a strategic way to enable the company to concentrate its efforts and resources on the so-called the key activity that determines the competitive position of the entity to the greatest extent (Wu & Park, 2009). The best practical reflection of this method seems to be the definition of M. F. Greaver Junior, who defines this concept as separating from the organizational structure of the parent company their functions and then transferring them to other entities (Schoenherr, 2010).

Regarding the theoretical foundations of outsourcing, they should be sought on the basis of both economic sciences and management sciences. Analysis of the literature on the subject indicates that the key to developing and implementing this method were other concepts such as:

- The concept of make or buy dilemmas. Is associated with the basic problems of the activities of each organization, that is, do it yourself (make) or buy and outsource (buy). Also, whether to undertake the venture yourself or together with other entities. Making the wrong decision in this respect may result in higher production and operating costs as well as inefficient use of resources (Graham, 2010).
- Theory of transaction costs R.H. Coase and O.Williamson. According to this concept, the basis for determining the boundaries of the enterprise, and thus the

scope of tasks carried out on its own should not be technological conditions, but the amount of costs that must be incurred in connection with the transaction hierarchically (within the organization) or between companies on the market. Emphasizing, therefore, that narrowly specialized entities usually gain economies of scale and are able to provide lower production costs of products offered compared to enterprises in which most of the business areas required to produce specific goods and services are carried out independently (Hirschheim et al. 2002).

- Contrast theory of A.Alchian and H.Demsetz. He describes the company as a combination of contracts concluded by the organizer in order to gain control over the various resources that make up the organization. The main element of the company's construction is in this case a "contract" and the company appears as a special economic system, which can be presented as a bundle of business contracts (nexus of contracts) (Kim & Mahoney, 2010).
- The principle of economies of scale. According to it, along with the increase in the scale of production, the unit cost of manufacturing is reduced, which results from the fact that fixed costs and investment costs are preferably distributed into a larger number of manufactured products or services performed (Tjader et all, 2014).
- The value chain concept. It allows for the separation of the stages of the value added process and the identification of strong and weak links in the enterprise, which allows the identification of potential elements for internalisation or externalization as part of outsourcing (Cong et al., 2018) .
- The concept of key competences C.K. Prahalada and G.Hemela. It assumes that the competitive position of the company depends primarily on shaping competitive advantages, i.e. distinctive competences which constitute an appropriate combination of production, technological and marketing skills, and allow for the selection of a reasonable strategy based on the vision of the future. These competencies determine the ability to efficiently and effectively combine technological solutions and production skills as well as market information in order to quickly adapt to opportunities in the environment and achieve profit and growth. (Schmitt & Van Biesebroeck, 2013)

At this stage of the discussion, it should be emphasized that in today's market reality, outsourcing is not an unambiguous term. Interpretation of this concept is also undertaken by representatives of technical or natural sciences. However, the author agrees with the thesis promoted in the literature on the subject, that the general approach is a management method, which consists in narrowing the scope of tasks carried out directly by the enterprise called the parent company and entrusting them to constant implementation to other economic entities called service companies. It is worth mentioning that thanks to its flexibility the idea of outsourcing assumes that for almost every function, area, process that could be implemented within the classic organizational structure of the company, one can find an alternative in the form of services offered by external, specialized suppliers (strategic partners). Otherwise, the whole process can be understood as a method of permanent external service by specialized entities, externalization, external management or, as a last resort, disintegration of the enterprise (Cong et al, 2018).

According to the author, it is the comprehensiveness of business and the level of complexity of production processes and the constant pressure to reduce costs and the increasingly common tendency among enterprises to focus on core business. Some or all of the processes are more and more often entrusted to specialized external companies in the European automotive industry (Aggeri et al, 2009).

On the basis of the above presented considerations, it can be wrongly assumed that outsourcing is a simple and easy to use method. In reality, however, it is characterized by a very complex character that goes beyond the mere task assignments of subcontractors. The main assumption of this concept is to focus on ensuring long-term partnership cooperation whose fundamental goal is to achieve benefits for both partners. The basis for the proper functioning of this process in practice is the determination of key areas for building the competitive position of the parent company. Most often these are activities related to:

- production, (as the best quality at the lowest possible costs,
- research on development (striving to improve the functioning of the company's units),
- implementing innovations, (using the introduced innovations and technological innovations),
- marketing,
- distribution and logistics,
- customer service,
- quality management (Camuffo et al, 2007).

Observations of market reality clearly show that all the above presented tasks depend on the specifics of the entity (eg business sector), but also on strategic decisions made by the chief "management". In addition, these areas can be modified during operations, as well as in the life cycle of the organization. After their correct determination, it becomes possible to outsource other, selected areas of activity to external, specialized business entities. All these factors result in the restructuring of the parent company's structure towards concentration around the selected key activity while developing sustainable, strategic partner relationships with service companies.

At this stage of the discussion, it is worth mentioning that in accordance with applicable law, the basic condition for the implementation of this concept is to give written consent in the area of cooperation, which leads to a situation where, among others, the transfer of responsibility for providing services to an external company and the distribution of benefits and risks between partners. Many experts emphasize that the relationship between entities should be of a long-term character, enabling establishing long-lasting and strategic business contacts of a partner nature for both parties (Danese, 2011).

As the observations of market reality indicate, another important feature of the use of outsourcing in business practice is cooperation in the implementation of set goals, a two-way exchange of information on cooperation and coordination of activities and a high level of trust. On this basis, the author puts forward the thesis that the concept of outsourcing is aimed at gaining tangible benefits by both parties (service company and parent company), in particular with an economic dimension. A great example is the Fiat Chrysler Automoblies car company, where the beginning of the Fiat and Chrysler group's cooperation were outsourcing services. (Becker & Zirpoli, 2003).

Summarizing the above considerations in today's market reality, outsourcing is perceived as one of the methods used to improve the optimization of the company's operations.

4. LOGISTICS AND OUTSOURCING

In the available literature, it is emphasized that modern logistics is becoming an increasing organizational challenge, which is why not every market operator is able to carry out this process in an independent and at the same time optimal (Bolumole 2001; Zachara et al, 2011; Chiung-Lin & Pei-Yu, 2016). Given that market reality observations indicate that cost reductions, improved efficiency and quality, and increased market service levels are the basic strategic assumptions of today's enterprises operating in highly competitive markets. As postulated by many authors to achieve success, it is therefore necessary to focus on the core business, while all other activities should be outsourced (if possible and after the analysis of profitability of outsourcing) to external companies (Zirpoli & Becker, 2011). On this basis, the author favors the thesis promoted in the literature on the subject that logistic outsourcing is an important factor in creating a competitive advantage that enterprises want to achieve by delegating some of their competences to specialized entities on the market, such as logistics operators. They take over the role of the link, which is responsible for the efficient and rapid organization of the supply of materials for the production of a given product or its subsequent distribution.

According to one of the representatives of economic sciences (Bolume, 2001), outsourcing in logistics is a "project consisting in separating from the organizational structure of the parent company their logistic functions and transferring them to other economic entities". Similarly, outsourcing defines (Zhu et al.; 2017) , according to which they are "undertakings aimed at separating functions in the field of logistics and transport implemented so far by the enterprise from the organization structure and the implementation of these activities in a more effective way by other economic entities". In turn, M. F. Greaver Junior defines outsourcing as: a venture consisting in separating from the organizational structure of the parent company, the functions they perform and transferring them to other economic entities (Zirpoli & Becker, 2011). Therefore, it can be assumed that enterprises entrusting logistics services to external companies, in principle, also strive to improve the quality of customer service.

On the basis of the considerations presented above, the author puts forward the thesis that, broadly speaking, outsourcing is the transfer of functions related to logistics processes. However, in a narrower sense, this concept should be defined as cooperation being the subject of the contract, consisting in the transfer of the function by the enterprise logistic in the hands of a logistics operator.

The available literature on the subject indicates that the main reasons for the development of outsourcing in the field of logistics services include:

- getting access to skills and technologies not available in the organization,
- improving quality and productivity,

– expansion thanks to the use of the partner's potential,
– focusing on core business, which improves efficiency,
– increasing the ability to react to changes in the environment,
– increasing customer satisfaction,
– reduction of investments for logistics purposes,
– conversion of fixed costs into variables,
– other reasons, eg improving credibility through cooperation with prestigious partners (Chiung-Lin & Pei-Yu, 2016).

Analysis of the available literature indicates that representatives of economic sciences for the most important benefits related to the use of outsourcing in the field of logistics include:

– reduction and control of operating costs,
– increasing the company's concentration on the core business,
– access to top-level production capacity,
– releasing own resources for other purposes,
– obtaining resources that the company does not have,
– acceleration of the emergence of benefits resulting from restructuring,
– raising capital,
– risk sharing,
– inflow of cash (Kim & Mahoney, 2010).

On the other hand, representatives of management sciences emphasize that outsourcing in the field of logistics services despite its many advantages, namely:

– improving the quality of the product,
– sharing risk and responsibility,
– high strategic flexibility,
– accessibility to modern technologies and know - how.

It also carries threats such as:

– less contact with the client,
– lack of control over the distribution system,
– disruptions in information flow between the producer, the operator and the customer,
– addiction to an external company,
– the risk of losing control over certain functions,
– the possibility of losing valuable information,
– showing the impossibility of performing certain tasks,
– the threat of companies losing their image and identity, which would result in reduced competitiveness (Zachara et al., 2010).

To sum up, the author shares the view promoted in the literature on the subject that outsourcing in the field of logistic services creates the possibility of a flexible functioning of the subject on the contemporary competitive market (Cong et al., 2018). At this stage, it is worth emphasizing that the use of outsourcing in the field of logistic services brings both benefits and threats. In the case of not every industry, outsourcing will bring the expected economic or organizational results.

For example, automotive logistics is the key factor determining cooperation with the carrier. In this case, the carrier should take into account its system capabilities regarding the integration of processes with the client and readiness to report cooperation indicators according to the model adopted in the contractor's industry. In addition, the logistics operator must demonstrate a constant readiness to operate throughout the supply chain. This applies not only to the delivery of components for assembly, but also to the logistics of the spare parts and returns market, where flows are not planned, and the unit size of shipments is usually small. In addition, the operator must be aware of the responsibility that he takes on the services that are key to the automotive industry: Just in time and Just in sequence (Aggeri et al., 2009).

Therefore, according to the author, the implementation of this concept should be conditioned by the implementation of earlier analyzes and research. Both in terms of benefits and threats resulting from the implementation of this concept in practice. Considering that constant service to the automotive industry for any logistics operator means quite a challenge. It is a sector characterized by high dynamics and variety of orders.

5. AN ATTEMPT TO ASSESS ECONOMIC BENEFITS FROM THE USE OF OUTSOURCING IN RELATION TO SELECTED LOGISTIC SERVICES BASED ON THE CATI METHOD

At the very beginning of the discussion, based on a thorough analysis of the outsourcing concept used in logistics services, it was assumed that:

– There is unanimity in the available literature regarding the economic effects of outsourcing implementation, that CATI research can be helpful in the process of assessing the economic benefits of using this concept in business practice. It is worth noting that the available literature on the subject discusses in detail and thoroughly both the conditions, the methods used and the examples of such research referring to individual industries and market sectors in the United States .
– The identified processes of growing multi-segment competition and cooperation in the European Union automotive industry resulted in the need to examine the impact of the use of the outsourcing concept in the field of logistics services. Author does not make a mistake if it assumes the following assumption: if using the accepted research method the benefits of using this concept were assessed and in case of this sector of the economy in the United States, then the same research tool can be used to assess the application of this method in relation to the European Union automotive industry. In addition, it was assumed that CATI studies may also be helpful as a tool to assess the competitiveness of the outsourcing application in relation to other entities operating in this industry. They can be used to verify the hypothesis whether the use of outsourcing in the field of logistic services leads to achieving noticeable economic benefits by entities operating on the Polish automotive market.
– For the purpose of assessing the economic effects of outsourcing in the field of logistic services, scientific significance is not only acquired by the adopted and applied research method, but also the data analyzed. For example, comparing financial outlays to particular outsourcing strategies, considering the diverse

nature of business operations and their size would be a logical error. Therefore, in order to maintain the scientific correctness and methodological value of the research, it was assumed that questions will be addressed exclusively to the supply side, which will allow to assess, in the scope of which logistic services measurable economic benefits have been achieved through outsourcing.

– From the point of view of the correctness of exploration and the possibility of capturing the necessary data, the research concerned answering the question of what benefits were achieved due to the implementation of outsourcing in the scope of selected logistic services in a given entity.
– Collective CATI results (average% of grades) are presented in Table 1.

Table 1. Ranking of benefits resulting from the implementation of outsourcing of logistics services in a given company, percentage indicator

Position		Average grades
1	Reduction of logistics activity costs	34%
2	Improving the quality and timeliness of delivery	23%
3	Time saling	16%
4	Employment reduction	11%
5	Development of the company's specialization	9%
6	Access to modern logistics solutions	4%
7	Other unspecified economic benefits	3%

Source: Own study

The analysis of the data presented in Table 1 shows that 35% of respondents consider the reduction of logistics activity costs to be the main benefit of outsourcing in the field of logistic services. In the next position (23%) respondents indicated that the effect of using outsourcing in the field of logistic services is to improve the quality and timeliness of delivery and save time (16%). It is worth emphasizing that in the opinion of respondents, the introduction of this concept in the field of logistics services also led to the reduction of employment costs.

6. CONCLUSION

Undoubtedly, the area of logistics operators' operations will grow as the complexity of production processes increases. This trend has already been observed in the automotive industry, which plays a leading role in the implementation of modern methods of management, production or logistics (Ciravegna et al, 2013). In addition, many authors postulate that the transfer of some or all of the processes into outsourcing made a much greater part of the added value of the product which is the car are logistics processes, often carried out by external operators (Zhu et al., 2017). Therefore, commissioning some or all services to logistics operators has created the possibility for manufacturers to continuously improve the quality of their products and better allocate resources by shifting them from marginal areas (e.g. transport) to those that determine its proper functioning (service and sale of vehicles), and many times about surviving in such a competitive market (Cong et al., 2018).

At this stage, it is worth emphasizing that the development of outsourcing of logistics services in the automotive industry is determined by the state of the economic situation in EU. The consequence of the increased demand for motor vehicles is the delivery of more products to customers. Thus, in order to concentrate on basic activities, the automotive industry was forced to give some services to external companies. Thus, in the period of a possible economic slowdown, these entities will face the requirement to optimize costs throughout the entire supply chain. During this period, they can drastically reduce the number of service providers and thus give up outsourcing services. It does not change the fact that this concept gives the possibility of flexible functioning on such a competitive market. However, it is worth remembering that the use of logistics outsourcing brings both benefits and risks. In any case, logistics outsourcing will not bring expected results. Therefore, its implementation should be conditional upon the performance of previous analyzes and research both in terms of benefits and threats resulting from the implementation of this method in business practice.

However, the analysis of the presented research results indicates that:

- 35% of respondents consider the reduction of logistic costs to be the main benefit of using outsourcing in logistics services.
- 23% of respondents indicated that the effect of using outsourcing in the field of logistic services is to improve the quality and timeliness of delivery and save time (16%).
- the introduction of this concept in the field of logistic services, according to respondents, also led to the reduction of employment costs.

As part of the interpretation of the test results, questions remain unanswered:

- Was the decision on outsourcing dictated by a thorough analysis or was it the result of a trend in the automotive industry?
- Has the use of outsourcing in any case led to measurable economic and organizational benefits, or were there real threats?
- Will the outsourcing service be permanent or periodic?

Summing up the author's considerations regarding the economic aspects of the use of outsourcing in the field of selected logistic services on the example of the automotive industry in EU, they do not fully exhaust the essence of the issue, but are only an attempt to signal the complexity of the problem. This does not change the fact that many aspects of the development of the outsourcing of logistics services in relation to the European automotive industry still needs to carry out detailed analysis and research and answer the following questions:

- Will the price or quality be still a decisive factor in choosing the logistics operator in the field of logistics services outsourcing in the future?

- What role in the process will be played by trained and qualified staff of companies providing outsourcing services?
- What will the market of logistics outsourcing services look like after global mergers of automotive concerns?

However, the correctness of the proposed assumptions will certainly verify the market within a few years, which will allow for further evaluation of the role that outsourcing plays in the processes of managing entities that conduct their activity in the automotive market.

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CHANGES IN SUPPLY CHAINS IN THE LIGHT OF EMERGING MARKET PROCUREMENT

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Abstract

Purchases and supply chain management are the fields, which have become one of the key element of any business activity in the recent years. Taking into account the beginning of the 21st century and its revolutionary changes in the business management, it is difficult to imagine the successful future of any enterprise operating on the modern market, already involved or integrated into the global competition, without any business support obtained by purchasing procedures. This also applies to the Polish companies, that without any modern purchasing development and widely shaped by the modern logistic megatrends, are currently unable to compete with others anymore. One of such 'megatrend' is transformation in logistics models (placement of business centres in Asia, Africa and Eastern Europe, namely to emerging markets), which directly influence functioning and the shape of supply chains and their individual elements. Thus, the supply chains have become more multidimensional and complex but still adapted to changing business environment, whereas global purchasing trends have become a difficult challenge for companies in the conditions of a modern, turbulent and very competitive global environment. In this respect, the author of this paper is making a pioneering attempt to indicate the changes in supply chains, which occurred as a result of the development of procurement in emerging markets (as for example modifications of the structure and number of foreign suppliers and ways to obtain general information about them, factors which inspire establishing cooperation as well as changes in the kinds of transport used and kinds of loading units). The above mentioned goal was achieved through comparison of the author's own surveys data carried out in 2012 and 2018. The studies were conducted on a group of 120 people - managers in the manufacturing companies responsible for supply chains management. The research method was based on electronic surveys, while a survey questionnaire made the research tool.

Key words: global sourcing, changes, megatrend, supply chain management, logistics management

1. INTRODUCTION

Continuous economic changes greatly affect the significance of procurement. It has become the core of operation for companies which perceive it as an opportunity to improve their competitive position in the market. Enterprises strive for minimising the costs of components manufacturing and reducing the flow time of products and information while maintaining the quality of products and services requested by customers. One of the strategies aimed to reduce the manufacturing costs is to cooperate with material suppliers located in emerging markets. The strategy to a great extent was shaped by contemporary logistic megatrends.

Logistic megatrends have the power to alter operation of logistic businesses. The megatrends apply directly to the way of enterprises operate and compete. They are the power which generally occurs globally and affects different aspects of an enterprise operation, including e.g. its supply chain (Gröhn, 2006). The most crucial megatrends which greatly affect supply chains include e.g. transformations within logistic models (locating business centres in Asia, Africa and Eastern Europe - in emerging markets) and the gradually increasing impact of modern, innovative and smart technologies, changes inside the existing corporations, global competition (development of e-commerce, e-shopping and expansion of mobile services) as well as numerous demographic and cultural transformations. The identified megatrends directly affect supply chains which become more complex, multidimensional and able to adapt to the constantly changing business environment (Galińska, 2018, p. 583-601).

Transformations of logistic models are among highly important logistic megatrends. The number of products available in the European markets and USA which come from emerging markets has been growing. The notion of 'emerging markets' includes all countries which have started their journey from developing to developed economy. They are essentially characterised by a fast economic growth and high level of investment (although it is not always a rule) and hence they become attractive places to locate capital.

The development of procurement from emerging markets constitutes a significant source of deep changes in supply chains and their components. Meanders of global shopping have become a tough challenge for enterprises in light of contemporary, turbulent and highly competitive global environment. Against this background the author of the paper makes a pioneering attempt to demonstrate changes in supply chains which occurred as a result of development of procurement from emerging markets. The above mentioned goal is reached as a result of comparing own surveys carried out in 2012 and 2018. The research method was based on electronic surveys, while a survey questionnaire made the research tool. The surveys were performed in a group of 120 respondents - managers in production companies responsible for supply chain management.

The paper has been divided into 6 sections. In the first one the background of the analysis is presented. The second section describes the most important emerging markets, where Polish companies aim at becoming more competitive. The third one presents methodology and the scope of empirical research, enabling objective of the studies. The fourth section contains results of the research and similarities/ differences in SCs functioning resulted from the development of emerging markets procurement.

In section five the final conclusions are presented. The paper is supplemented by a list of references (sixth section).

2. CONTEMPORARY EMERGING MARKETS

Emerging markets are the countries which have started their journey from developing to developed economy. There are five main characteristic features of them. Firstly, they have a lower-than-average per capita income. Secondly, they are characterised by a rapid growth. The third characteristics is high volatility mainly as a result of three factors: natural disasters, external price shocks and domestic policy instability. Yet, emerging markets are more susceptible to volatile currency swings, such as those involving the U.S. dollar. They are also vulnerable to commodities swings, such as those of oil or food. It happens as they do not have enough power to influence these movements. Furthermore, the capital markets are less mature in these countries than the developed markets, which makes their fourth characteristic feature. In addition, they do not have a solid track record of foreign direct investment. Finally, the fifth characteristic is the higher-than-average return for investors, as many of these countries focus on an export-driven strategy. They do not have the demand at home, so they produce lower-cost consumer goods and commodities for developed markets (Amadeo, 2019). According to the Morgan Stanley Capital International Emerging Market Index (MSCI, 2019), 24 developing countries qualify as emerging markets - these are: Brazil, Chile, China, Colombia, Czech Republic, Egypt, Greece, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Qatar, Russia, South Africa, Taiwan, Thailand, Turkey, and United Arab Emirates (Figure 1). The index follows the market caps of the companies on the countries' stock markets.

Figure 1. MSCI ACWI Index market allocation

Source: (MSCI, 2019)

In addition, the International Monetary Fund (IMF) classifies 23 countries as emerging markets. Standard and Poor's (S&P) classifies 23, Russell classifies 19 countries as emerging markets, while Dow Jones classifies 22 countries.

A list of countries that all five institutions classify as emerging markets includes: Brazil, Chile, China, Colombia, Hungary, Indonesia, India, Malaysia, Mexico, Peru, Philippines, Russia, South Africa, Thailand and Turkey. The remaining countries on the IMF emerging market list are: Argentina, Bangladesh, Bulgaria, Pakistan, Poland, Romania, Ukraine and Venezuela. The remaining counties on the MSCI list are Czech Republic, Egypt, Greece, Pakistan, Poland, Qatar, South Korea, Taiwan and the United Arab Emirates. The S&P list has these remaining countries: Czech Republic, Egypt, Greece, Pakistan, Poland, Qatar, Taiwan and the United Arab Emirates. The Russell list has such remaining countries, as: Czech Republic, Greece, Taiwan and the United Arab Emirates. And finally the Dow Jones list includes such countries, as: Czech Republic, Egypt, Greece, Poland, Qatar, Taiwan and the United Arab Emirates.

At any of these institution's discretion, a country can be removed from the list by either upgrading to a developed nation or downgrading to a frontier nation. Likewise, developed nations may be downgraded to an emerging market, as was the case with Greece, or frontier markets may upgrade to an emerging market, as was the case for Qatar and Argentina (Kenton, 2019).

China and India are said to be the main emerging market power houses. Together, these two countries are home to 40 percent of the world's labour force and population. In 2017, their combined economic output ($32.6 trillion) was greater than the European Union ($20.9 trillion) or the United States ($19.4 trillion) (Amadeo, 2019). Although China and India have high production and industry, other factors like low per capita income or a heavy focus on exports, qualify them as emerging markets (Sraders, 2018).

China is a country which plays an important role in production migration to emerging markets. Direct foreign investment in China applies to industry, and processing in particular. The country is a dominant producer of such industrial goods, as: electrical machinery, machinery (including computers), furniture (including bedding, lighting, prefab buildings) and clothing (Pines, 2019). Other recommended products include metal parts, wire harnesses, cables, electronic components, special chemicals, textiles, footwear, promotional and office products (Kerkhoff, 2005, p. 125-133).

China's competitive advantage, besides low remuneration level, is based on the following factors (Zinzius, 2019, p. 3-16):

- minimum cost burden on remuneration,
- improved work efficiency and labour force,
- entrepreneurship and discipline, which are typical of Chinese employees.

It is worth highlighting that recent years saw a significant improvement in the level of education and technical qualifications of employees from China. The number of students, including students of foreign universities, has also gone up. The increase in the quality of human resources contributes to changes in the structure of employment (Hu et al., 2014, p. 63-79). Interest in procurement from China results from legislative changes as well. Owing to the changes the Chinese market has opened to new business aspects (Marszałek-Kawa, 2008, p. 222-224).

China is a market regarded as perfect for manufacturing of products characterised by unchanging and easily predictable demand and with long expiry dates. The solution is beneficial for less innovative companies which manufacture standard products that do not require sophisticated technologies.

India is the second strongly developing emerging market. India's economy today relies mainly on a few industry markets (India's Culture Guide, 2019; Para, 2015):

- telecommunication industry, which is now the world's fastest growing and which surpassed the US in 2017 to become the second largest smartphone market in the world after China,
- automotive industry, which is now the world's second fastest growing,
- pharmaceutical and biotechnology industry, which is among the world's most significant emerging markets (India is the world's first generic drugs producer and exporter yet),
- textile and clothing industry,
- electrical and power engineering industry.

Traditional export goods include e.g.: generic drugs, oil-based products, textiles and craftwork - mainly jewellery, leather, noble stones, mineral raw materials, jute, spices and tea (India is the largest producer of tea in the world), software and chemicals (Portal Importuj z nami, 2019).

India is considered as the world's sixth-largest economy by nominal GDP and the third-largest by purchasing power parity. According to several studies, India's growth rate should stabilise at 8% during the next decades, ranking the country as the world's fastest-growing economy. Its GDP could overtake that of the US before 2050, turning India into the strongest economy worldwide.

India's key growth factors are (India's Culture Guide, 2019):

- a young and rapidly growing working-age population,
- rising education and engineering skill levels, accentuating growth in the manufacturing sector,
- a rapidly growing middle-class, implementing a sustained growth of the consumer market.

The dynamics of development rate in India is high. India is ranked as the third Asian economy for its GDP value after China and Japan (Para, 2015).

3. METHODOLOGY AND THE SCOPE OF EMPIRICAL RESEARCH

The purpose of the paper is to demonstrate changes in supply chains which occurred as a result of development of procurement from emerging markets. Surveys were used as the method of fulfilling the purpose. The research method was based on electronic surveys, while a survey questionnaire made the research tool (Matejun, 2018, p. 237-246). From a technical point of view a survey is based on clearly defined persons (respondents) giving answers to questions which form an informed, logical, consistent and coherent set of answers intended to solve a scientific problem. This type of research is characterised by a lack of active, dynamic and substantial interaction between a researcher and respondent.

The selection of survey methodology was justified by the research specificity and the need to reach a wider group of respondents. Moreover, the method has a clear and friendly form and is characterised by a higher degree of respondents' anonymity. When making a decision to use a survey, the methodology limitations were also taken into account (e.g. low return rate of the questionnaires and possible difficulty reading or interpreting some of the questions). In order to eliminate them, a market research agency carried out the research. Owing to interviewers (who fulfil a technical and not substantial role) answers to the survey questions were obtained.

Research data (empirical material) were collected, summarised and analysed quantitatively in a Microsoft Excel spreadsheet. The following two main statistical parameters were used to present the research results - respondents' answers:

- quantity - frequency table, frequency of indications of the analysed feature; a common feature is the one which gets the highest number of indications,
- median (also called a middle value, average value or the second quartile) - a feature value above and below which there is the same number of observations; it is used for estimating significance of each feature.

The research was carried out in a group of 120 respondents. They represent companies where some materials are purchased from suppliers from emerging markets. The population of respondents included people responsible for supply chain management, especially sourcing directors and specialists (from large and medium-sized enterprises) as well as owners and CEOs (for small enterprises). The respondents were selected purposefully, focusing on those who notice the changes that occur in supply chains as a result of development of procurement from emerging markets.

The respondents represent companies of different sizes (Table 1). Pursuant to the Law it has been presumed that (Commission Regulation (EC) No 70/2001):

- large companies employ more than 250 employees,
- medium companies employ up to 250 employees,
- small companies (including micro-companies) employ up to 50 employees.

Table 1. Size of the studied group of enterprises

Enterprise size	2012	2018
Large companies	28	22
Medium-sized companies	37	25
Small companies	55	73

Source: author's own research

They are companies with different organisational and legal forms (Table 2). The greatest number of respondents represent limited liability companies.

Table 2. Organisational and legal frame of business activity in the studied group of enterprises

Organisational and legal frame of business activity	2012	2018
Limited liability company	61	64
Registered partnership	13	20
Joint stock company	6	3
Natural person conducting a business activity	24	27
Another frame of business activity	16	6

Source: author's own research

The majority of enterprises whose representatives participated in the research have been operating for more than 20 years (Table 3).

Table 3. Period of business operation of the studied group of enterprises

Period of business operation	2012	2018
Up to 5 years	7	9
5-10 years	15	11
10-15 years	17	14
15-20 years	23	14
20-25 years	27	38
Over 25 years	31	34

Source: author's own research

The respondents who took part in the research represent different companies - different depending on the division criteria. This way a general overview of companies can be obtained in which supply chain organisation and management are characterised by various complexity levels. Their representatives point out different aspects of changes in supply chains which occurred as a result of development of procurement from emerging markets in recent years. The results of research in the area are presented in the following section of the paper.

4. RESULTS OF THE RESEARCH

The research (carried out in 2012 and 2018, in a group of 120 respondents) helped to identify changes in supply chains which occurred as a result of development of procurement from emerging markets.

Polish entrepreneurs are more likely to buy different materials from suppliers from emerging markets (Table 4). The number of companies whose suppliers come from China has gone up by 11%. China is now the most important emerging market although India has been gaining importance as particularly attractive for Polish clothing and pharmaceutical companies. The most popular Eastern European markets include Russia, Czech Republic and Hungary. Gradually more friendly legal regulations contributed to the development of supply chains from the aforementioned markets.

Table 4. Percentage of enterprises whose suppliers come from emerging markets

Emerging market	Respondents' indications in 2012 (quantity, %)	Respondents' indications in 2018 (quantity, %)
China	17	28
India	8	12
Eastern Europe	33	43

Source: author's own research

A change in the number of foreign suppliers who make an important cell of contemporary supply chains results directly from the above. According to the research results, the total number of foreign suppliers in the analysed time period did not increase significantly but its structure changed (Table 5). The studied enterprises tend to cooperate with a growing number of foreign suppliers (see e.g. the range of 30-50 suppliers). The majority of them represent emerging markets (see Table 4).

Table 5. Number of foreign suppliers in a supply chain

Number of suppliers	Respondents' indications in 2012 (quantity, %)	Respondents' indications in 2018 (quantity, %)
Less than 5	30	27
5-10	12	15
10-30	30	25
30-50	8	19
50-100	8	13
Over 100	1	3

Source: author's own research

As a result of changes in supply chains and their increasing complexity, the ways of gaining information about foreign suppliers have also changed (Table 6). Own data base became more important than the Internet or Word of mouth. The author of the paper assumes that on the early stage of global supply chains development (2012) entrepreneurs were just starting their cooperation with suppliers from emerging markets. They had to look for information on the Internet, get it from their cooperating partners (word of mouth) or use other way such, as establishing contacts during branch fairs. Over recent years the cooperation has been established, and suppliers selected and proven. That is why entrepreneurs these days mainly use their own data bases and get information on potential suppliers from there.

Table 6. Sources of general information about foreign suppliers

Source	Respondents' indications in 2012 (quantity, %)	Respondents' indications in 2018 (quantity, %)
Own data base	21	36
Internet	57	33
Word of mouth	49	31
Branch fair	55	27
Professional magazines, branch-specific	16	6
Press advertisements	4	5
Sector data bases	2	3
Economic chambers	2	1
Other	3	5

Source: author's own research

Other changes in supply chains as a result of growth of procurement from emerging markets can be observed in the factors which drive companies to establish cooperation with a supplier (Table 7). The factor of better quality of the goods/services offered requires special attention. Changes in supply chains affected both the likelihood of indicating the factor (from 53% to 57%) as well as its significance (median increase from 4 to 5). The share of the main factor which determines establishing cooperation with emerging market suppliers, i.e. lower prices of goods/services offered, also increased (for 64% of respondents nowadays this is the factor which makes them establish cooperation). Nonetheless it turns out that it is now less important than in 2012 (median drop from 5 to 4).

Table 7. Factors which foster a decision to establish cooperation with a supplier from an emerging market

Factors	Respondents' indications in 2012		Respondents' indications in 2018	
	Quantity	Median	Quantity	Median
No possibility to make goods/services with own resources	57%	5	53%	5
Lower price of the goods/services offered	60%	5	64%	4
Better quality of the goods/services offered	53%	4	57%	5

Supplier's cooperation with the company's key competitor	41%	3	26%	3
Supplier's know-how	53%	4	26%	2
Company restructuring	23%	2	26%	4
Will to improve company's attractiveness	22%	4	27%	3
Will to extend the company's product range	33%	4	45%	4
Will to develop and reach a better position against competitors	34%	3	43%	4
Will to improve the company efficiency	51%	4	56%	5
Will to improve company flexibility	45%	4	53%	5
Outsourcing - focusing on key operations, outsourcing of auxiliary operations to the supplier	45%	4	49%	4
Establishing of cooperation imposed by the main customer/ contractor/ mother company	32%	5	34%	3

Source: author's own research

The changes in supply chains which occurred as a result of growing procurement from emerging markets can also be observed in other elements of the supply chains, including the kind of transport used (Table 8) and kind of loading units (Table 9).

Table 8. Kind of transport used for collecting materials from foreign suppliers

Kind of transport	Respondents' indications in 2012 (quantity, %)	Respondents' indications in 2018 (quantity, %)
Outsourced vehicle transport - external carrier	41	47
Supplier's vehicle transport	16	24
Maritime transport	13	18
Inland transport	11	14
Own vehicle transport	17	13
Air transport	8	10
Combined/mixed transport	6	6
Railway transport	4	3

Source: author's own research

Table 9. Kind of loading units used

Loading unit	Respondents' indications in 2012 (quantity, %)	Respondents' indications in 2018 (quantity, %)
EURO pallets	46	75
Wooden pallets	51	44
Big-Bags	6	23
Containers	17	21
Drums	10	21
Special tanks	11	18
Tanks	6	16
Cardboard boxes	15	13
Bulk	13	7
Other	18	20

Source: author's own research

Road transport (own, supplier's and outsourced) is the most commonly used form of transport. It is widely used for transporting materials from Eastern European market suppliers. Maritime transport has gained importance (increase by 5%), which is supported by gradually increasing interest in such emerging countries, as China or India (maritime transport is regarded as the main form of transport in global transportation). The above directly affects the kind of loading units used. EURO pallets have become more common (standard unit in road transport, 29% rise) alongside with containers (standard unit in maritime transport, 4% rise).

5. FINAL CONCLUSIONS

Modern sourcing is greatly affected by contemporary logistic megatrends. Changes in logistics models (locating business centres in Asia, Africa and Eastern Europe, i.e. in emerging markets) are among the megatrends which directly impact supply chains and their elements. This aspect is the key purpose of the paper. The completed research enabled the identification of the most important changes in supply chains, which occurred as a result of development of procurement from emerging markets. The changes include modifications of the structure and number of foreign suppliers and ways to obtain general information about foreign suppliers, factors which inspire establishing cooperation as well as changes in the kind of transport used and kinds of loading units.

It is a fairly common practice for contemporary enterprises to cooperate with suppliers from emerging markets (mainly China, India and Eastern Europe). The number of suppliers has been growing year after year. Enterprises acquire information about suppliers using own data bases which were developed during the last few/dozen years.

Significant changes in supply chains can also be observed in reference to the factors which stimulate the decision to establish cooperation with a supplier from an emerging market. Despite the fact that the factor of 'lower price of the goods/services offered' is the most common, it is not the most important one. The respondents regarded 'higher quality of the goods/services offered' and the 'will to improve the company's efficiency' as key factors. This is testimony to a change in the approach to procurement which is no longer treated as a standard purchasing transaction but has gained a status of an operating strategy based on a long-term and fruitful cooperation with suppliers. The suppliers offer top quality material, which directly affects the quality of the company's end products, makes them more competitive and improves efficiency.

The above mentioned research indicates changes in the supply chains which according to the author will be gradually more complex in the forthcoming years. As a result of growing competition, enterprises have to minimise the costs of component production and to reduce the flow time of products and information, while maintaining the quality of products and service required by customers. A strategy intended to reduce the manufacturing costs is to cooperate with material suppliers from emerging markets. The strategy has been developing nowadays and there are no premises to disturb this process.

In the author's opinion further research should be carried out in two directions:

1. Further, cyclical analysis of supply chain changes resulting from development of emerging markets procurement process. Thus, it shall be necessary to repeat the research after the five years period i.e. in 2024 (previous research was carried out in 2012 and 2018).
2. Analysis of modern, turbulent and competitive global environment. It shall provide the way of conducting the procurement process (whether to continue the cooperation with the emerging markets, if so - which in particular?).

Main research limitations will be the size and the structure of research sample in comparison to the research previously conducted, however still aiming to sustain the research efforts.

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VII. INTERDISCIPLINARITY IN LOGISTICS

FRANCHISING AND LOGISTICS: WAY TO GROW OR NOT

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Abstract

Logistics as an important part of the company's operations were going through different phases of development in order to fulfill the demands of the companies. Logistic operators needed to develop and to grow with their business and to expand internationally. When companies reached that phase, they needed to decide how to expand nationally or internationally.

Franchising is one of the most popular business models for the expansion and growth of businesses. As a business model franchising is present in almost every industrial sector worldwide.

The main aim of the paper is to examine if the franchising business model is an appropriate way for logistics companies to grow and to give a review of current franchise networks in the logistics sector. In the first part of the paper, we will present what franchising is and its influence on the world economy. In the second part of the paper, we will present a literature review about franchising potentials in logistics. In the third part of the paper several logistics companies will be analyzed and their attitude toward franchising as a growth business model. Finally, in the last part, conclusions and the proposals for further research will be presented.

Keywords: franchising, franchisor, economics output, logistics, growth

1. INTRODUCTION

Franchising is often seen as an efficient way to grow business from the franchisor side and as a safer way to start a new venture. This business model is present in almost all countries worldwide. Its current shape can be thanked famous Ray Kroc who started franchising revolution in 1960-ties in the USA when he became an exclusive master franchisee for the McDonalds brothers. He created so-called salesman suite which meant that everything at every location (franchisors or franchisees) had to be the same – from products and services offered to the interior and exterior design of location (Erceg, 2017). One of the most well-known definitions of franchising states that it occurs when a company (franchisor) licenses its brand and way of doing business to another company (franchisee) which agrees to work in accordance to the franchising contract (Boroian & Boroian, 1987). It is important to state that both parties involved in the franchising business model are legally dependent but economically interdependent (Michael, 2000). Emmerson (1990) stated that franchising can be examined from an economic and legal perspective as a possible alternative for production and distribution undertaking integration into a single company.

Today there are several different types of franchising but most known are business format franchising and product distribution franchising. In both types of franchising, logistic services within a company or as a company's main purpose are of big significance. Business logistics in today's global and competitive economy has a significant role no matter if we are speaking about business-to-consumer or business-to-business activities.

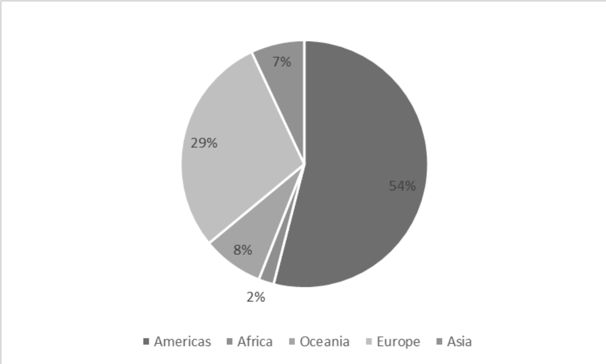
The main aim of the paper is examining the potential of the use of franchising for the growth of logistics companies. The main research question of this paper is to check the current situation within the logistics sector to see if the companies are using franchising as the growth model. In the first part of the paper impact of franchising to the world, economy will be examined while in the second part literature review about franchising in the logistics sector will be presented. Several examples which are using franchising in logistics will be presented in the third part of the paper. In the last part of the paper, the conclusion will be presented, and further research proposals will be given.

2. FRANCHISING AND THE IMPACT ON THE WORLD ECONOMY

Franchising is present in almost all countries in the world and usually companies which want to grow their business geographically but don't want to depend on their financial resources or don't have enough of their financial resources for the growth (Alon, Alpeza & Erceg, 2010). Franchising business model offers benefits to franchisees and franchisors thus the influence of franchising is increasing on the global economy (Zeidman, 2014).

World Franchise Council and FranData conducted research on a sample of 26 countries in which franchising exist to determine the influence on the national economy. Countries included in sample contribute 53% of total world GDP and economic influence of their franchise businesses makes 2.3% of total world GDP. In conclusion of FranData research on the impact of franchising on the global economy Schwarzer (2016) stated that franchising generates 1.6 trillion USD in more than 2.2 million companies employing more than 19 million people in 20 countries for which the data has been collected (Figure 1). The total economic output franchising creates is at 2.3 of total global GDP and on average 4% of national GDP. Further confirmation of impact franchising business model has on the world economy is in its expansion across national borders and thus increasingly becoming the fastest growth strategy for companies around the world (Castrogiovanni & Justis, 1998).

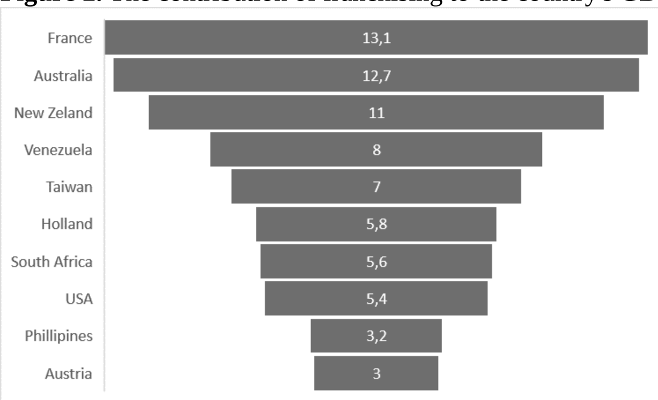
Figure 1. The economic output of franchising in the world



Source: adapted from Schwarzer, 2016

Americas has the highest economic output for the national economy. In average, franchisors and franchisees worldwide employ 9 people per location and franchise employ around 1.2% of totally employed in national economies. Franchising is not used the same in all parts of the world. Developed countries are using more franchising and influence of franchising on national economies of those countries is higher. According to the research there is a strong correlation (0.9) between the franchising's economic output and the number of franchised business in the country and weaker correlation (0.73) between the number of franchised businesses and the country's population as well as the country's population and the number of the jobs created by franchise systems (0.76). The contribution of franchising to the national GDP is significant in some countries (Figure 2).

Figure 2. The contribution of franchising to the country's GDP



Source: adapted from Schwarzer, 2016

Based on Figure 2, the highest share of national GDP franchising has in France followed by Australia and New Zeeland, while the world franchising leader, USA, has only 5.4% share in national GDP. The franchising economic output in different countries is presented in Table 1.

Table 1. Franchising economic output in countries

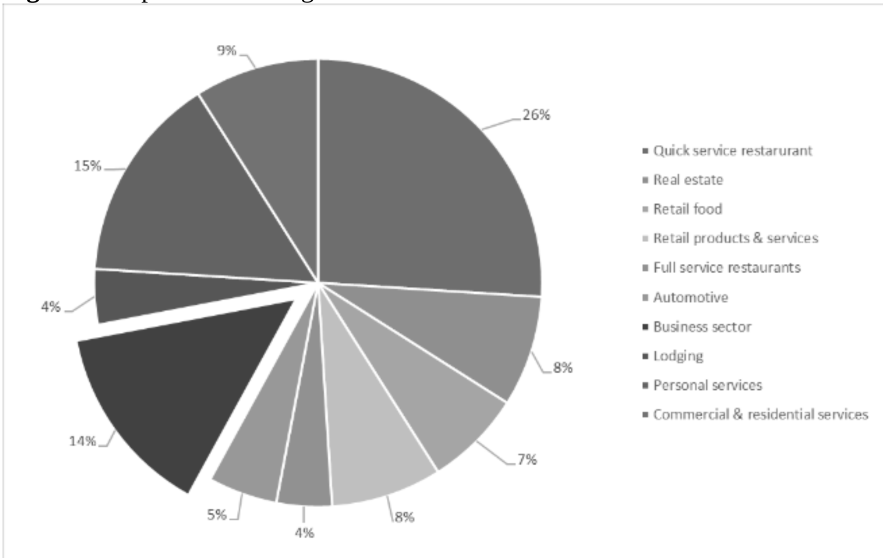
Country	Number of brands	Percentage of domestic brands	Number of units	Franchise Economic Output in billion USD
Argentina	550	90	18,000	8.80
Austria	445	51	8,720	8.50
Australia	1,160	86	79,000	126.50
Belgium	350	60	11,000	15.30
Brazil	2,013	N/A	N/A	43.00
China	2,100	N/A	120,000	30.00
Croatia	180	12	1,000	1.60
Finland	280	75	4,555	6.70
France	1,719	90	65,133	300.00
Germany	994	80	76,500	78.50
Holland	749	86	30,785	39.40
Indonesia	480	19	70,000	13.20
Italy	938	85	51,110	29.20
Malaysia	667	79	7,525	7.50
Mexico	1,400	81	75,000	1.00
New Zealand	485	88	22,400	15.40
Philippines	1,500	65	130,000	14.00
Portugal	500	N/A	11,760	5.300
Russia	595	N/A	22,800	28.00
Slovenia	108	43	1,580	N/A
South Africa	627	88	31,050	30.80
South Korea	3981	70	203,349	8.60
Spain	1,199	80	44,619	14.70
Sweden	700	80	26,000	21.00
Taiwan	2,433	88	128,305	70.00
Turkey	1,200	70	30,000	37.00
United Kingdom	935	82	39,000	13.70
USA	3,828	95	769,683	844.00
Venezuela	530	58	12,500	30.808

Source: author compilation adapted from European Franchise Federation, 2015; World Franchise Council Survey, 2016

The highest output is in the USA and followed by France, Australia, and Germany.

Franchising is present in almost every sector of industry although is mostly recognized in fast-food restaurants industry (Figure 3).

Figure 3. Top 10 franchising sectors



Source: adapted from IHS Economics, 2018.

Among the top 10 industrial sectors where the franchising has a significant presence in the business services sector which among other includes logistic services such as business transportation, warehousing, and storage (IHS Economics, 2018). This is showing that there is franchising potential for logistics services – transportation, warehousing, and storage. This potential is recognized worldwide and there are many different logistics services companies which have decided to grow their business using the franchising business model. Some of these worldwide examples will be presented later in the paper.

3. FRANCHISING AND LOGISTICS – LITERATURE REVIEW

Franchising has been and still is of great interest in researches worldwide. Different authors are examining different perspectives and viewpoints of the franchising business model. Some of those authors are trying to explain franchising and reasons for franchising through different theories such as agency theory (Eisenhardt, 1989), resource scarcity theory (Oxenfeldt & Kerry, 1968), institutional theory (Combs, Michael & Castrogiovanni, 2009), property rights theory (Mumdžiev & Windsperger, 2011), etc. Other authors have been looking from different disciplines so Dant, Grünhagen, and Windsperger (2011) found that in the period from 2000 to 2010 there were almost 80 research papers about franchising covering it from management, financial, entrepreneurship, and marketing viewpoint. Another research conducted by Young and McIntyre (2011) resulted in a list of studies about franchising (Table 2). They found that the majority of studies were looking at the franchisor perspective but from different topics.

Table 2. Order of topics presented at International Society of Franchising conferences 1986-2010

1986-1999		2000-2010	
Topic of paper	Number of papers	Topic of paper	Number of papers
Franchise Management	69	Franchise Management	106
International Franchising	67	Performance & Growth	92
Relational Issues	57	International Franchising	53
Performance & Growth	50	Legal & Political	52
Legal & Political Issues	43	Relational Issues	47
Marketing	36	Marketing	33
Nature & Scope Franchising	35	Entrepreneurship	18
Economics	12	Modelling & Methodology	15
Entrepreneurship	12	Knowledge Transfer	13
Modelling & Methodology	9	E-Commerce/Internet	9

Source: adapted from Young & McIntyre, 2011: 15

Review of franchising research is showing that there is no research about franchising in logistics in the top 10 categories. It is important to state that out of 69 different research papers connected to marketing, 14 papers were about the place as part of the marketing mix (Young & McIntyre, 2011). Although one could state that if there is research about retail, then franchising logistics could be covered as part of the relationship between franchisor and the retail franchisee (Quinn & Alexander, 2002; Doherty, 2009). The same could be stated for research about international franchising where logistics plays an important part in delivering goods to a foreign country (Dant & Grünhagen, 2014).

Regarding the direct research about franchising in logistics only several papers were found in our research. Dapiran (1992: 11) researched global logistics in action on the example of Italian clothing producer Benetton and concluded that it presents an example of *an organization which has truly grasped the meaning of integrated logistics across national boundaries* and that *the real Benetton product is nothing less than integrated logistics*. This statement showed the importance of logistics for franchising systems in retail business and that franchisors, if want to expand nationally and/or internationally, must think about logistics. Carrie, Hayfron and Bititci (2000) found a connection between franchising and logistics to reduce logistics costs for the manufacture franchising. Fenies, Gautier and Lagrange (2014) in their research about the decisional model in network franchise and supply chain network evaluated the model for optimization logistics and financial flows in franchise networks. They found a possibility to represent the relationship between each transaction and logistic chains in the franchise network. Pumpinyo and Nitivattananon (2014) researched reverse logistics of waste management and found that franchise bring more benefits and organization than non-franchise activities.

There are other studies (Hellstrom & Saghir, 2007; Chanut & Pache, 2011; Junjie & Min, 2013) which were researching the influence of franchising in logistics services but the only paper which examined franchising in logistics sector studied the dynamics of the logistics industry in China and possibility of TNT franchise system in China. Cen (2005: 35) found possibilities for franchising of logistics services in *(i) network of facilities such as distribution centers or warehouses as franchising members (ii) transport capacities such as small or medium size trucking companies as franchising members under the uniform brand of franchisor and (iii) service chains like 7-11, such as dispersed, unorganized individual stores as franchising members, etc*. These findings show the main directions for the use of franchising in the logistics industry.

4. FRANCHISING IN LOGISTICS – WORLDWIDE EXAMPLES

Franchising worldwide is present in more than 275 different industrial sectors (IHS Economics, 2018) and has a significant impact on economic output. In the same time franchising in getting more presence in the logistics sector. Worldwide there are more than several logistics companies which are using franchising as a growth model. These companies include companies involved in transportation, courier service, and warehousing. In every part of the logistics sector, there are franchise networks (Table 3).

Table 3. Franchise systems in logistics worldwide

Sector	Examples
Storage and moving sector	Zippy Shell U'Haul Smartbox
Courier services and micro logistics sector	UPS Store DHL TNT MailBox Etc PostNet
Forwarding and transport sector	BlueGrace logistics Inxpress

Source: author's own research

The table presents only representatives of different franchising systems in the logistics sector and in the next part of the paper, we will present some of the leaders of franchising in the logistics sector. On the Entrepreneur Franchise 500 list there is only one logistics franchise on the 410th place – Inxpress while the list presents four more logistics companies which are using franchise for their growth – Craters & Freighters, Unishippers Global Logistics LLC, Safe Ship and BluGrace Logistics (Entrepreneur, 2019). Other franchise systems in the previous table are placed in other sectors – business services which are one of the most important sectors for franchising as it is seen in Figure 3.

4.1. UPS Store franchise

The UPS Store offers mail and parcel receiving, packaging and shipping services using different courier companies' carriers and provides a wide range of other products and services (printing, copying, office supplies, and notary service). Locations target the need of all size companies, small office/home office workers and all other customers who are looking to save time and costs in logistics. The UPS Store franchise offers a range of location-styles which are intended to fit the wishes of their franchisees. Initial franchise costs are different depending on the size of the location and location of the center (UPS Store, 2018). Franchise network currently has 4,600 franchise locations and they are the top brand in postal and business service category according to the Entrepreneur Magazine's 2018 Franchise 500 list (Entrepreneur, 2018). Franchisees get ongoing support and a comprehensive training program, advertising and marketing campaigns, a network of knowledgeable and dedicated franchisees; name recognition and reputation. On the other side, the franchisor is using franchisees resources for the growth of network and business. The company is using only franchising for the growth and has opened more than 200 new locations in the last 2 years, and they are currently present in the USA and Canada with a few locations worldwide

4.2. InXpress

InXpress started using the franchise business model in 1999 and with sustained growth, they became the world's largest franchiser of worldwide express parcel delivery and transportation services (Franchise Business Review, 2019). The company is established in 13 countries with ambitious plans for new growth across all major markets. They are currently operating with some 300 franchisees worldwide (around 100 in the USA and 200 worldwide). The company is working with DHL and shipping to more than 220 countries (InXpress, 2019). They have been using the franchising business model for growth which has resulted in a growing pace of 20% year-over-year.

It is important to state that although InXpress relates to shipping they are not shipping franchise. They are service reseller business based on establishing a connection and making relationships. The whole franchise system turn-over is almost 150 million USD per year and their aim is to help SME's growth by providing contact to the best possible shippers at reduced prices which are usually offered to the large corporations. The transporters benefit with outsourcing some of the customer services to InXpress while franchisees earn money in finding customers who want to have better service and lower costs. InXpress leverages their global agreements with world-class carriers (such as the one with DHL) to get the favored rates for providing, different shipping possibilities (domestic and international express, mail and freight) to customers. The rates are conceded to the InXpress franchisee's customer. Franchisees are managing the customer relationship by providing the best possible customer services and perform administrative activities (i.e. invoicing, accounting, collecting money, etc.) with the customer.

4.3. BlueGrace logistics

BlueGrace logistics is one of the fastest growing third-party logistics providers in the booming industry. They are USA franchise system with more than 200 locations nationwide. The company offers B2B sales and consultation and their franchisee is involved in helping small, medium and enterprise businesses find far more efficient or advanced shipping solutions (BlueGrace, 2018). They are technology provider in logistics sector who offers web-based management system for transportation named BlueShip for consulting SMEs in streamlining and optimizing their transportation needs.

Similarly, as InXpress, BluGrace uses their strong technical capabilities and relationships with carriers for offering outsource of the transportation process to their customers. They offer benefits of transportation needs consolidation, lover costs, modern technology, and best possible customer service. Their business model resulted in a yearly growth of 7.4% in revenue yearly. Based on growth they achieved they decided to create a franchise system for further expansion.

Their franchises help SME's in better managing their shipping needs by using abovementioned BlueShip IT solutions, providing shipping solutions crafted for each SME especially, searching for faster carriers or carriers with better rates, or even becoming SME's outsourced logistics department. Main BlueGrace logistics customers are SMEs, distributors, and retailers which need to transport goods one location to another, and they do this regularly, but do not require a whole truckload. These companies usually spent huge amounts of money on shipping so BluGrace offers them crafted logistics solution which is significantly better then what SMEs can do on their own.

4.4. MailBox Etc

MailBox Etc together with UPS Store is one of the largest franchise networks of centers which are offering business logistics services to companies. Their main goal is to improve customer's productivity by outsourcing different processes like shipping which are not customer's core activities.

After UPS purchased American part of their network and rebranded them in UPS Store, MBE Worldwide from Italy acquired the remaining part. The company is now present mostly in 38 countries worldwide. In Europe they are present is in Austria, France, Germany, Ireland, UK and from recently in Croatia. Worldwide they had

1,600 locations in 2016 and the total turnover was 427 million EUR. The company came back to the American market in 2017 when they acquired PostNet International Franchise Corporation. Today MailBoxes Etc has more than 2,500 location worldwide (Mailboxes Etc, 2019).

MBE's main clients are micro and small businesses, and stand-alone professionals, where MBE can take full care of logistics jobs. The main services that such clients use address registration and rental of mailboxes, mail, and mail receipts, collecting, sending and forwarding, etc. For medium and large companies MBE mainly helps to improve packet delivery processes, special packaging, and micro logistics.

4.5. To grow or not to grow – is franchising the answer

If we use search phrase "freight forwarding franchise" in Google one can get tens of different logistics companies (i.e. InterCargo, Cargocall, RPX, JML Corporation, AllCargo Worldwide Service, etc.) offering franchise business model. A similar result in a number of companies (i.e. InXpress, BluGrace, SupplyPoint, Nexterus, Diamond Logistics, etc.) can be seen if the phrase "logistics franchise" is used in Google. These results confirm that the franchising business model can be an answer for growth in the logistics sector.

In the previous part, we have presented several successful franchising networks in logistics sector whose growth and worldwide presence would not be possible without franchising (Table 4). Their growth without franchising would be limited by their own resources. Thus, their growth and use of franchising are confirming the resource scarcity theory. The resource scarcity theory state that the company starts with franchising due to the scarcity of expansion resources. It is needed to highlight that these resources are not only financial (capital scarcity) but can be organizational (for expansion), managerial (knowledge-based), etc. (Elango and Jawahar, 2002). Shane (1996) concluded that growth with franchising is allocating ownership rights to retail outlets managers (franchisees). In business format franchising (used for growth in logistics sector) franchisor maintains limited ownership and authority regarding business procedures, use of trade name, the location of franchised outlet and franchising contract while franchisees are managing and operating outlets (Child, 1987).

Table 4. Franchise systems in logistics worldwide

Characteristics	BlueGrace	Inxpress	MailBox ETC	UPS Store
Founded	2007	1999	1980	1980
Franchising since	2011	2006	1980	1980
Number of franchise locations	200	300	1500 + PostNet locations	4600
Own locations	10	N/A	N/A	N/A
Franchise fee	22,000 – 82,500 USD	50,000 USD	20,000 EUR	9,950 – 29,950 USD

Characteristics	BlueGrace	Inxpress	MailBox ETC	UPS Store
Total investment	39,500 – 181,250 USD	65,000 USD	40,000 EUR	166,659 – 398,323 USD
Royalty fee	15-19%	30%	6%	5%
Marketing fee	2%	N/A	2.5% + 1.5%	2.5% + 1.5%

Source: author's own research

Above stated characteristics for selected logistics franchise network show that starting as a franchisee in this business is not unexpansive. But the name which franchisee gets to carry brings business for him and for franchisor this represents further growth on the market where franchisor maybe would not go. This confirms that it is possible to use franchising as a growth option in the logistics business.

Another big logistics and express courier company TNT used franchising for its expansion into a new market – China but their story didn't finish successfully. Their intention was to establish a franchising model of trucking network for covering entire China since there was no national company in China trucking market in 2004 (Cen, 2005). The TNT franchise episode was not successful, and the company had a huge loss from its operations in China. On the other hand, one of the largest logistics and courier company DHL (a part of Deutsche Post Network) usually don't use franchising for its growth but due to the regulations in China they have started to use joint venture and in India, they are using franchising for network growth.

Big logistics companies in the USA are selling transport or delivery routes as a franchise (i.e. FedEx) which is another way of growing end expanding logistics business. Franchising is mostly used by companies which want to expand their business internationally and this is also the case with logistics companies. So big players like FedEx and UPS are using franchising for smaller markets such as Croatia where both companies have franchisee or authorized representative company (i.e. Rhea d.o.o. Zagreb).

5. CONCLUSION

Franchising is present worldwide as a way to expand the business and to start a new venture. It is present in almost all industrial sectors and almost everything can be franchised. The decision to grow for all companies is not easy due to the needed resources for growth. Franchising is an answer to this potential problem since franchisee is the one providing resources for growth while franchisor gives know-how and the brand. Franchising has a significant impact on national economies through economy output and the creation of jobs.

Need for reliable logistics services is growing worldwide thus companies need to cover this demand by expanding their presence in the market. Franchising is probably the best way for this purpose due to the benefits it provides for both parties and for the final customer. Franchising can help logistics companies in solving problems with resources since franchisees are the ones providing those and they know the market on which they are opening a franchise.

The presented situation in logistics regarding franchising is confirming that the franchising can be used for the growth and expansion no matter if it is national or international. All examples have been using franchising for their growth and all of them have succeeded in the growth although there has been as always, some failures in this process.

This research has limitations since the author has used only secondary data gained from the different source out of which the conclusions were drawn. In order to confirm these findings, it is necessary to conduct full-scale research with statistical data.

Due to the great possibilities franchising has for the growth of the logistic companies' future research is proposed to determine:

- What are the major steps for the logistic company to start using franchising?
- How to increase further use of franchising in logistics since this is still not the main way of expanding the business geographically?

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EVALUATION OF THE VEHICLE REPAIR SUBSYSTEM WITH MARKOV MODELS

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Abstract

Analysis and evaluation of repair subsystem in the transport system is extremely important. It has a direct impact on the quality of performed tasks and the readiness level of surveyed organization. It also enables to identify factors that have a negative impact on the repair process, its duration and quality. These include e.g. waiting times for spare parts, for specialists (mechanics) or free repair stations (channels), as well as availability of equipment or tools necessary for implementation of renewal procedures. The level of training, knowledge and experience of mechanics, which can be key to the success of planned repairs, is also extremely important.

This article presents an analysis of the example of repair subsystem. The Markov models were used for diagnostics, which enabled to determine the probability limit values of duration of the operating states distinguished in this subsystem and, on this basis, to determine the imperfections of implemented processes and possibility of their improvement.

Key words: Markov models, vehicle readiness, repair subsystem

1. INTRODUCTION

Complex systems of operations require a proper management strategy not only in terms of use and tasks carried out, but also in terms of planned maintenance and repairs. Regular inspection of the technical condition of objects is a form of support in this respect. One of the ways to effectively counteract the destructive processes that accompany each and every machine from the moment of its manufacturing until its decommissioning is proper scheduling of preventive replacements and improvement of diagnostic methods (Żółtowski, 2012).

There are many strategies of object operation within the company, with the most common ones including (Żółtowski, 2012):

- according to reliability,
- according to economic efficiency,
- according to the amount of work done,
- according to technical condition.

The most desirable approach is preventive maintenance that anticipates the inoperable state of a technical object and prevents failures from occurring. It allows to avoid additional costs, but at the same time requires systematic monitoring and diagnostics to precisely determine the moment preceding the failure, which ultimately leads to sufficiently long operation of a given element.

The choice of the right strategy of object operation is, however, not enough. It is also important to regularly control the processes carried out within its framework. In the transport company presented in the article an analysis of the readiness of the owned vehicles was carried out, which indicated that the vehicles spend more than 20% of the total time of operation in the repair subsystem. It resulted in the decision to carry out a detailed analysis of the repair activities carried out in order to answer the question whether it is justified to devote 1/5 of the time to repairs. An additional objective of the article was to present a mathematical method enabling such a study. Markov processes were used.

Examples of application of Markov models are common in literature, especially in the area of reliability and readiness of both individual elements (Alvarez & Lane, 2016) and complex systems (Hu et al., 2017; Pilch, 2017). Studies are carried out for discrete time, in which binary implementations of operating states are possible, as e.g. in (Eryilmaz, 2016; Levitin et al. 2017). Multistate combinations are also analyzed, both in discrete (Troaes, 2015) and continuous time (Iscioglu & Kocak, 2019; Liu et al. 2016; Liu & Zio, 2017).

The area which is most frequently explored is the wear of individual devices (elements) or assemblies (Knopik & Migawa, 2018; Moghaddass, 2015). This is facilitated by constant technological progress and competition on the market, both of which determine the development of effective and reliable methods of measuring the performance and reliability of devices and equipment. Despite the abundance of such models in the literature, there are no comprehensive descriptions of repair subsystems functioning in complex systems of operations. There are several reasons for this. It is primarily caused by the difficulty of obtaining and processing data for such a study. The data is often available in the form of paper documentation, which is difficult to analyze and requires time-consuming creation of appropriate electronic databases. The second problem, mentioned in publications, is the quality of such information, which makes it difficult to obtain reliable results. The authors draw attention to the lack of appropriate statistical data (necessary variables) (Nowakowski, 2012; Urciuoli, 2011) or their incomplete or fragmentary state (Mlynczak & Nowakowski, 2006). This makes calculation procedures difficult (Szkoda & Kaczor, 2016; Szawłowski, 2008], or even renders obtaining reliable results impossible (Nowakowski, 2006).

Moreover, transport companies, being focused on their core business activities, do not always pay adequate attention to the carried-out repairs, which also means that such analyses are not frequent. This is the reason behind them becoming the basis for the studies presented in this article.

2. RESEARCH METHOD

Randomness of object operation processes, which means that in subsequent moments of time the examined technical object may be in different operating states, allows to apply the theory of stochastic processes. In each of the defined states there is a possibility of modifying it, making corrections and controlling the analyzed process in a way ensuring the highest level of readiness of technical objects treated individually, as well as of the system as a whole. The article analyses the repairs carried out in the company, as a result of their aforementioned worryingly long durations.

Markov and semi-Markov processes are popular in such analyses. In such a case the analyzed object operation process is – from the functional perspective – a process of changes in the distinguished operating states of the object, belonging to a finite set $S = \{S_i;\ i = 1, 2, 3, \ldots, I\}$.. The elements of this set are the values of the process $\{W(t): t\ >\ 0\}$,, i.e. consecutive states $S_i \epsilon S$ remaining in a causal relation [0].

The application of the theory of stochastic semi-Markov processes and, in special cases, the theory of Markov processes requires the fulfilment of specific assumptions.

Their basic property is the memorylessness of the process, which means that the conditional probability distribution of a random variable X_{n+1} depends only on the probability distribution of one of the random variables X_n, and does not depend on the whole past, i.e. on the values that the process assumed in states $i_1, i_2, \ldots, i_{n-1}$ [0].

Conditional probabilities $p_{ij}: P(X_{n+1} = j | X_n = i) = p_{ij}$ are called the probabilities of transition from the state i at the moment n to the state j at the moment $n + 1$ (Cui & Wu, 2019).

The form of distributions of the average durations of individual operating states is also of great importance. For Markov processes, they must have an exponential distribution. If these distributions belong to any known parametric family, then it is possible to use the semi-Markov processes theory (Sericola, 1994). If this distribution does not belong to any known parametric family of distributions, perturbed Markov processes theory can be applied (Grabski & Jaźwiński, 2009).

The mathematical model is by definition a simplification of the actual systems of object operation and therefore requires certain assumptions. In the analyzed system it is assumed that the technical object (an automobile) can only be in one of the possible operating states at any given moment of time, the set of these states is discrete and finite, there are no transient states, and the moments of their changes are measurable.

3. PRELIMINARY TESTS

The research sample consisted of data on repairs carried out for the studied transport company. The fleet of vehicles consisted of Scania R420 Euro 5 trucks equipped with manual transmission. As all vehicles came from a single production batch, the sample could be considered as homogeneous. The operation process was analyzed from the moment of transferring the vehicle to the automobile repair shop.

The database was developed using records from repair registers and vehicle service record books. On the basis thereof, a set of operating states was distinguished, presented in the table below (Table 6).

Table 6. Operating states distinguished for the examined technical objects

Operating state	Function
State S1 – physical repair process	The state in which the physical activities associated with restoring the vehicle's operability are performed. It includes not only mechanical repairs, but also body and paint work as well as vehicle maintenance.
State S2 – waiting for a mechanic	The state in which the vehicle, after determining that it is necessary to transfer it to the automobile repair shop, awaits repair. This is due to the schedule of repairs, the occupancy of all repair stations, and sometimes the time of day when the car is transferred (if it is transferred at the end of the work day, repair will start not earlier than on the next day). It is also a state in which repair processes (those started earlier) cannot be continued due to the lack of a mechanic. The mechanic may be involved in activities with another vehicle (which will indicate a shortage of staff) or it is required to call an expert on specific repairs or adjustments. An example of that is a specialist in disassembling damaged and stuck injections and glowplugs, who is able to perform these operations without removing the cylinder head, which will reduce the overall cost of repair.
State S3 – waiting for parts	The state in which repair processes cannot be continued due to the lack of suitable spare parts or subassemblies. This is a result of the organization of the repair subsystem, in which the parts are ordered only if a failure is diagnosed, thus reducing inventory to basic components such as oil filters, air filters, cabin pollen filter, fuel, or brake disks and pads only. There are some subassemblies/parts in the case of which waiting time is usually prolonged. This is the case with powertrain components in particular, e.g. drive shafts, steering system components, such as a steering gearbox. The waiting time may also be extended due to the decision to repair (instead of replacing) a damaged part, e.g. alternator, starter motor, steering gearbox.
State S4 – diagnostics	Diagnosis takes place at the beginning of the repair process, it is then that the scope of repair works is determined. This state covers both the diagnosis of the damaged component or subassembly, as well as preventive diagnostics of the whole vehicle, carried out mainly on the basis of failure testers (diagnostic computers), modern tools and the mechanic’s experience. It is also a state that finalizes the repair process by checking whether all failures were rectified and the vehicle is fully operational.

Source: own elaboration based on the repair register

The distinguished operating states were subjected to detailed statistical analysis. According to the presented assumptions, first of all the so-called memorylessness was checked. It means that the probability of transitioning to any given state at a given moment $t+1$ depends only on the state at the moment t, and not on the states at previous moments. The homogeneity of an unknown chain can be checked by performing statistical significance tests on randomly calculated differences from a subsample of values of probabilities p_{ij}. If the Markov chain is homogeneous, the distribution of probabilities of transitions between individual states will be constant, expressed in a stochastic matrix of transition probabilities P. The next step was to check whether the time distributions belong to a known parametric family. Such information allows to express the dependencies between the transition probabilities using a formula and facilitates the calculation of basic characteristics of the Markov or semi-Markov process. It also allows to determine which of these models is the most suitable one. Fit to several families of distributions: lognormal, exponential, Weibull and normal was checked using the value of the Akaike information criterion. The distribution for which it reached its lowest value was considered the best. An example of the analysis for the operating state S1 is shown in Table 7.

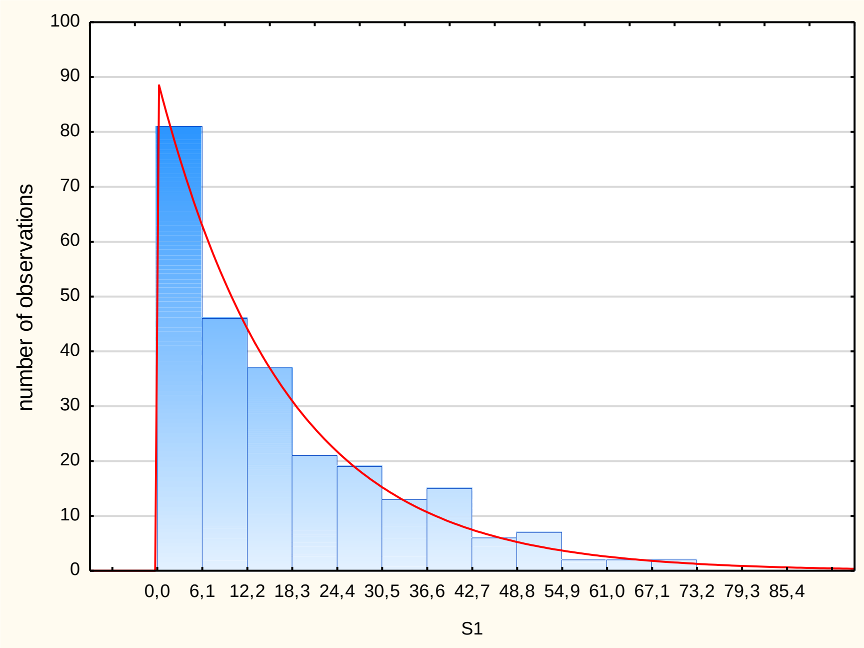
Table 7. Value of Akaike Information Criterion (AIC) and parameters of selected distributions for state S1

Family of distributions	AIC	Parameters				
Log-normal	1964.59	$\mu = 2{,}31$	$\sigma = 1.20$			
Log-mixtures	1939.90	$\mu_1 = 1.61$	$\sigma_1 = 1.15$	$\mu_2 = 3.13$	$\sigma_2 = 0.58$	$\lambda = 0.54$
Exponential	1929.59	$\lambda = 0.06$				
Weibull	1930.65	$\kappa = 1.05$	$\lambda = 0.06$			
Normal	2095.99	$\mu = 17.11$	$\sigma = 15.62$			

Source: own study

Then the goodness of fit was checked using the Kolmogorov–Smirnov test. The obtained result was not statistically significant, which did not allow to reject the h0 hypothesis of the goodness of fit between empirical and theoretical distribution. The goodness of fit is also confirmed by Figure 24. presenting the empirical distribution of duration times of state S1 and the graph of density of exponential distribution with the parameter $\lambda = 0.06$.

Figure 27. Histogram of time of S1 with the fit of the exponential distribution



Source: own study

Then, the basic measures of descriptive statistics for the analyzed operating states were determined, which are presented in Table 8.

Table 8. Values of basic measures of descriptive statistics of the distinguished operating states

Descriptive statistics						
Variable	Mean [h]	Median [h]	Min. [h]	Max. [h]	Standard deviation [h]	Coefficient of variation [%]
State S1	16.5	12.1	0.2	71.7	15.6	94
State S2	2	1.8	0.5	4	13.9	67
State S3	12	10.7	6	48	20.3	169
State S4	0.9	0.79	0.25	2	9.8	108

Source: own study

The obtained results show a large variation in the duration of individual states, which results from the specificity of the repair process. E.g. for state S1, simple actions related to rectifying an on-board computer error caused by low battery voltage lasted several minutes, hence the minimum value for this state is 0.2 h. On the other hand, long times (maximum value of 71.7 h) usually were related to the body and paint works, which include the time of surface preparation, its painting and waiting for drying or activities related to anti-corrosion maintenance of the chassis, which requires disassembly of many subassemblies, including the exhaust system and fuel supply system.

The collected data is characterized by high variability, resulting from the variety of tasks performed. The mean and the median differ from each other, in all cases the median is lower than the mean value, which is characteristic for exponential distributions.

4. ESTIMATION OF MARKOV MODEL PARAMETERS

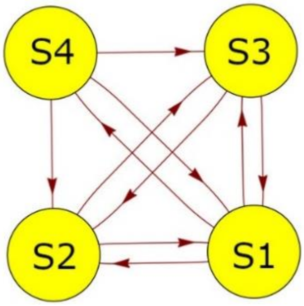
The first stage of constructing the Markov model is the assessment of dependencies between the states by defining permitted and prohibited transitions, marked as $p_{ij.}$. In the examined system, they were determined on the basis of empirical state changes. If in the entire process transitions from state S_i to state S_j took place, they were considered permitted and marked 1, otherwise were prohibited and marked 0. The obtained results are presented in Table 9. and the graph of transitions, is shown in Fig 25.

Table 9. Transition probability matrix of the Markov process

Operating state	S1	S2	S3	S4
S1	0	1	1	1
S2	1	0	1	0
S3	1	1	0	0
S4	1	1	1	0

Source: own study

Figure 28. Graph of relations between states of the studied process



Source: own study

After determining the occurring relations (Fig. 2.), on the basis of the frequency of individual occurrences, the values of elements of the transition probability matrix were calculated. The results are presented in Table 10:

Table 10. Transition probability matrix of the distinguished operating states

Operating state	S1	S2	S3	S4
S1	0	0.12	0.38	0.5
S2	0.89	0	0.11	0
S3	0.78	0.22	0	0
S4	0.34	0.08	0.58	0

Source: own study

The first important characteristic describing Markov chains is their limit properties. They provide information on the process behavior after a long period of time (theoretically when $n \rightarrow \infty$). The calculation of limit probabilities requires solving the system of equations (1):

$$\begin{cases} \Pi^T P = \Pi^T \leftrightarrow \\ \pi_1 + \pi_2 + \pi_3 + \pi_4 = 1 \end{cases} \tag{1}$$

For the process described by 4 operating states, the above formula takes the form (2):

$$\begin{bmatrix} \pi_1 \\ \pi_2 \\ \pi_3 \\ \pi_4 \end{bmatrix}^T \cdot \begin{bmatrix} 0 & p_{12} & p_{13} & p_{14} \\ p_{21} & 0 & p_{23} & 0 \\ p_{31} & p_{32} & 0 & 0 \\ p_{41} & p_{42} & p_{43} & 0 \end{bmatrix} = \begin{bmatrix} \pi_1 \\ \pi_2 \\ \pi_3 \\ \pi_4 \end{bmatrix}^T \tag{2}$$

with the normalization condition (3):

$$\pi_1 + \pi_2 + \pi_3 + \pi_4 = 1 \tag{3}$$

which is equivalent to the following system of equations:

$$\begin{cases} \pi_2 \cdot p_{12} + \pi_3 \cdot p_{13} + \pi_4 \cdot p_{14} = \pi_1 \\ \pi_1 \cdot p_{21} + \pi_3 \cdot p_{23} = \pi_2 \\ \pi_1 \cdot p_{31} + \pi_2 \cdot p_{32} = \pi_3 \\ \pi_1 \cdot p_{41} + \pi_2 \cdot p_{42} + \pi_3 \cdot p_{43} = \pi_4 \\ \pi_1 + \pi_2 + \pi_3 + \pi_4 = 1 \end{cases} \tag{4}$$

The solution of the equation [Grabski & Jaźwiński, 2009] are the stationary probabilities π_j presented in Table 11.

Table 11. Limit probabilities of the Markov chain

State	π_j	π_j[%]
S1	0.3968	40
S2	0.1250	13
S3	0.2797	28
S4	0.1984	20

Source: own study

The calculated probabilities express the limit frequencies of the system remaining in particular operating states. The highest value refers to the state in which the vehicles are subject to repair operations. It equals 40% and is, together with state S4, for which the limit value is 20%, a desirable and necessary element of the whole subsystem (60% incidence frequency of all observations). The remaining 40% consist of the frequency of waiting for spare parts and mechanics, the incidence of which should be as low as possible. However, because these are the results concerning the frequency of occurrence of particular states in the set of events, they may not fully reflect the specificity of the process. The parameters calculated for the Markov process for continuous physical time will be more important.

The first step of such analysis is to determine the value of the elements of the transition intensity matrix Λ which is another important characteristic of Markov process. For homogeneous processes, these elements are constant and equal to the opposite of the value of the expected conditional state duration S_i before S_j (5). On the other hand, the intensities $\lambda_{ii} \leq 0$ for $i = j$ are defined as a complement to the sum of the intensities of transitions from state S_i for $i \neq j$ to S_j (Bielecki et al., 2017):

$$\lambda_{ij} = \frac{1}{E(t_{ij})} \tag{5}$$

The first step was to calculate the average conditional duration of particular states. The obtained results, expressed in hours, are presented in Table 12.

Table 12. Expected conditional values of durations of particular operating states [h]

State	S1	S2	S3	S4
S1	0	16.6	16.4	16.5
S2	1.9	0	2.1	0
S3	12.1	11.85	0	0
S4	0.9	0.87	0.99	0

Source: own study

This allowed to calculate, according to the conditional formula (5), the values of transition intensity of the Markov process, presented in Table 13.

Table 13. Transition intensity matrix of the distinguished operating states

State	S1	S2	S3	S4
S1	-0.18	0.06	0.06	0.06
S2	0.53	-1.00	0.48	
S3	0.08	0.08	-0.17	
S4	1.11	1.15	1.01	-3.27

Source: own study

The determined transition intensity matrix allows to determine the limit probabilities p_j in continuous physical time. To this end, it is necessary to solve the system of equations (6):

$$\begin{cases} \Pi^T \Lambda = 0 \\ p_1 + p_2 + p_3 + p_4 = 1 \end{cases} \tag{6}$$

where:

$\Pi^T = [p_j]^T = [\,p_1\,;\,;\ p_4\,]$ is the transposed (line) vector of limit probabilities p_j of states S_j number $j \in \{1;\,;4\}$,
For the studied process, the equation (6) takes the form:

$$\begin{bmatrix} p_1 \\ p_2 \\ p_3 \\ p_4 \end{bmatrix}^T \cdot \begin{bmatrix} -\lambda_{11} & \lambda_{12} & \lambda_{13} & \lambda_{14} \\ \lambda_{21} & -\lambda_{22} & \lambda_{23} & 0 \\ \lambda_{31} & \lambda_{32} & -\lambda_{33} & 0 \\ \lambda_{41} & \lambda_{42} & \lambda_{43} & -\lambda_{44} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}^T \tag{7}$$

Which comes down to solving the system of equations (8):

$$\begin{cases} -\lambda_{11} \cdot p_1 + \lambda_{21} \cdot p_2 + \lambda_{31} \cdot p_3 + \lambda_{41} \cdot p_4 = 0 \\ -\lambda_{22} \cdot p_2 + \lambda_{12} \cdot p_1 + \lambda_{32} \cdot p_3 + \lambda_{42} \cdot p_4 = 0 \\ -\lambda_{33} \cdot p_3 + \lambda_{13} \cdot p_1 + \lambda_{23} \cdot p_2 + \lambda_{43} \cdot p_2 = 0 \\ -\lambda_{44} \cdot p_4 + \lambda_{14} \cdot p_1 = 0 \\ p_1 + p_2 + p_3 + p_4 = 1 \end{cases} \tag{8}$$

The obtained results are presented in table 14.

Table 14. Limit probabilities p_j of the system remaining in states S1-S4 in continuous physical time.

	S1	S2	S3	S4
pj	0.4876	0.0739	0.4296	0.0089
pj %	49	7	43	1

Source: own study

The calculated values P_j are limit probabilities determining that the system will be in a given operating state for a longer period of operation ($t \to \infty$). In this case, the highest probability concerns state S1 – repair, and equals almost 49%. The dominance of this state is a positive result, but value for state S3 is also alarmingly high, at 43%. This means that the limit time spent in the repairs state is almost equal to the duration of the state of waiting for parts. Other results are satisfactorily low, 7% value is generated by delays related to the absence of staff, and diagnostics amounts to only 1%.

The obtained limit probabilities of the Markov process clearly indicate the area requiring correction and the reason for prolonged repair times. It is necessary to reorganize the system of ordering spare parts by, for example, renegotiating contracts with suppliers, increasing the inventory of the most frequently needed components or creating the so-called technical first aid kits including components of the electrical system such as alternators and starter motors, the acquisition of which from the market is often associated with long waiting times, while the replacement process itself is not time-consuming.

The calculated limit probabilities can be presented as a function of time, because they fulfil the Chapman – Smoluchowski – Kolmogorov differential equations. This dependence, in the form of a matrix is represented by the equation (9).

$$\prod^T \Lambda = \frac{d\prod^T}{dt} \tag{9}$$

Which, for the system under examination, takes the form (10),

$$\begin{bmatrix} p_1(t) \\ p_2(t) \\ p_3(t) \\ p_4(t) \end{bmatrix}^T \cdot \begin{bmatrix} -\lambda_{11} & \lambda_{12} & \lambda_{13} & \lambda_{14} \\ \lambda_{21} & -\lambda_{22} & \lambda_{23} & 0 \\ \lambda_{31} & \lambda_{32} & -\lambda_{33} & 0 \\ \lambda_{41} & \lambda_{42} & \lambda_{43} & -\lambda_{44} \end{bmatrix} = \begin{bmatrix} p_1{}'(t) \\ p_2{}'(t) \\ p_3{}'(t) \\ p_4{}'(t) \end{bmatrix}^T \tag{10}$$

solved with the normalization condition (11),

$$\Sigma j \; p_j \; = \; 1 \tag{11}$$

therefore, the system of differential equations equivalent to the above relations has the form:

$$\begin{cases} p_1{}'(t) = \; -\lambda_{12} \cdot p_2(t) - \lambda_{13} \cdot p_3(t) - \lambda_{14} \cdot p_4(t) + \lambda_{21} \cdot p_2(t) + \lambda_{31} \cdot p_3(\\ p_2'(t) = \; -\lambda_{21} \cdot p_1\,(t) - \lambda_{23} \cdot p_3(t) + \lambda_{12} \cdot p_1(t) + \lambda_{32} \cdot p_3(t) + \lambda_{42} \cdot p_4 \\ p_3'(t) = \; -\lambda_{31} \cdot p_1\,(t) - \lambda_{32} \cdot p_2(t) + \lambda_{13} \cdot p_1(t) + \lambda_{23} \cdot p_2(t) + \lambda_{43} \cdot p_4 \\ p_4'(t) = \; -\lambda_{41} \cdot p_1(t) - \lambda_{42} \cdot p_2(t) - \lambda_{43} \cdot p_3(t) + \lambda_{14} \cdot p_4(t) \\ p_1(t) + p_2(t) + p_3(t) + p_4(t) = 1 \end{cases} \tag{12}$$

The solution of this equation, obtained with the assumption that at the initial moment of time $t = 0$ process $X(t)$ is in state S4 – diagnostics, time dependencies of probabilities of observation of states S1-S4 occur, which are described below – equations (13-16):

$$P_1(t) = \frac{-0.27\,e^{1.3\,t} - 0.22\,e^{3.54\,t} - 0.006\,e^{4.4\,t} + 0.49652012919442656 e^{4.6\,t}}{1{,}6 \times 10^{-15} e^{1.3\,t} - 3{,}9 \times 10^{-16} e^{3.5\,t} + 9{,}7 \times 10^{-19} e^{4.4\,t} + 1,e^{4.6\,t}} \tag{13}$$

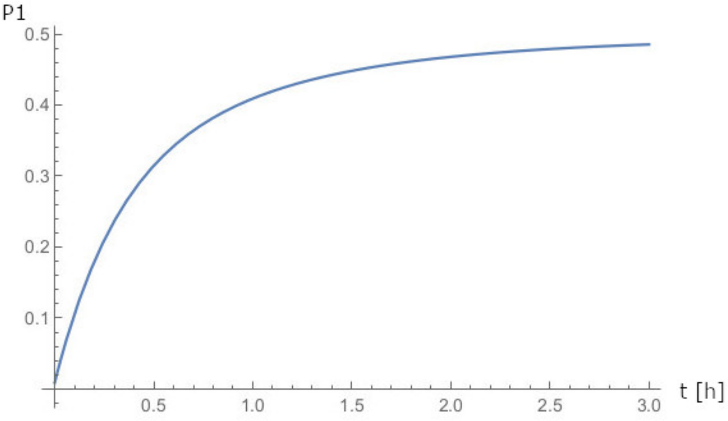
$$P_2(t) = \frac{-0.49\,e^{1.34\,t} + 0.41\,e^{3.54\,t} - 0.000009\,e^{4.37\,t} + 0.07 e^{4.62\,t}}{1{,}55 \times 10^{-15} e^{1.33\,t} - 3{,}9 \times 10^{-16} e^{3.54t} + 9{,}74 \times 10^{-19} e^{4.37t} + 1.\,e^{4.62t}} \tag{14}$$

$$P_3(t) = \frac{-0.24\,e^{1.33\,t} - 0.19\,e^{3.54\,t} + 0.006\,e^{4.37t} + 0.43 e^{4.62\,t}}{1{,}55 \times 10^{-15} e^{1.34\,t} - 3{,}91 \times 10^{-16} e^{3.54\,t} + 9{,}74 \times 10^{-19} e^{4.37\,t} + 1.\,e^{4.62\,t}} \tag{15}$$

$$P_4(t) = \frac{0.99\,e^{1.34\,t} - 0.006\,e^{3.54t} - 0.0001\,e^{4.37\,t} + 0.008946308634133860 e^{4.62\,t}}{1.55 \times 10^{-15} e^{1.33\,t} - 3.9 \times 10^{-16} e^{3.54\,t} + 9{,}74 \times 10^{-19} e^{4.37t} + 1.\,e^{4.62\,t}} \tag{16}$$

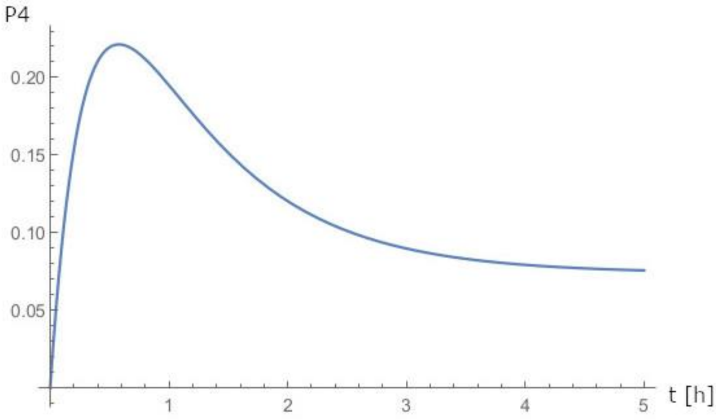
They allow to make a graphical representation of the system's achievement of limit equilibrium. Sample graphs for the state with the highest probability value – S1 and for the state with the lowest value – S4 are shown in Fig. 26 and Fig 27.

Figure 29. Time for reaching the limit equilibrium for state S1



Source: own study

Figure 30. Time for reaching the limit equilibrium for state S4



Source: own study

The results obtained indicate that the system reaches the state of limit equilibrium a few hours after inducement. This means that the processes are stabilized and will not improve without specific and decisive steps. Therefore, it is foremost necessary to thoroughly diagnose the causes of prolonged spare parts waiting times and to take initiatives to improve the process.

5. FINAL THOUGHTS

The company's activity is influenced by many elements, which together define the reliability of the entire system. Its smooth operation requires control over each area, including the one related to the repair of technical objects. It is often a case that only a thorough diagnosis of repair processes exposes their shortcomings. It also allows to indicate directions for improvement. Mathematical methods and tools supporting the evaluation of processes are helpful in this respect.

The article presents the possibility of using one of such tools. Modelling using Markov processes was selected. They are used to describe random processes, which undoubtedly include tasks performed by vehicles. On the basis of the data on repairs provided by the transport company, an assessment of the repair subsystem was made and a long-term forecast was presented for the implementation of the individual states distinguished for the studied system.

The conducted research allowed to indicate the characteristics of the system, especially long stays in the state of waiting for spare parts. In the author's opinion, the problem related to restocking the components necessary to perform repair operations is that it takes too long and it requires detailed analysis and correction. There is a chance that, after appropriate changes, the total time spent by vehicles in the repair subsystem will be reduced.

The aim of the article was also to show that it is possible to apply mathematical modelling for assessment and shaping of the repair subsystem in a vehicle operation system (transport company). Reliable forecasting in this area is important both for the persons responsible for it and for the freight forwarder securing the assigned transport tasks.

In the course of further research directions, primarily it is worth making a detailed analysis of the repair subsystem, which will allow to diagnose the cause of prolonged waiting times for spare parts. In a broader perspective, it is worth considering the possibility of automation and computerization of the presented calculations. This would increase the usefulness of the proposed method by making the form of the presentation of complex mathematical procedures useful for transport system owners/users, e.g. simple mobile applications.

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THE FORMS AND CONDITIONS OF SUCCESSFUL CONFLICT MANAGEMENT IN THE METAL AND MACHINERY SUPPLY CHAINS

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Abstract

According to a basic theory of sociology conflict belongs to life so it belongs to business life as well. If we face this view logically the next step is how companies avoid the unnecessary conflicts and how they handle inevitable conflicts. Our empirical paper suggests several successful conflict management methods which were identified through qualitative methodology. In depth interviews managers from the metal industry and machinery supply chains explain their experiences and failures regarding conflict management. We found that business actors do their best to avoid legal procedure as conflict resolution. They prefer different informal tactics for managing conflict such as better communication or personal discussion. However formal solutions are becoming increasingly important. For example nowadays a used complex enterprise resource planning (ERP) software heavily determines actions and timing of actions upon deviation from normal or agreed business processes which leaves little room for human words and reflection. We suggest some proven methods for successful conflict management. Based on our results and experiences a larger scale, quantitative survey could give more general results.

Key words: conflict management, supply chain management, metal and machine manufacturing supply chain

1. INTRODUCTION

The efficiency of any transaction in the supply chain depends to a large extent on a trust-based business relationship (Wu et al., 2012). Finding a strategic supplier on a business-to-business basis is crucial to business success, as it reduces transaction costs, but not only cost savings are a key factor, but rather an increase in ownership and stakeholder value. Supply chain integration is a strategic tool as it attempts to minimize operational costs and thereby add value to customers and shareholders (Kwon & Suh, 2005; Lee, Kwon & Servance, 2007). In the relationship between suppliers and customers, the source of the conflict can put the companies concerned on the opposite side. Each actor only sees part of the image and ignores global or network-level optimization. In such circumstances, it would be difficult for global or even any competition to maintain the growth path. Because each party only seeks local optimization long-term success will not be fulfilled.

The conflict is a visible struggle, with a minimum of two, somewhat interdependent parties, with incompatible goals, little reward (Hocker & Wilmot, 1985). Practically "conflict is a way of life in relationships that can be explicitly and implicitly expressed, but it is the way in which we handle or manage these conflicts that determines the quality of our relationships" (Tatum & Eberlin, 2006).

Dyadic business relationships involve countless disagreements and conflicts, additionally all of which appear generally in business networks and in supply chains. However, supply chains are growing, developing and even surviving various difficulties, but even crises. This suggests that they are able to handle different problems and disagreements flexibly. It seems that actors of supply chains apply consciously or instinctively various successful and effective conflict management techniques.

Supply chains, by their nature, tend to show sectoral differences, so we have narrowed our research into a sector, which is metal and machine manufacturing. In our qualitative survey what we want to know are the followings:

a) how practitioners handle their problematic business partners;
b) what kinds of conflict management tools or other techniques seem to be successful;
c) if they terminate any of their most cumbersome, problematic business ties.

Before introducing our empirical findings we show a short theoretical background.

2. LITERATURE REVIEW

Social Exchange Theory comes from sociology (Blau, 2009; Emerson, 1976) and from social psychology (Thibault & Kelley, 1959) and describes the functions of interpersonal relationships. The essence of the Social Exchange Theory is that people consider social interactions based on their social and / or economic benefits. Comparison of all the parties makes it possible to examine the benefits of possible relationship alternatives and thus to assess the relationship dependence. If after a while the balance of the economic and social development of the relationship is considered positive, trust between the parties begins to grow, and it is in the interest of all stakeholders to maintain the relationship in the long term (Lambert et al., 2001). As a result of his research at the micro level, Peter Blau raised the theory to the macro level and concluded that Social Exchange theory pervades the social world, forming an endless series of exchanges (Blau, 2009).

Business relations are economic, legal, technical, technological, social, and administrative ties. According to the relationship marketing, the concerned parties share their common interests and form a community. Relationships in general are not concentrated on one contract but the processes are influenced by the constant change and adaptation (Elo, 2003). In a business relationship – and generally in a supply chain as well – organizational goals are completely convergent. Different views that can evolve in unexpected situations during a relationship can lead to disputes that can turn into misunderstanding or conflict. According to several authors, cooperation is the counterpoint to conflict. However there are several and various conflicts between business partners emerging due to constant political, legal, economic and social changes. On the other hand, the changes have been becoming integrated, so business integration is not just new opportunities, but also unexpected conflict situations. It may happen that a company has to work with a former competitor in a new network (Hagberg-Andersson & Tidström, 2008). Gadde and Håkansson (1993) claim that cooperation, conflict and competition can coexist. According to them on one network suppliers compete, but may cooperate in another situation. If we wish to understand this situation, we should investigate this not only from the perspective of a central company within the network but also from non-central relationships between suppliers. Piricz (2018) empirically find that actors of supply chains already see their network as a natural condition however this view is rather passive and based on acceptance. They still clearly prefer to manage their dyadic relationships even if they realize certain network-level problems.

Therefore it is important and useful to manage customer relationships accordingly for the following reasons (Ford, Gadde, Hakansson & Snehota, 2006):

- Reduces or resets the cost of searching for new customers or suppliers.
- Enables employees of the organization to understand customer problems and also to learn about their own skills in order to get develop a better offer for them.
- Reduces adaptation costs once you have reached your relationships initial investment.
- Reduces the cost of interaction, such as buying and selling time spent on checking.
- Enables employees to focus on important customer resources.

In a situation where trust is high, the parties share their doubts much more easily, thus reducing the risk of conflict (Jap and Ganesan, 2000). By contrast, however, it is logically assumed that trust can increase the incidence of conflict. Indeed, in a situation where there is trust between the parties, but their motivations are different and there are no effective governance structures, conflicts can be predicted. However, a study points out that a long-term relationship that is able to survive these conflicts tends to create fewer new conflicts because of the experiences accumulated in the vascular treasures (Zaheer et al., 1998).

According to the definition of Hunger and Stern (1976), conflict is an "opposite-cantered episode," or a series of episodes which are based on directions, goals, or values. Hagberg-Andersson & Tidström (2008) see that, conflict situations are usually short and other researchers point out that the quality of the relationship is fundamentally conflict management (Tatum & Eberlin, 2006). Conflict often means a certain process that is at different stages (Thomas, 1992; Pondy, 1967).

Power plays a decisive factor during behavioural perceptions (French & Raven, 1959), and has impact on reaction as well (Wilkinson, 1996; Kähkönen, & Lintukangas, 2011). A business relationship determines the position of the parties involved and these positions will, by their nature, affect companies' relationships with others, both directly and indirectly (Johanson & Mattsson, 1992). Blois (2008) adds despite the fact that a business relationship is asymmetric and even conflicting, it can work successfully for decades.

Bahlmann, Schulze & Spiller (2007) collect those dimensions which are considered to have negative effects on trust between business actors; opportunism, power asymmetries and structural bonds. However conflict usually misses from these negative lists.

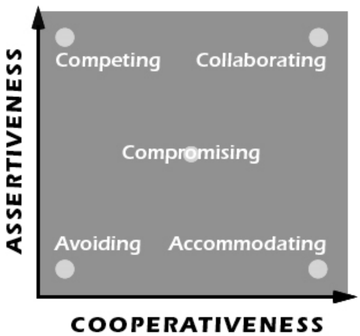
If we accept the general view of sociology that conflict is a natural part of life, we should concentrate on preventing or solving conflicts. To see clearly we should define conflict management, which is opposed to resolution of conflict. According to Robbins (1978) and Boulding (1968) the difference is more than semantic. "Conflict resolution implies reduction, elimination, or termination of conflict" (Rahim, 2001:75). Conflict management however is boarder term and means more active approach. It involves design of proper efficient strategy, taking relevant steps within a process of organizational learning and increasing efficiency of company (Rahim 2001).

The conflict management process includes (Rahim, 2001): 1) Diagnosis: The involved actors recognize and identify the problem. This first step is vital while this determinates the other future decisions and actions as well. Some scholars suggest certain formal and informal techniques for this (for example Brown, 1979; DuBrin, 1972). 2) Intervention: They decide if intervention is necessary, and if so, what from. 3) Process: This part is little similar to Intervention but this is a bit broader and basically include a few relevant organizational learning and acquiring some new skills at company level. This stage could support company resilience however after a concrete fire-fighting specific conflict solution, system-level problem management is often missing. In summary, conflict management should be fulfilled first at individual, then group and company level as well.

Some experts suggest turning to a third, neutral actor or a mediator (Jameson, 1999) or using a proper communication concept (Magrath & Hardy 1989).

Kemp and Ghauri (1999) claims that trust and norms that are long-term development results which reduce the potential for conflict. This view is confirmed by Hausman (2001) who found fewer constraints and fewer conflicts in case of longer-term relationship. Other researchers have experienced an increase in sales under similar circumstances (Woodburn et al., 2004).

Figure 1. An Overview of the Thomas-Kilmann Conflict Mode Instrument



Source: [available at: https://www.kilmanndiagnostics.com/overview-thomas-kilmann-conflict-mode-instrument-tki access May 7, 2019]

The Thomas-Kilmann Conflict Mode Instrument (TKI) focuses on personal conflict management by using two dimensions in their model which are assertiveness and cooperativeness as it can be seen in Figure 1. In this system they identify five methods of dealing with conflict: Competing – "simply trying to win"; Collaborating – "competing for resources, or confronting and trying to find a creative solution"; Compromising – "the objective is to find an expedient, mutually acceptable solution that partially satisfies both parties"; Avoiding – the person "does not address the conflict" but rather withdraws; and finally Accommodating – a "form of selfless generosity or charity, obeying another person's order" (Thomas and Kilmann, 2008:3). While this Conflict Mode Instrument is one of the most cited conflict management models we analyse our results with the help of the methods above.

3. OUR EMPIRICAL RESEARCH

As a short methodology explanation this survey is the Hungarian pillar of a Finnish scientific project. The methodology of the research – in which companies in Hungary, operating in the supply chains of metal and machinery industry – are surveyed for business ethics and more connecting topics – was developed at the University of Turku. The in-depth interviews are semi-structured, so we did it on the basis of relatively detailed sketch points, and sometimes we did not touch all the points during the conversation (Malhotra, 2007). The pilot survey was conducted in Finland. Finally ten depth interviews could be fulfilled in 2015-2016 in Hungary whereby in 3 cases the interviewees are experts and in the other cases we talked to different levels of leaders in companies – such as commercial director, quality senior manager, CEO – operating in metal and machinery supply chains. The companies represented by the managers are different in terms of both size and market orientation but the respondents are mainly small and medium-sized and multinational companies that are either exporting or are essentially on the domestic market. In spite of this, our research is not representative therefore our conclusions must be treated with this restriction.

We turn our focus on metal and machinery industry due to the following reasons. According to statistics in Hungary this sector has attracted the most of FDI (half of total inflow has focused there). For example in mechanical engineering foreign ownership represents 78 %. Almost three forth of industrial investments are fulfilled by foreign companies (Karsai, 1999). Inzelt and Szerb (2006) state that the social impact of FDI may contribute to Hungarian citizens' fear of losing national identity meanwhile Farkas (2002) calls the increasing number of foreign companies and their business relationships as 'technological economic dualism'. However this sector contributes heavily to the dynamic growth in Hungarian industry.

In this paper we introduce our results concerning conflict management which are summarized in Table 1. Here we structure the main characteristics of applied conflict management methods by our respondents. Based on this we create 4 categories (Formalized solution processes, Better communication, Informal resolution and Legal process) and investigate if these groups fit the Thomas-Kilmann Conflict Management Model. While the building elements of this Model are broad we can integrate our results in this well-known model.

Generally we can say that basically the methods and approaches in cases of conflicts depend on situations, e.g. volume and nature of risks, importance and size of business partner, type of relationship (e.g. strategic partner) and market situation (e.g. existence of substitute product/ supplier). Below we describe the conflict management methods and characteristics of each category.

Formalized solution processes. The large companies usually prefer formalized solutions. According to their logic: Point 1: Immediately solve the problem, Point 2: See who caused the problem. In another case complain-resolution is fulfilled in 8 steps in a huge multinational company while there is no quality control of in-coming stocks (it is the task of the supplier). These steps are fixed in their supplier's handbook and each of their suppliers has to accept this handbook too. In quality management the “technique” of self-accusation is well-known which means that a company recognizes its own fault or mistake and inform the involved partners immediately and does not wait if the others notice this or not. These kinds of processes may give little freedom for personalized, flexible solutions but can be beneficial because of their automatic and visible nature.

One of the experts emphasizes that traditional – operative – communication is vital here due to more reasons: a) the scheduled delivery constraint, b) constantly working technology in the metal sector as well, c) the blast furnace cannot be stopped (just a little restraint). Another expert complains about the routines, which are heavily determined by the applied ERP software (e.g. SAP).That’s why they exclude flexible, informal solutions and prevent any compromises (e.g. reminding or warning messages go out automatically in case of payment delay). In these solution forms we cannot recognize cooperativeness but rather assertiveness that’s why we think this category belongs to Competing in Thomas-Kilmann Model.

Better communication. Honesty was always the subject of strong debate, especially in business. One of our respondents thinks that sincerity is thin ice but adds it is the best in long term! As a researcher of this survey I note that each of our interviewee represented successful companies and these firms have been operating for more than 15 years. These practitioners from metal,- or machinery supply chains highlight the importance of understanding of mutual interest and correct communications however they often explain unethical or even illegal behaviour in their practice. But it seems they have a strong belief that sooner or later, unethical and unprofessional actors will be revealed, and the market will slowly clearer and clearer. Generally these approaches show an unambiguous wish and will for Compromising.

Informal resolution has long traditions in business and naturally it is a frequently used set of tools between coequal parties. But we found that personal arrangement plus flexibility were actively applied also in metal and manufacturing sector in case of high tech product packages, more concretely among actors of very different sizes in alternative energy branch. Therefore we have the view that these resolutions include both Compromising (“moderate in both assertiveness and cooperativeness”) and Collaborating which “involves an attempt to work with others to find some solution that fully satisfies their concerns” of Thomas-Kilmann Conflict Mode Instrument.

Legal process, lawsuit. None of respondents has finished a business relationship due to conflicts but every time they try to find solution. A CEO says: “If we go to court, it will result liquidation” (for either or both parties). He adds that here prices start at millions, which is taken seriously by both parties; supplier sees price, and buyer considers value. If the dispute is not resolved in a short time, they will have to resolve it over a longer period of time. "If the two sides understand the needs of the other, it is very easy to get to the vineyard. There may be fierce debates, but we can agree and everyone is happy."

Table 1. The forms of successful conflict management among companies comparing with the elements of Thomas-Kilmann Conflict Mode Instrument

Thomas-Kilmann Conflict Mode Instrument	Categories of our survey	Main features of our survey
Competing	Formalized solution processes	based on internal policy
		scenarios of (multinational) supplier's handbook
		heavily determined by the applied ERP software (e.g. SAP)
		self-accusation (often in quality management)
Compromising	Better communication	being sincere – best in long-term
		understanding of mutual interest
Compromising, Collaborating	Informal resolution	discussion between coequal parties
		personal arrangement
Accommodating	Legal process, lawsuit	actually almost never

Source: Own study based on empirical results and the Thomas-Kilmann Conflict Mode Instrument

A sample and condition of relationship-termination: "a business connection had to be interrupted because the buyer wanted a technological or manufacturing process that we could not satisfy; or because on the spot – for example in Romania – they can produce it cheaper."

Briefly we can say business actors do their best to avoid lawsuit and prefer informal solutions. In this way this category theoretically belongs to Accommodating as its consequences ("unassertive", "obeying another person's order when you would prefer not to, or yielding to another's point of view.").

4. CONCLUSION

We have the view that the conflict approaches of Thomas and Kilmann can be identified in our survey as well. Due to technological development, globalisation and growth of company-sizes and the supply chains, the formalized solution processes are likely to strengthen which can create obstacles to flexible and formal relationship management solutions within supply chains as well. In parallel, various formal solutions and conflict-handling modes are also available (where these are not yet regulated by the used ERP system). Perhaps it is not surprising that companies do not like to sue (because of their risky and costly nature), but the fact that they remain in contact with a cumbersome, troubled business partner is, in fact, more limited in terms and conditions (for example regular prepayment). While the metal and machinery industry is traditionally capital, and technology intensive sector written communication is extremely important, which limits, often determines the ways and modalities of conflict management in these supply chains.

Qualitative methodology provides an excellent opportunity to present conflict situations, solutions in the network. However this methodology has natural limitations. The analyses of information received is difficult and complicating process. Besides small number of respondents there might be a possibility of misinterpretation which are limitations of such research.

On the basis of our results, we propose further research on the practice of managing the supply chain conflicts by sector. On the other hand, it would also be useful to learn about network-level good practices as they can contribute to increasing the stability and resilience of supply chains.

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CONCEPTUAL MODELING FOR DISCRETE SIMULATION OF SUPPLY CHAIN

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Abstract

Modeling and simulation is very powerful technique for studying complex systems. There exists increased concern of this phenomenon, generally through workshops, conferences and special journal issues during last several decades. Despite a number of case studies and books written, there is still some gap within methodology of modeling itself. Plenty of authors concerns much more on particular simulation study, its system and results and they do not dedicate a lot of attention to the methodology. The aim of this article is scope on the conceptual modeling for discrete-event simulation for supply chains as a vital part of whole simulation study. It concerns about the framework of conceptual modeling and conceptual model and their definitions and requirements and gives a guidance on conceptual modeling independently of the computer model coding.

Key words: Conceptual modeling, conceptual model, simplification, validity, credibility, utility, feasibility

1. INTRODUCTION

Modeling and simulation are very popular tool used for decision making by the manager in wide spectrum of business, mostly in production and services, transportation, supply chain management, hospitals, military etc. This continuous spreading of this method is supported by the hardware and software development. Computers with adequate or sufficient performance became accessible for more users, and even more people can prepare its modeling studies without knowledge of coding due to variety of modeling and simulation software.

Despite the spread of modeling and simulation, increasing number of conferences and workshops, papers and studies, there is still lack of books or studies focused at the conceptual modeling as the method itself. The main part of published studies pay attention mostly to whole case studies instead detail analysis and methodology of particular part of the simulation study preparation, such as conceptual modeling, experiments preparation and settings, result interpreting, although the understanding of each phase of modeling process and its contains is vital in order to reach expected output.

This paper focuses on the conceptual modeling and simulation for supply chain management. The aim is discuss the meaning of conceptual modeling as a method itself, description of the request on the conceptual model considering the aim of the model study and setting the its frame.

2. CONCEPTUAL MODELING

Conceptual modeling for discret event simulation deals with abstraction of the real system to the model, when the simulation models are simplifacion of the reality (Zigler, 1976). Subject of the conceptual modeling is the appropriate abstraction of reality (Pidd, 2003). These definitions indicate the meaning of conceptual modeling in general overwiev. The question is, how can be the terms conceptual model and conceptual modeling define precisely.

Generally, the meaning of conceptual modeling, used in studies of modeling and simulation, is rather vague than precise including different interpretation of terms. Usually, they agreed about the placement of the conceptual modeling to the early phase of the simulation study. This suggests a process from defining the problem to be solved by simulation to determining what is actually modeled and how.

Balci (1994) divides the initial stage of the modeling process into several steps - problem definition, assessment of simulation options, system definition and simulation goals, model formulation, model representation and programming, but does not indicate which of these steps are part of the conceptual modeling process and which not.

Similarly, Law (2007) defines the various steps in simulation processing - problem formulation and its understanding, data collection and model definition, model validation, model building and programming, initial simulation, model validation, experiment definition, implementation, analysis of outputs and usage results and dossier processing. However, it does not specify which of these steps belongs to the conceptual model preparation phase.

Nance (1994) separates the ideas of the conceptual model and the communication model. Such a conceptual model is then one that is in the mind of the modeler and the communication model represents the exact representation of the conceptual model. At the same time, it separates the conceptual model from the final model, in other words, the conceptual model does not deal with how the model will be programmed.

Significant debate over conceptual modeling was also conducted among modelers of military simulations. Pace (2000a) identifies the information provided by the conceptual model as a set of assumptions, algorithms, characteristics, relationships between elements and data. At the same time, it separates the conceptual model from the computer model and its programming. Furthermore, Robinson (2002) says that modeling of military simulators can be very different from business-oriented models.

Military models are often very large and are often developed by program developer teams. At the same time, these models are often required to be reused. Business-oriented models can be, in scope, simpler and at the same time one-time, as they are processed to address specific and specific systems. Although conceptual modeling requirements and procedures should be the same for both areas, it is advisable to keep this distinction in mind.

Based on the approach of individual authors, key elements of conceptual modeling and conceptual model definition can be identified:

• conceptual model is a simplified representation of the real system

• the conceptual model is independent of the model programming or the software used

• Conceptual modeling is a process from problem analysis to model requirements, modeling object definition and modeling methods

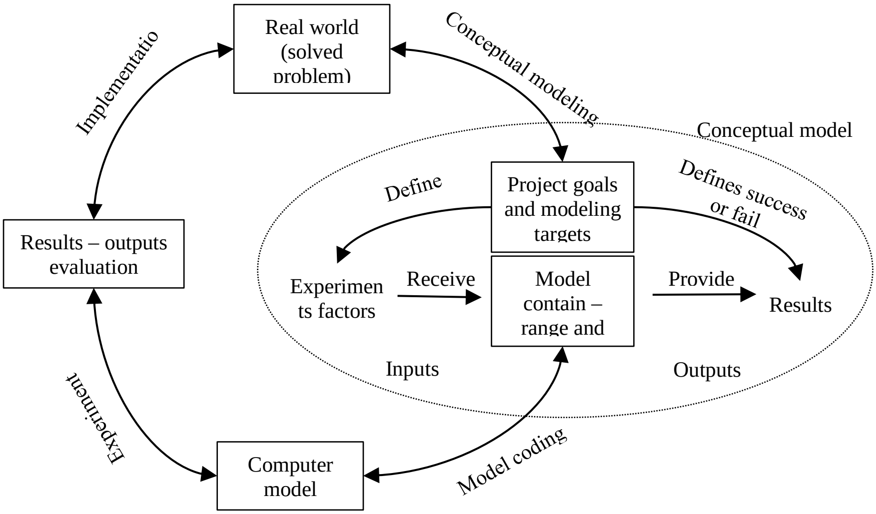
• the conceptual modeling process is iterative and repetitive in the ongoing review of the model study during its solution,

• For the conceptual modeling, both the client's perspective and the modeler's and expert's views, who can be involved in the study, play a role.

2.1. Definition of the Conceptual model

Figure 1 shows the conceptual model in the ellipse following the discussion in the previous chapter, incorporated into the broader context of the simulation study (Robinson 2004). The scheme includes key elements of the process in preparing and using simulation: conceptual modelling, model programming, experiments, and model implementation. At the same time, it shows the outputs of individual processes: conceptual model, computer model, results for improvement of the solved situation and own improvement of the solved problem. Bidirectional arrows represent mutual interaction, which means that, despite the logical sequence of individual implementation steps of the model simulation solution, situations arise where the findings in the sub-processes call for a revision of some attributes for correct modelling in order to obtain and valid model and relevant outputs.

Figure 1. Conceptual modelling in the framework of simulation study



Source: Robinson (2004)

As shown in this scheme, the conceptual model derives from an understanding of the real situation (the problem addressed). The interaction between the problem solved and the conceptual model suggests the fact that the modeller can, by querying the solved and modelled issues, bring the client into another possible view of the problem and thus influence the perception of this problem and adjust the simulation goals. The conceptual model itself consists of 4 main components - goals, inputs (experiment factors), outputs and model content.

The modelling goals set their own reason for model preparation and simulation. The general objectives of the project define the general nature of the model, in particular the time frame for its implementation, the requirements for flexibility, the visualization of results, the level of complexity of the operator, etc.

The definition of the project objectives is crucial for the actual elaboration of the model, which determines the final nature and use of the processed model. To put it simply, different project goals can lead to different outcome models when solving the same system. For this reason, goals are included as definitions of the conceptual model. The model simulation inputs are the variables that can change during the experiments, in order to evaluate their changes or in order to understand the behaviour of the system under different conditions and should be defined by the model objectives. The outputs are the results of the execution of each simulation experiment and have two main purposes: first, to determine whether the simulation objectives have achieved, secondly to identify the reasons why the model objectives have not achieved.

The content of the model includes the model's own elements and their behaviour, the links between them and the direction of their interaction, and the model content can be viewed on two levels – model range and model detail. The model range defines the part of the real world (its boundary), that is processed into this model, and the detail level specifies the level of details definition of the properties of all model components. The contents of the model derives from the required inputs and outputs and their accuracy, in order to be able to receive and process the required inputs and provide appropriate outputs with a given accuracy while allowing a correct and comprehensible interpretation of the results obtained. The definition of the model content, necessary prerequisites and simplification should be recorded in its dossier for further use.

Based on these ideas, a conceptual model definition can be formulate. **The conceptual model is then a specific description of the real system, processed outside the simulation software, to process its computer form, which describes inputs, outputs, content, assumptions and levels and methods of simplification**.

This definition directly states that the conceptual model is not proceed in the simulation program. In doing so, he says that the essence of the conceptual model is to design the appropriate model regarding its goals, regardless of how it will proceed by computer, so its processing should not be primarily influenced by the way it is programmed (programming in a particular programming language or its processing in selected simulation program). This is not denying the use of other programs for processing a conceptual model such as decision processors and development diagrams for a clear and illustrative flowchart, programs for drawing the system, spreadsheet for data preparation and definition of variables, or text editors for processing documentation to the entire model. In reality, however, we encounter a situation where the modeller has one or two simulation tools (or can use them) and his ability to process the computer version of the model according to his conceptual version then backwards the modifications of the conceptual model as shown in the figure by a two-way arrow. Limitation of modellers capability of coding or software application can bring more adverse effect to the whole model or simulation results.

It is worth noting that the definition does not state the form and detail of the documentation of the conceptual model. However, in view of the fact that the definition emphasizes the separation of the conceptual model from its numerical form, explicit processing in some form of formal document is beneficial and in some cases necessary to achieve and demonstrate compliance between the client, the modeller and any experts involved in the processing a conceptual model. At the same time, the importance of processing this documentation is to capture all the adjustments to the project objectives that have occurred in the conceptual modelling process, to understand and agree with all stakeholders. This documentation allows for precise processing of the resulting model in the simulation program, and subsequently evaluates whether the processed model corresponds to the objectives of the study commissioning by the contracting authority and thus eliminates possible disputes during its presentation and handover to the customer.

An equally important benefit of the explicit processing of the conceptual model, including its documentation, is the definition of all model components, its characteristics, and the links between them. This enables, if necessary, independent verification and validation of the model, utilization of the model or its part to solve similar or identical systems with different targets (desired outputs). The quality of the processed documentation significantly helps to understand the model, compare the goals achieved with the planned ones, and at the same time, it enables the understanding of the processed algorithms and the ligament for the solving team members.

In conclusion, an explicitly elaborated and clearly defined conceptual model provides an appropriate tool for communication between all stakeholders during the implementation of the entire simulation study. In this way, it enables correct understanding of the situation and the correct character of the model, the course of its simulation and consequently its application in practice.

2.2. Conceptual model requirements

Modelling as such is not a simple matter because it is difficult to define measurable criteria, to evaluate this process or the model's own value. Nevertheless, it is recommended to have a set of criteria that help us to maintain the planned direction of the study in the modelling process and indicate whether the model is appropriate to the objectives of the study. Setting criteria for models and modelling has been discussed in a wide-ranging review by authors, such as Gass and Joel (1981), Robinson and Pidd (1998) and Balci (2001), but their focus was rather on setting criteria for the constructed model than on their own conceptual modelling. In terms of setting the criteria for conceptual modelling, let's mention, for example, Willemain (1994), which lists 5 properties: validity, usability, customer value, feasibility, and suitability for solving the problem however, there are other studies that even list up to 11 criteria. Taking into account individual studies, we will focus on four main requirements, namely validity, credibility, usefulness and feasibility.

In general, there is a consensus that a valid model is a model that accurately describes the problem addressed. In a situation where we consider that the conceptual model does not necessarily have numerical outputs, **we can define validity as a possibility of processing a conceptual model into a computer model that displays reality with sufficient precision from the modeller's perspective**.

The ability to process into a computer model as one dimension of validity shows the fact that the conceptual model itself is a simplified description of reality and not just its computerized version. The validity of the model, as defined above, emphasizes that this is the modeller's opinion, while taking into account the fact that each model is designed for a specific purpose that provides a framework for self-evaluation.

The credibility of the model can be considered similarly as validity, but rather from the perspective of the customer rather than the modeller. Then, similarly, we can say that **credibility is the possibility of processing a conceptual model into a computer model that displays reality with sufficient accuracy from the perspective of the customer.**

It expresses the fact that it must be convinced that the model is sufficiently precise to solve the desired problem, i.e. it contains all the required elements of the system with all the proper features and links. At the same time, it is essential that the customer understands the model and its results.

Validity and credibility distinguished differently, because of a different view of the final model. There might be a situation, where the model author is convinced of its validity and the submitter is not. In this case, the model should be adjusted by additional elements or details, which do not affect its validity, but will increase its credibility on the part of the client. Extending the model for credibility is not inherently a negative phenomenon, but the modeller should not allow such an extension of the model to lead to an overly complex and confusing model.

The third requirement for a conceptual model is its usability. Here we can define **the possibility of processing a conceptual model into a computerized form, which will be usable as a tool for decision-making in a given situation, both from the client's perspective and from the perspective of the modeller.**

It is a consistent attitude of both the customer and the modeller to evaluate the model with respect to the objectives and purpose behind which the entire simulation study is being proceed. The main question here is no longer the accuracy of the model, but the suitability and accuracy of the final model as required. It can include customer-friendliness, flexibility (the ability to change some model components or variables), and simulation speed, visual processing of results, or in some cases the ability to use the entire model or part of it to solve other problems.

As part of the simulation studies, a conceptual model can be developed, which is valid from the perspective of the modeller and trustworthy from the customer's point of view, however, due to its complexity, time-consuming or cumbersome nature, its usability is limited or zero.

The last of the conceptual model requirements discussed is feasibility. **This can be defined as the conviction of the client and the modeller that the conceptual model can be converted into its computerized form at the scheduled time, with the given resources and available data.**

There can be countless situations, which have a major impact on the feasibility of a simulation study. During the analysis of the study objectives, we can find that we do not have enough information about the real system or that the modeller does not have sufficient skills to process a computer model, obtaining the necessary data can be difficult or impossible, etc. Another factor may be the mutual misunderstanding of the study with it can lead to the extension of the study award, thereby increasing the time and financial resources to implement it.

These conceptual model requirements are not isolated but generally related and they need the evaluation on a case-by-case basis. In some cases, we can find that the solved model is not, in its scope, feasible by means of a computer simulation, but a conceptual model that has been designed can be useful for understanding the real system. On the contrary, a simulation study is finalize to a computer model, but with the passing of time, its purpose can expire or disappear for some unforeseen reason.

3. LESSON LEARNT

We started to prepare several models at the University of Defence concerning the military supply chain, mainly in the foreign operations of the Army of the Czech Republic and during the lessons with our students. According our specialization, we are not real coders, but logisticians and managers, what is the main reason we have to use the modelling a simulation software instead model coding.

During our first models, students did not follow precisely the conceptual model methodology; mainly they did not clarify the questions, which should the simulation response and they started immediately design the model in available software without preparation of the conceptual model. This caused them huge loss of time due to the repeated changes of the model design.

The second problem were changes of the model´s setting during validation due to misunderstanding the function of the model validation. They tried to change several elements of model and its behaviour in order to receive like hood or expected results instead to do proper analysis of the results and finding why the results are different from expected one and its justification.

Just the student does not do mistake. My personal experience from the deviation of the methodology was also negative Brunclik, Vogal and Foltin (2018). We prepared particular model for the conference and due to some delay during the modelling; we did not note immediately changes or adjustment to its documentation. In that case, we spent a lot of additional time during the paper preparation and justification the final model settings.

Specific situation occurred very often even with the over expected possibility of the simulation regarding the model details. We started prepare the model and put there immediately lot of details. During the phase of the construction of the model, we decided to put less effort about the model run animations, and we put more effort in order to receive valid and accurate outputs. This decision brought us more time for data analysis and justification of results instead useless animation.

4. CONCLUSION

Despite the wide spread of modelling and simulation to practice we can still register a lack of books, which would not solve particular case studies, but which should be aim to the methodology of modelling and simulation itself. However, not precise or vague definition of all phases of modelling study and its misunderstanding by a client or a solver leads to repeating problems or incomprehension during solving of the study, repeating changes of requested outputs, expected objectives etc. Those causes considerable loss of time and money during the study and they even cause its fail.

Extensive study of discrete event models and simulation is not important just for the solving of study cases, but especially for further development of this method and avoiding its degradation to “executing case study in software”, how it is very often taken by the public without deeper understanding of the whole problematics.

The design of a conceptual model for discrete event simulation has its own place in the process of simulation study. The separation of this part from model coding by simulation software or by the code, underlines its value and importance in analytic a conceptual phase of simulation study, which should be solved by modelling and simulation. It shows that the biggest part of work, including system analytics, system model design, its parts (elements) and links between them, their behaviour etc. have to be done before the coding. Simultaneously, there is the place for discussion, adjustment of objectives and outputs of experiments and other system settings when necessary.

I suggest finishing design the conceptual model before the programing (coding) phase and do not let decrease the quality or approach for solution up to personal knowledge of coding. It does not mean that there is no chance to adjust the structure of outputs during coding phase, but it should be in minimum cases, but the reason should not be personal lack of coding capability, that we can hire another coder with sufficient capability.

The very important part of modelling study is the detailed documentation of the conceptual model and the study itself. The importance of it bases on recording of the approach of problem solution – data resource and data analysis tools, designing the model structure and its description and also the type and structure of outputs. It serves to distinguish if the final model matches with the model requested by the client, what is very important during handover phase of the study. This documentation give the information to solving team about the ongoing phase of the project, so they can check the partial outputs or used methods. In case of necessary adjustment of some procedures, steps or outputs it allows identification of its impact to whole project or specific parts of the project and facilitate the implementation of change if and only if the client agreed.

The documentation remains important event when whole study is finished and the outputs and results are handover to the client, because it is useful, if the modelled system is about being extended or there is important change of parameters within the system. In this case, it can be faster and less expensive to study the previous model and its design in order to execute requested updates than pass the whole process of modelling and simulation with all the time and financial costs.

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