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BUSINESS LOGISTICS IN MODERN MANAGEMENT

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C O N T E N T

FOREWORD

While customer expectations are more demanding than ever, supply chains are developing new processes to connect people and companies more efficiently. Demand for logistics expertise is continuously increasing, and logistics and supply chain management as scientific disciplines are following it. Novel research areas and innovative approaches to existing problems in logistics and supply chain management represented at this year's 22nd international scientific conference Business Logistics in Modern Management, prove that the European academic community follows new requirements.

For the 22nd year in a row, the Faculty of Economics in Osijek, J. J. Strossmayer University of Osijek, has organised the international scientific conference Business Logistics in Modern Management 2022. On the 6th and 7th October 2022, 68 authors representing seven countries (Czech Republic, Germany, Hungary, Poland, Serbia, Slovenia, and Croatia) participated in the Conference. The Organising committee of the BLMM2022 Conference has received 37 papers, and 28 of them successfully passed the international, double-blind review process and were presented during two days of the Conference. The Conference sessions were characterized by a fruitful and affirmative series of discussions. In coordination with their Editorials, 13 selected papers were sent for publishing process in 3 respectably indexed scientific journals: Logforum Scientific journal of Logistics, Econviews: Review of Contemporary Business, Entrepreneurship and Economic Issues, and Economic Thought and Practice. Consequently, Proceedings of the 22nd international scientific conference Business Logistics in Modern Management consists of 15 selected scientific papers covering a wide range of supply chain management and logistics topics.

Proceedings of 22nd international scientific conference BLMM2022 are divided into four chapters. The first chapter, titled Supply chain cooperation and theory analysis, covers the development path of military-civilian cooperation, and gives theory analysis contribution to the simulation usage in logistics as well as to indicators used in bullwhip effect evaluation. Chapter Supply and logistics digitalization consists of four papers. It starts with a study on an adequate assessment framework in higher education considering digitalization within supply chain and logistics. The following paper explores possible strategies for inland waterway transport digitalization in Hungary and is followed by connected research on data digitization in transport processes. The fourth paper suggests an additional model for the digitalization of information and goods flow processes in the supply chain. The following chapter, Distribution logistics analysis, starts with a demonstration of the ARAS method for efficiency analysis of trade companies in Serbia. The chapter continues with artificial intelligence solutions for improving master data quality for consumer safety and with a paper that explores a relationship between sustainable public catering and short supply chains using supply chain mapping methodology. The end of the chapter deals with contemporary challenges of category management in online retailing. The final chapter of a Proceedings deals with Efficiency and coordination in supply chain and is opened with an analysis of startups as a business model for enhancing the supply chain. The following paper considers indicators on a path to smart city services and quality of life improvements. There is also a study on how to use the Dupont indicator

system to support logistics companies' management. Finally, the Proceedings end with a paper on applying quality management tools to visualize the bullwhip effect phenomenon.

There are numerous ways to highlight the significance of logistics in everyday life. We were honoured and grateful that this year our keynote speaker was MSc Ivana Jakir-Bajo, Vicegovernor of Croatian National Bank, who clearly and interestingly presented enormous Logistical challenges of national currency changeover. The Republic of Croatia is currently in the middle of this rare but exceptionally logistically demanding process, and there was no better person to talk about it.

Once again, BLMM Conference was recognized by the Ministry of Science and Education of the Republic of Croatia, and we are grateful for their support in the organisation of the 22nd BLMM Conference. We will continue with the intent to include Proceedings of BLMM in leading scientific databases which evaluate each annual issue of this publication individually. While we are sincerely thankful to all authors who decided to participate in BLMM2022 Conference, our special appreciation goes to authors who regularly come to Osijek and present their new research for the whole series of years. A team of reviewers from different countries connected by a passion for excellence in logistics significantly improved the quality of received papers and consequently the Conference itself. Finally, the Editorial board, Honorary program committee, and Organisational committee successfully guided the BMM2022 Conference.

In Osijek, October 6th, 2022.

Davor Dujak,
Editor

I. SUPPLY CHAIN COOPERATION AND THEORY ANALYSIS

DEVELOPMENT OF MILITARY-CIVILIAN LOGISTICS COOPERATION

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Abstract

Continuous improvement of the military logistics system is one of the key conditions for the proper functioning of the armed forces. The necessity to transform structures, procedures and implement new solutions in the field of logistic security of troops results directly from the changes taking place in the modern world, and in particular from political, military and social transformations. Nowadays, in this process of key importance is the use of external logistic potential for the needs of the armed forces, which for years has been a natural phenomenon in the activities of military units and institutions, both during peace, crisis and war. Logistic military-civilian cooperation brings tangible benefits to both parties, in many cases ensuring maximum effectiveness of the tasks performed.

The aim of the article is to identify and assess the factors shaping contemporary logistic military-civil cooperation and to indicate the directions of its further, effective development. The structure of the article has been subordinated to the purpose of the work, which includes two main parts. The first theoretical, relating to the evolution and essence of logistic military-civil cooperation, and the second presenting the results of empirical research related to the research problem undertaken. The empirical part of the article presents the results of quantitative research carried out using the diagnostic survey method. It should be emphasized that the presented considerations are part of extensive scientific research conducted by a research team from the Faculty of Management and Command of the War Studies University in Warsaw, Poland. Their goal is, above all, to initiate an in-depth, scientific discussion in the civil and military logistics community, aimed at further development of military-civilian logistic cooperation.

Key words: logistics, management, cooperation, military, business

1. INTRODUCTION

One of the necessary conditions for the proper performance of tasks by the armed forces is to have a well-organized, effective logistics system. This system should, among others, characterized by the ability to integrate resources and activities necessary in the process of securing troops in all states of state functioning. In the contemporary conditions of the functioning of military logistics systems, the external potential begins to play a significant role, supporting organic military resources. It is not only economic, but in many cases also operational reasons that speak in favour of undertaking extensive logistic military-civil cooperation. It is indisputable that modern military logistics should make use of the latest achievements of science and technology, which under the current conditions are implemented most quickly in the civilian environment (Pecina & Husak, 2018).

The aim of the article is to identify and assess the possibilities of implementing logistics solutions from the civil sector, which could contribute to the improvement of the logistic efficiency of the armed forces to the maximum extent.

In the research process, logistic efficiency was defined as the relation of the obtained effects to the expenditure incurred, related directly to the logistic resources of the organization. This type of efficiency as a multidimensional concept should be treated as one of the measures of organizational effectiveness, identified in economic sciences with both organizational effectiveness (management science) and economic effectiveness (economy). The assumed goal was achieved using both theoretical and empirical methods, carried out by the method of a diagnostic survey with the use of a questionnaire. The adopted approach made it possible to obtain a cross-sectional character of the considerations, at the same time providing the basis for further, extended research on this extremely complex problem.

2. MILITARY AND CIVIL COOPERATION – SELECTED PROBLEMS

2.1. LITERATURE REVIEW

Development of military-civilian logistics cooperation is closely related to both the development of logistics and the following changes taking place in the logistics systems of the armed forces. As one of the features of logistics (both civil and military) is its interdisciplinary nature. The cooperation between civil and military entities is largely determined by the advancement level of both (military and civil) logistics systems.

Contrary to the beginning of logistics, nowadays solutions proven in civil logistics are implemented into the logistics of the armed forces (Rutner, 2012). Many others indicate that the development of logistics, including military, will be determined by the dynamic development of new technologies, in particular IT, such

as the Internet of Things, robotization, Big Data (Fernández-Villacañas, 2020; Wang, 2020).

The issue of the development of military logistics, due to its interdisciplinarity, is the subject of research aimed at identifying development trends and indicating the possibility of optimizing the processes taking place in military logistics systems. In the past few years, there has been an increased interest in the planning and execution of military logistics operations. Military logistics as a branch of science is also responsible for providing comprehensive solutions in procurement, demand forecasting, inventory control, warehousing, and transportation operations in the most effective and efficient manner possible (Zeimpekis, 2015).

The very important area in civil-military logistic cooperation is the provisions of the law and procedures for managing the logistic support of forces, correlated with the changes that have occurred in recent years in the security environment and systems of the armed forces of states, especially in Central and Eastern Europe. There are also trends for the adaptation of business solutions to the needs of military logistics systems (Bury, 2021).

All the above-mentioned elements determine the proper military-civil cooperation in the field of logistics and therefore should be taken into account when planning and organizing the cooperation of military and civilian entities. The all ultimately, military-civilian supply chains can function efficiently, providing troops with timely deliveries at an acceptable cost.

2.2. THE ESSENCE OF LOGISTIC MILITARY-CIVILIAN COOPERATION

The use of civilian potential for the needs of the army is not a discovery of years but has a very long history. Detailed analyses of conflicts and warfare over the years show how important it is to support the efficient functioning of the civil service. Over the years, only the form of this type of "cooperation" has changed, from robbery, plunder or requisition to the form of cooperation adequate to the realities of the free market economy (Slavić et al., 2020). Spectacular New Useful Use of the Departments of the First Intermediary Joseph Joffre, who in September 1914 commandeered 600 Parisians and threw them recommended reinforcements to the front, so that another counter-light in the fight against the German, effective battle on the Marne against German forces (Juźwik, 2011).

Nowadays, both national and allied doctrinal documents relating to the sphere of logistical support for troops in a special way emphasize the significant role of the external potential in the implementation of tasks both within the territory of the country and abroad. Support by external contractors (civilian suppliers) in many cases supplements the military logistic potential in military and non-military operations (Moore & Antil, 2011). The experience of recent years clearly shows that contracting supplies and services is an important source of logistic support (Grubmüller et al., 2021). Currently, the functional elements of the logistics system of the armed forces commonly use the services of external contractors to support the implementation of logistic support tasks for troops. The contracting of supplies and services is of

particular importance in supporting the activities of military contingents carrying out tasks within the framework of operations outside the country (Lis, 2016). Contractors provide a wide range of services, from transportation, construction, and base support to intelligence analysis and private security (Church & Schwartz, 2013).

Contractors provide logistic support and services in many NATO, EU and UN operations both for micro and macro scale. According to doctrines, Contractor Support to Operations (CSO) enables competent commercial entities to provide a part of the support to the military, so that such support meets the Operation Commander's operational support requirements and optimises the most efficient and effective use of the resources. The basis for the delivery of CSO is a contract. Contractor support in EU-led military operations mainly focusses to logistic support functions; but, in general, it can provide an essential part of the support to the military (Brussels 2014).

The contractors have been used many times during UN peacekeeping missions and NATO and EU military operations, also with the participation of Polish military contingents in Iraq, Afghanistan, Kosovo, Bosnia Herzegovina, Chad and the Central African Republic. Contractors realized, among others strategic transport during the transfer of forces to the area of operation and supported its functioning. Ensuring the current needs of the contingents, especially those whose implementation by the national logistic system is incompatible or too time-consuming, required the use of local civilian companies (Grala, 2011).

Regardless of the number of benefits resulting from the use of contractors in supporting military forces, it is necessary to mention the basic limitation of this solution, which is, as a rule, less responsibility for the task's completion, especially in the conditions of enemy intervention (Lis, 2016). Soldiers render military service under what has been termed “the unlimited liability contract” The “unlimited liability contract” is not a formally written contract, but rather an implied and collective understanding that lies at the heart of all military service, regardless of nationality. Fundamental to this “implied contract” is the notion that the mission is paramount. Liability is accepted as unlimited-the soldier accepts that he or she may lose his or her life in carrying out the mission (Mileham, 2010).

The same cannot be expected of civilian contractors. No implied “unlimited liability” understanding applies to civilian contractors who are not expected-and importantly, have no expectation- that they may like their military counterparts be expected to sacrifice their lives and well-being for the ultimate success of the mission. Civilian contractors do not accept “un” limited liability: they will carry out their duties, but only up to a certain point. Their liability is limited by their overarching need to preserve their own lives in preference to sacrificing them for the success of the mission. This is a significant paradigmal difference from that of soldiers. In order to mitigate the exposure of civilian contractors to unacceptable levels of risk (as the liability accepted by civilian contractors is not “unlimited”) commercial logistic support should best be “tailored” according to the nature and intensity of the operation. Generally, in Humanitarian Assistance and Disaster Relief (HADR) and Peacekeeping (PK) operations, the use of commercial contractors may be highly appropriate, efficient, and cost-effective. Alternatively, the use of any commercial contractor elements in a conventional conflict situation may be highly inappropriate (Ti, 2018).

The noticeable increase in the importance of logistic military-civil cooperation over the last several years is mainly due to the fact that for some time now a number of NATO (North Atlantic Treaty Organization) countries have been reducing the size of their armed forces while increasing the scope of their functions (Galić et al., 2021). The troops are faced with new tasks, for which they are often not properly equipped and prepared. In addition, budget constraints mean that the priority is to adopt solutions that guarantee the effectiveness of logistical support for activities while reducing their costs (Minárik, 2020). One of these solutions turns out to be the support of military potential by external contractors, which is a significant supplement and strengthening of military logistic capabilities.

A detailed analysis of military operations, during which some logistic tasks were carried out with the use of external potential, shows that this form of task implementation allows the armed forces to maintain their own, scarce logistic resources, which can be used to carry out other tasks or extend the period of self-sufficiency of the troops. The main factors determining the scale and scope of the use of external contractors in the field of logistical support for troops include (Jałowiec, 2020):

- operational conditions enabling / indicating the necessity to use external potential;
- real needs to supplement the national or allied potential and logistic resources of the armed forces;
- remoteness from organic sources of supply or logistic resources;
- ensuring the correlation of the time of delivery / service provision with the real needs of troops;
- local market opportunities in terms of timeliness, quality and security of supplies / services provided.

Selected areas in the field of the military logistics system particularly susceptible to the implementation of tasks in the military-civil formula are presented in Table 1.

Table 1. Selected areas of the military logistics system susceptible to the implementation of tasks in the military-civil formula

Field	Task range
servicing and operation	– weapons and military equipment; – specialist systems and devices for the protection of facilities
acquisition of military equipment	– passenger and heavy goods vehicles (including war time and crisis situations); – sanitary cars; – reloading equipment; – machines, aggregates and specialist devices

Field	Task range
utilization	– combat measures (non-prospective); – rocket propulsion materials; – rubber products; – chemicals, disinfectants; – medical waste, overdue medicinal products – and medical devices, veterinary agents and waste, and poisons; – other waste, including kitchen waste
transport	– road; – air; – railway; – marine.
stockpiling and maintenance	– food; – uniforms; – fuels; – medicinal products and medical devices
securing the living needs of troops	– order-based feeding; – laundry and repair services
maintenance of military real estate	– maintenance, renovation, repair, construction inspections and expert opinions; – servicing and exploitation of energy, water and sewage, gas, ventilation and air-conditioning systems; – communal services
training	– drivers of lorries and specialized vehicles; – special equipment operators; – service and technical personnel; – aviation technology specialists
supporting military contingents	– comprehensive nutrition of troops; – delivery of fuel products; – laundry and repair services; – supply of materials for common use; – organization of camps, accommodation and social services; – servicing of modern equipment

Source: own.

The scope of this material does not allow for a full description of the role and importance of military-civil cooperation in the logistics of troops. The considerations presented above, in accordance with the assumed goal, were only intended to signal this extremely important and complex problem. Nevertheless, it should be unequivocally emphasized once again that without external support, a number of logistics tasks in the army would be significantly difficult, and sometimes even

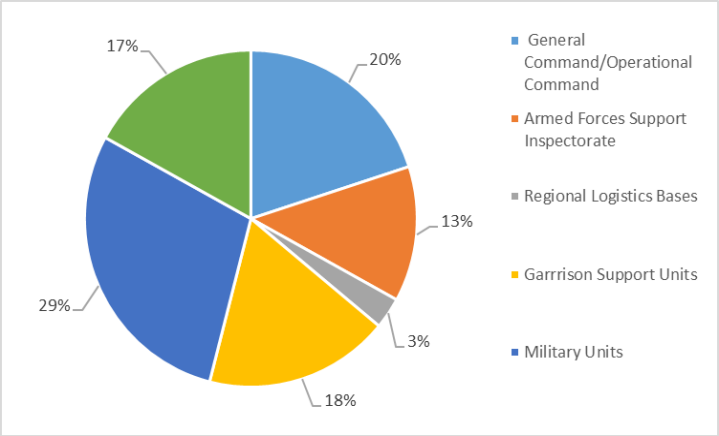
impossible to implement. Moreover, in the light of the complexity of the area under consideration, it is important that the solutions currently functioning in this field in the armed forces require improvement, which may be helped by the research results presented in the next part of the article.

3. PERFECTION OF LOGISTIC MILITARY-CIVILIAN COOPERATION - EMPIRICAL RESEARCH

In order to identify and assess the key factors determining the effective improvement of the effectiveness of the military logistics system through the implementation of logistic solutions from the civil sector, it is worth quoting the results of research carried out at the War Studies University in Warsaw. The basis of scientific inquiries in this area was the method of a diagnostic survey conducted with the use of the questionnaire technique. The developed research tool in the form of a questionnaire comprised 4 questions.

The research covered 126 officers representing all levels of the logistics system of the armed forces and entities cooperating with it. Non-random, deliberate selection of the research sample was aimed at guaranteeing the conditions for obtaining the widest and fullest possible information relating to the studied phenomenon. Among the respondents, the most numerous group - 37 people (29%) were officers representing military units of the Land Forces (31 people), the Air Force (5 people), and the Navy (1 person). Taking into account the contemporary dimension of the territorial logistic security system in the Polish Armed Forces, it is worth emphasizing that 18% of the respondents served in military economic branches. What is also extremely important from the perspective of the conducted research is the fact that 13% of the respondents represented the Armed Forces Support Inspectorate, an institution directly responsible for organizing and managing the logistic support system of the armed forces, including the logistical support of military units used or staying outside the country. In addition, the study covered officers directly or indirectly related to the military logistics system, representing, inter alia, the General Command of the Armed Forces, the Operational Command, War Studies University, Military Research Institutes, the Academy of Land Forces and Regional Logistics Bases. A detailed distribution of the studied sample in terms of the represented institution is presented in Fig. 1.

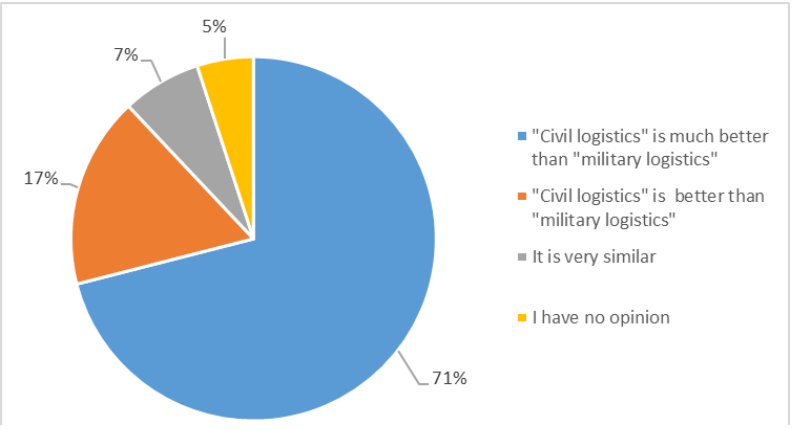
Figure 1. Structure of the research sample in terms of the represented institution



Source: own.

The first question related to the opinion of the respondents on the level of implementation of logistic tasks in the civilian sphere against the background of the military environment. The dominant conviction (71% of responses) that "civil logistics" is much better than "military logistics". 17% of respondents were in favor of "military logistics", and 7% believed that "it is very similar". The obtained results may indicate that, in the opinion of the respondents, it is possible to search for the best models for the development of logistic support for troops in solutions used successfully in the civilian sphere. A detailed distribution of the answers obtained is presented in Fig. 2.

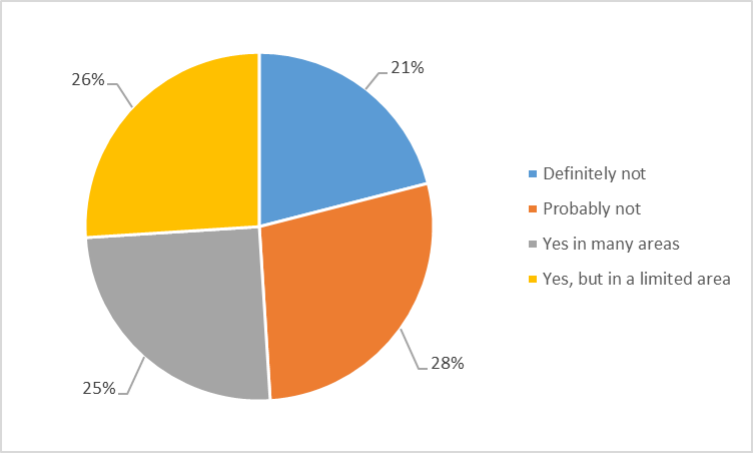
Figure 2. Assessment of the level of implementation of logistic tasks in the civilian sphere against the background of the military environment



Source: own.

The next question was aimed at obtaining the respondents' position on whether the currently functioning procedures for the implementation of tasks in the military logistics system create conditions for the implementation of innovative solutions improving the efficiency of logistic support for military subunits and divisions. The received responses were almost evenly distributed, around 25% (from 21% - "definitely not" to 28% - "probably not"). The configuration of the obtained results may indicate a significant variation in the military environment in relation to the studied area. A detailed distribution of the answers obtained is presented in Fig. 3.

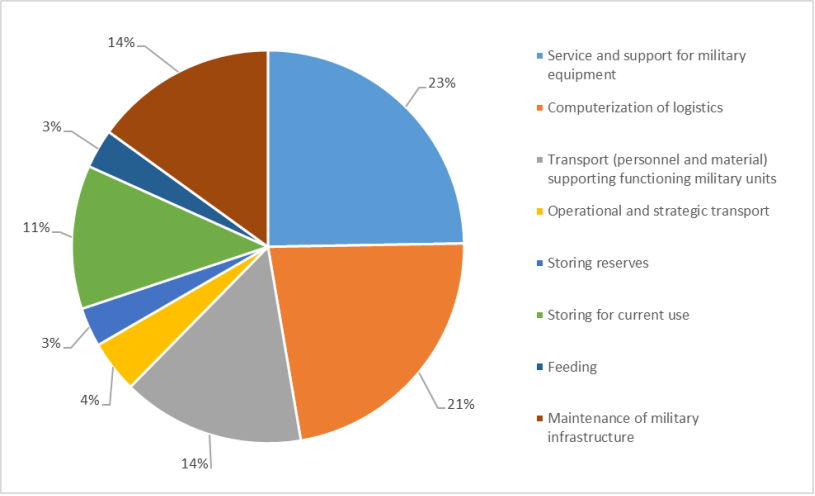
Figure 3. Assessment of currently functioning procedures for the implementation of tasks in the military logistics system in terms of the implementation of innovative solutions improving the efficiency of logistic support of troops



Source: own.

In the next question, the respondents were asked to indicate a maximum of three functional areas of the military logistics system, and in which they see the need and opportunities for wider use of innovations currently successfully used in the civilian sector. The greatest number of responses (23%) was given to the answers "service and support for military equipment" and "computerization of logistics" - 21%. Only 2% of the respondents were in favor of "storing reserves", and only 3% of them expressed the belief that this is the area of "personal condition nutrition". The answers obtained may, in a way, constitute a hint for decision-makers managing individual areas of logistic security for troops. A detailed distribution of the obtained responses is presented in Fig. 4.

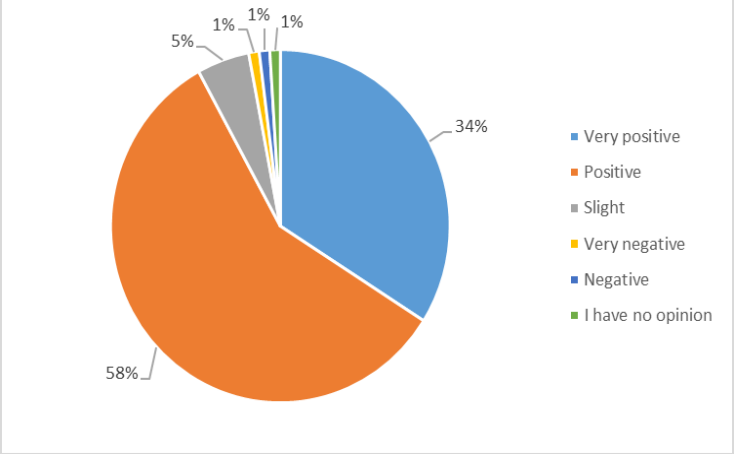
Figure 4. Identification of functional areas of the military logistics system that can be used more widely with innovations currently successfully used in the civilian sector



Source: own.

The last question of the survey questionnaire concerned the impact that, according to the surveyed officers, may have innovative solutions derived from the civilian environment on the functioning of the military logistics system. In this case, there was great unanimity, as 92% of them indicated that it may be "very positive" or "positive. Only 5% supported a slight influence, and 1% each received "Very negative", "negative" and "I have no opinion". A detailed distribution of the answers obtained is presented in Fig. 5.

Figure 5. Assessment of the impact of innovative solutions derived from the civilian environment on the functioning of the military logistics system



Source: own.

In an attempt to generalize the obtained results of empirical research, it should be emphasized that, in the opinion of the authors' team, the collected material is only a contribution to further extended scientific investigations of this extremely important phenomenon today. The research carried out and the results obtained encourage a broader focus on the issue of the use of "civil" logistic solutions in the process of improving the functioning of the logistics system of the armed forces. As shown by the experiences of other armies in the process of improving the logistic security of troops, one should not limit oneself to any sources of innovation, which is also confirmed by the obtained research results.

4. CONCLUSION

The results obtained in the research process entitle to draw the following general conclusions.

1. Innovative solutions are implemented into the military logistics system, but their single scale and scope do not fully allow for a qualitative “leap” guaranteeing the expected level of task performance at each functional level.
2. Logistic solutions from the civilian sector can be largely implemented in the military sphere, but nevertheless, it requires their comprehensive assessment in terms of the specificity, needs and capabilities of military security and security entities.
3. The greatest obstacle in the effective implementation of innovative solutions to the practice of the functioning of the elements of military logistics systems seems to be the maladjustment of the binding normative documents and, consequently, the mechanisms and procedures for the implementation of tasks to the dynamic changes taking place inside the armed forces and their environment.

One of the currently significant problems that remains to be solved in the future is the development of formal, transparent procedures and assumptions, which provide the basis for the widespread implementation of innovative solutions for the logistics of troops. This seems to be extremely important in the light of the growing logistical needs of troops during the implementation of training and operational tasks by their elements. The problems indicated in the article are subject to certain research limitations - during terrorist and war threats, the basic research limitation is the inability to obtain complete information on the said cooperation, which in turn is a result of the need to keep certain activities and logistic operations secret.

However, the presented research limitations should be treated as a basis for further discussion on the development of research in this field. Continuing research on civil and military logistics, we should strive towards the development and promotion of green energy. From the perspective of science, it should also be noted that there is still a lack of research in the specialized literature that would comprehensively cover the phenomenon of implementing innovations into the multi-faceted logistics system of the armed forces.

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A BIBLIOMETRIC RESEARCH OF THE SIMULATION USAGE IN LOGISTICS

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Abstract

The reality of the modern world is changing towards the usage of the latest technologies in everyday life. This could also be said about the improvement in the logistics field with the usage of Industry 4.0 tools and creating a more autonomous and transparent system that would create the possibility not only to see but also to forecast the logistics process. Many authors have already studied the influence of simulation on logistics processes. However, no attempt has been made so far to measure the topic from a bibliometric point of research. This study aims at covering this research gap and providing information for further research connected with this field. The research consists of a literature review, methodology, bibliometric study and conclusions. Bibliometric research includes the study of the publication year, author, journals and conference proceedings, key word co-occurrence and word cloud. In the process of literature review and bibliometric analysis, it was found that the usage of simulation in logistics has positive potential and several tendencies. The research was limited to the papers available in the English language only and could be further improved by adding other sources and/or comparisons. These findings could provide useful information for future publication and be used by practitioners to monitor tendencies.

Key words: simulation, logistics, Industry 4.0

1. INTRODUCTION

The contemporary competition in the business world put a great influence on the existing processes. The products become more varied, the demands become more personalized and the processes become faster. Each production system and each service are currently improving so that the cost of the final product would be decreased while the quality would remain or even become better. The economic fluctuation and difficulties in many countries motivate companies to reduce costs of the production to be able to survive the competition in the market.

Modern technologies and the introduction of new principles of industrial automation have a great influence on the processes and provide a profitable tool for

improvement and development. This influence is connected with all the industrial processes and services connected with it, including logistics. As an inseparable part of any modern service and/or product logistics plays a crucial role in business success. Considering the fact that globalization is continuing to grow and products are now delivered worldwide, logistics influence the success of any enterprise greatly.

The logistics processes are currently estimated from the point of view of their correspondence to the new reality in the scopes of the so-called "Industry 4.0" paradigm, and improved methods and methodologies have already been offered by many scientists (Pareja Yale et al,. 2020, Wang et al., 2022) many which highly rely on the simulation of logistics processes.

Despite the fact that the process simulation is currently getting a lot of attention from both practitioners and scientists as one of the main technologies used in the scopes of Industry 4.0, simulation has proved its successful influence on many business-related processes long before the notion of Industry 4.0 (or any related such as Smart factory, etc.) has been mentioned at Hannover fair in 2011 (Efimova & Briš, 2021). Thus, many papers have already been written discussing the influence of simulation on logistics and offering different simulation techniques for this field. However, to the best author's knowledge, so far there have not been any papers that evaluate the conjunction of simulation and logistics from the bibliometric point of view, however, there are some papers dealing with logistics in separate fields (Roy et al., 2021). At the same time, bibliometric research might provide useful information for scientists and future researchers.

In this paper, an attempt is made to respond to the research gap of the lack of bibliometric research and to measure the simulation usage in logistics from the bibliometric point of view. The research consists of the literature review, methodology discussion, bibliometric study, discussions and conclusions and provides useful information for future research in this field.

2. LITERATURE REVIEW

2.1. Simulation Usage in Logistics

With the growing speed and increasingly personalized customer demand (Efimova et al., 2021), the role of logistics is becoming more and more important. The development of technologies influences the logistics processes greatly. The introduction of RFID, sensors, Big Data analytics, Robotics etc. has a crucial impact on logistics processes. Moreover, as globalization continues to develop, new structures of marketing systems appear (Segetlija et al., 2011) and customers buy products from around the world, logistic processes require constant improvement so that the companies would be able to provide the required services and profits (Cudziło et al., 2018).

Simulation is a method of creating a computer model which allows working with probable dynamic situations (Vogal & Pecina, 2019). It is highly used for complex processes and is considered to be a powerful tool in situations of uncertainty

(Trauzettel, 2014). Simulation for logistics purposes has already been used for many years. The search in the SCOPUS database shows that the first paper that combines the words "Simulation" and "Logistics" in the name of the article was published in 1963 and was connected with space logistics, where computer-based mathematical models allowed engineers to use simulation to plan the activities (Richardson & Salas 1963). Since then simulation in logistics has been analyzed in many industries, surroundings and applications, the studies have covered different fields including industrial (Gyulai et al., 2020), healthcare (Roy et al., 2021), humanitarian (Pareja Yale et al., 2020) and others. Simulation appears to be a useful tool for solving many logistics problems by allowing one to analyze and assess the problem before it appears. Process automation, the usage of robots and RFID sensors, mobile technologies and other contemporary technologies are being evaluated as they possess tremendous potential for logistics processes optimization (Saini et al., 2021, Gyulai et al., 2020, Wei Wang & Shidong Fan, 2009, Paixão & Bernard Marlow, 2003). The focus currently is to create a flexible and automated system for transporting, where the simulation will play an important role.

Simulation in logistics has proved to have positive results for complex industrial processes as it allows one to verify new ideas without process interruption (Gyulai et al., 2020). Moreover, as the logistics processes are also complicated from the point of view of the cooperation between stakeholders (Becha et al., 2020), simulation of some processes might ease this communication. Here, simulation is one of the ways to "overcome logistics challenges" (Pareja Yale et al., 2020) as it serves "to bridge the gap between theory and practice" (Steenbergen & Mes, 2020). The development of computer technologies allows the simulation to be further developed (Vabek et al. 2021).

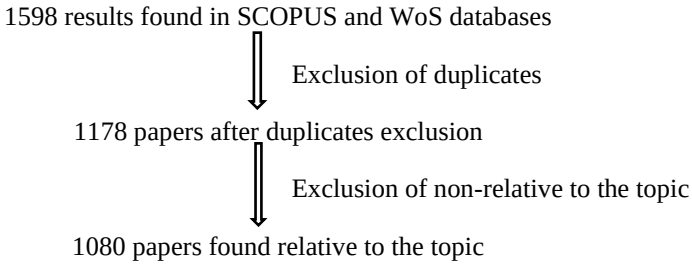
However, there still are many aspects that have not yet been fully investigated, such as transparency and standardization of simulation processes (Cai et al., 2022), some new techniques that require experiments, IT solutions for intelligent simulation (Wei & Sun, 2022) and much research still going on in simulation usage for logistics. At the same time, the amount of data on every simple topic is growing rapidly and sometimes it is complicated to keep a track of the data. To solve this problem bibliometric research is offered here in order to provide researchers and future authors with systemized information on the topic.

3. METHODOLOGY

The research topic was identified based on the literature review and bibliometric analysis was proposed to cover the research gap. Two source databases were used for the research WoS and SCOPUS as they usually generate major interest from academic and research communities. Both journal articles and conference papers were considered in this bibliometric research. The search was limited to the results available in English, thus it is important to note that the research could not provide a full-scale review. Moreover, the research considered only journal articles and proceedings papers, thus, book chapters, reviews and other similar documents were excluded from the search. Another important aspect is that the bibliometric analysis considered all

the articles published till August 2022 (including August), but there were no limitations connected with the first publication time, and this is important to consider as another limitation for the given research. The process of selection of articles and conference proceedings for the paper is presented in Figure 1 and is also described further in more detail.

Figure 1. The search process and results



Source: own research

The process it consisted of several steps: first, the advanced search was used in both WoS and SCOPUS limited to "Simulation" AND "Logistics" in title names. The search resulted in 574 results from WoS and 1024 results from SCOPUS. After the exclusion of duplicates, the result was 1178. Then, only conference papers and articles written in English were left and the results became 1080 These results were further analyzed and the conclusion was drawn.

4. RESULTS

To begin with the bibliometric analysis all 1080 found articles were classified according to the source type. It was found that 363 journal articles were published and 717 conference papers. In some journals and conference proceedings, only a couple of articles (up to 3 for journals and up to 4 for proceedings papers) were published, other sources are mentioned in Table 1, where it could be seen that the most popular journal for this topic is "International Journal of Simulation Modelling" while the most popular conference is "Winter Simulation Conference" with 85 papers published there. Winter Simulation Conference which was in different places all around the world has received the biggest attention from researchers in this field. Thus, it might provide important feedback for researchers that Winter Simulation Conference is a shop floor for discussion and cooperation in this field.

Table 1. The number of articles and conference proceedings

Journal		Conference	
International Journal of Simulation Modelling	12	Winter Simulation Conference	85

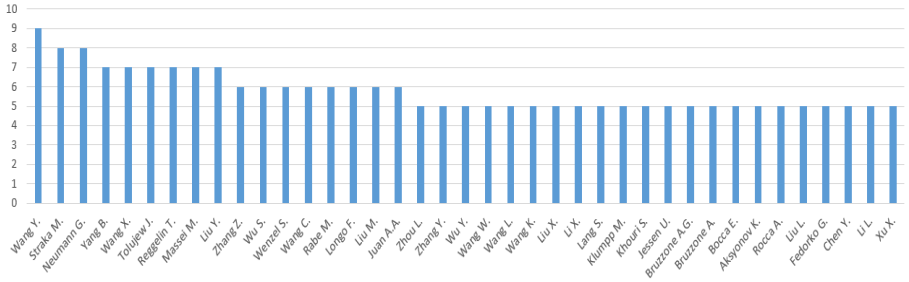
Simulation	10	Simulation In Produktion Und Logistk 2013	15
Sustainability (Switzerland)	9	Transportation Research Procedia	12
Computers and Industrial Engineering	7	Applied Mechanics and Materials	10
Journal of Simulation	7	Journal of Physics: Conference Series	9
Journal of Statistical Computation and Simulation	6	Simulation Series	9
International Journal of Industrial Engineering: Theory Applications and Practice	5	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	8
International Journal of Production Research	5	Advanced Materials Research	7
BMC Medical Research Methodology	4	ESM European Simulation and Modelling Conference: Modelling and Simulation	7
International Journal of Simulation and Process Modelling	4	Lecture Notes in Electrical Engineering	7
Simulation Modelling Practice and Theory	4	The International Society for Optical Engineering	7
Statistics in Medicine	4	International Conference of Chinese Logistics and Transportation Professionals - Logistics: The Emerging Frontiers of Transportation and Development in China	7
Applied Sciences (Switzerland)	3	European Modeling and Simulation Symposium, EMSS	6
Computational Intelligence and Neuroscience	3	Advances in Intelligent Systems and Computing	6
Computers in Industry	3	IFIP Advances in Information and Communication Technology	6
Environmental Science and Pollution Research	3	International Conference on Harbour, Maritime and Multimodal Logistics Modelling and Simulation	6
ICIC Express Letters	3	IOP Conference Series: Materials Science and Engineering	6
Journal of Coastal Research	3	Procedia Engineering	6
Journal of Convergence Information Technology	3	European Conference on Modelling and Simulation, ECMS	6

Open Engineering	3	Summer Computer Simulation Conference	6
Polish Journal of Environmental Studies	3	Int. Conference on Harbor, Maritime and Multimodal Logistics Modeling and Simulation, HMS , Held at the International Mediterranean and Latin American Modeling Multiconference	5
		ACM International Conference Proceeding Series	5
		AIP Conference Proceedings	5
		Communications in Computer and Information Science	5
		IFAC-PapersOnLine	5
		International Conference On Industrial Engineering And Engineering Management	5
		Simulation in industry	5

Source: own research

The author analysis demonstrated in Figure 2, illustrates that there are several authors that are the leaders in this field. As it could be seen the biggest number of publications have Wang Y., Neumann G and Straka M., authors that have 4 and less articles are not depicted here. At the same time, it was seen that there were many authors that have 2 or more publications – 260 authors (app. 24%), that could prove the sustainability of the mentioned topic.

Figure 2. Number of publications per author



Source: own research

The authors were also analyzed from the point of view of their cooperation on the topic. It was found that although the majority of papers were created by a group of authors, the cooperation between different groups is weak. For the analysis of author cooperation, a VOSviewer software was used and all the authors were included in the cooperation analysis. In Figure 3 only the authors that work in cooperation

(there were 344 chosen by the program) are presented. As could be seen the cooperation between authors in this field is much higher in Asia and all these authors were divided into 29 clusters based on their cooperation. So, it is possible to say that although the cooperation between authors on the topic of Logistics and Simulation exists, it is low.

To better understand the correlation between the cooperation of authors and the number of published works, the same analysis for cooperation between authors was made in VOSviewer software. The minimum amount of published papers by an author was set to 5. All the authors have already been mentioned in Figure 2. As it Figure 4 depicts, the cooperation between authors who wrote the majority of papers is weak. Although there are several authors that work in cooperation, there are some authors that don't cooperate on this topic. The best cooperation was found to be between 5 groups of authors that are:

1st group: Liu L., Wang X. (cooperate with other teams), Wu Y. (cooperate with other teams), Yang B. (cooperate with other teams), Zhou L.;

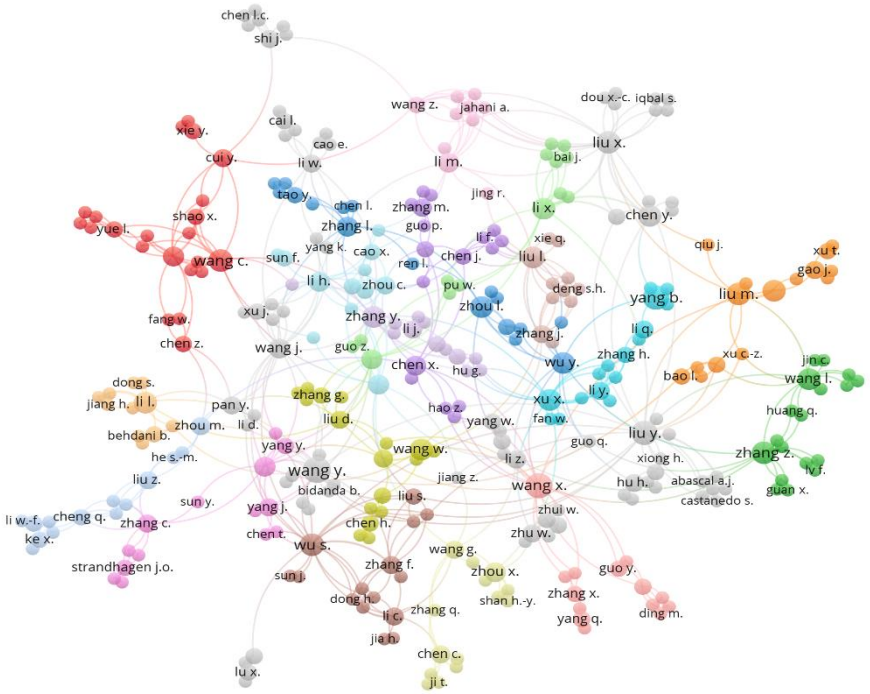
2d group: Li L., Liu Y. (cooperate with other teams), Wang Y., Wu S.;

3d group: Chen Y. (cooperate with other teams), Li X. (cooperate with other teams), Liu X. (cooperate with other teams);

4th group: Liu M. (cooperate with other teams), Wang K. (cooperate with other teams);

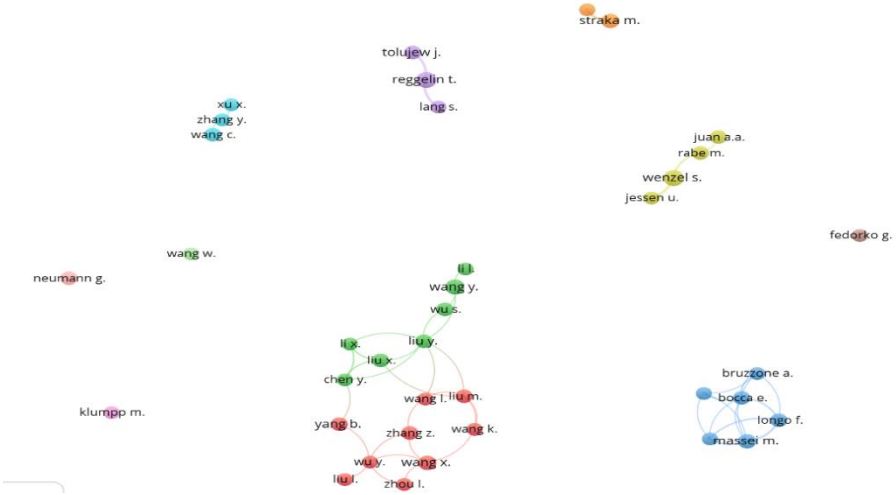
5th group: Wang L. (cooperate with other teams), Zhang Z. (cooperate with other teams).

Figure 3. Cooperation between authors



Source: own research (VOSviewer software was used)

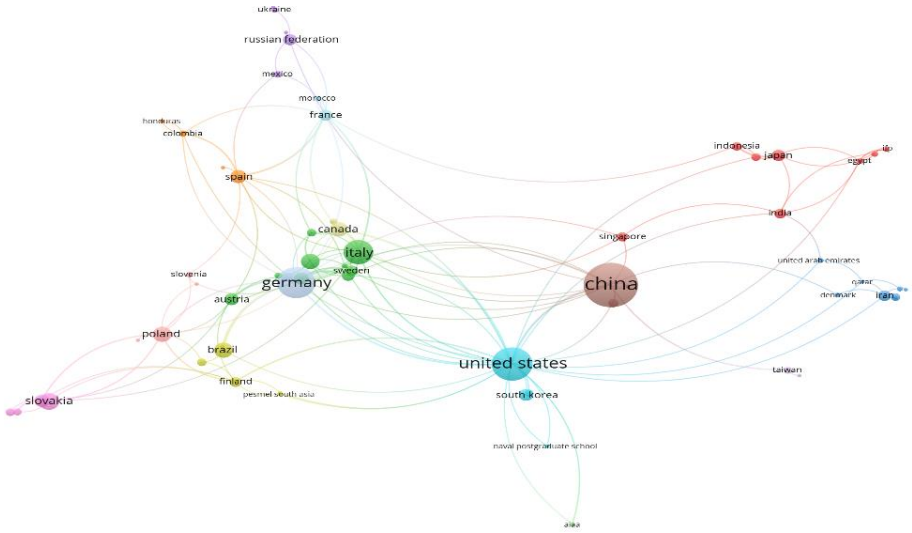
Figure 4. Cooperation between authors who wrote more than 5 papers



Source: own research (VOSviewer software was used)

Considering the weak cooperation between authors an attempt was made to assess the cooperation between countries on this topic and it was found out that although their cooperation is not strong in some cases (as the parameters were set to 1 publication by a country), some countries have several connections on the topic. 15 clusters of cooperation were identified by the VOSviewer software where from 3 to 10 countries were cooperating (the clusters are shown in color). As could be seen in Figure 5, the leaders are China, the USA, Germany, and Italy.

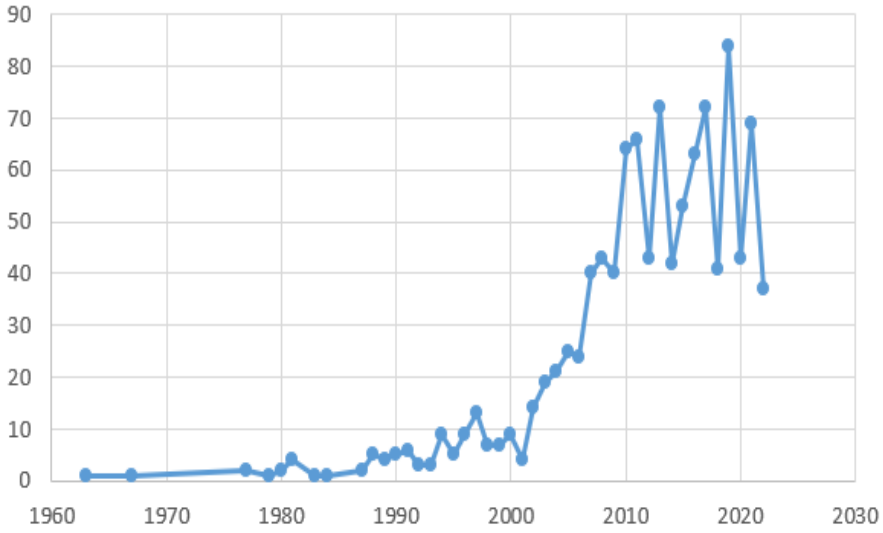
Figure 5. Cooperation between countries



Source: own research (VOSviewer software was used)

The constantly growing importance of the given topic could also be proven by the number of publications per year. As it could be seen in Figure 6, the number of publications rose from up to 10 till 2001 to above 40 starting from 2009. Although some fluctuations could be seen in different years, it is still obvious that in the last decade the topic connected with the usage of simulation and simulation tools for logistics and transportation remains important and gets high interest from researchers. As it could be seen, the highest amount of publications on this topic was made in 2009 when 84 papers on the topic were published. However, there is a decrease in the following years in the number of publications per year, the number is still high with 43 papers in 2020 and 69 in 2021. It is not yet possible to fully assess the year 2022 as the data for the research is gathered in August of 2022 and the year is still in progress, however, it is already seen that the combination of Logistics and Simulation remains critical, because up to date there have been 37 papers published already.

Figure 6. The number of publications per year



Source: own research

To better understand the tendencies in the field, a word cloud was created for the author key words. The word cloud was generated with the help of the word cloud generator at https://monkeylearn.com/word-cloud. As it could be seen from the word cloud (Figure 7) the most popular words, that are mentioned much more often than the others are “Simulation” and “Logistics”. These words are closely followed by the following group of words that are also mentioned in many papers: Supplies chain, optimization, modeling, events, logistics systems events simulation. Other words that could be seen in the word cloud are also important for the research as they may provide new ideas and/or directions for future research and help authors to concentrate on something that has already been investigated by other authors. This could help to understand the general tendencies of the topic and identify the major focus of the researchers that have already published their works. This word cloud could also improve the search related to the study as it might provide some deeper insights on the general search topics.

Figure 7. Word cloud

Source: own research (with the help of word cloud generator at https://monkeylearn.com/word-cloud)

Following the construction of the word cloud, a map was constructed showing the connections between different keywords. For this purpose, a software program called VOSviewer was used. The minimum number of keyword occurrences was set to 7 to provide the visual information that can be analyzed. Thus, 44 keywords were chosen by the program. As could be seen in Figure 8, all the keywords can be classified into 8 clusters that are different in color and contains from 2 to 11 items per cluster. For a better understanding of the clusters and their compounds they are given below:

Cluster 1 (red) 11 items: container terminal, decision support system, discrete event simulation, flex sim, logistics center, logistics simulation, logistics system, modeling and simulation, production logistics system, simulation model, vehicle routing problem.

Cluster 2 (green) 7 items: modeling, optimization, petri nets, RFID, scheduling, simulation, transport.

Cluster 3 (blue) 7 items: discrete simulation, discrete-event simulation, logistics, modelling, production, simulation modelling, virtual reality.

Cluster 4 (yellow) 6 items: agent-based simulation, reverse logistics, simulation modelling, supply chain, sustainability, urban logistics.

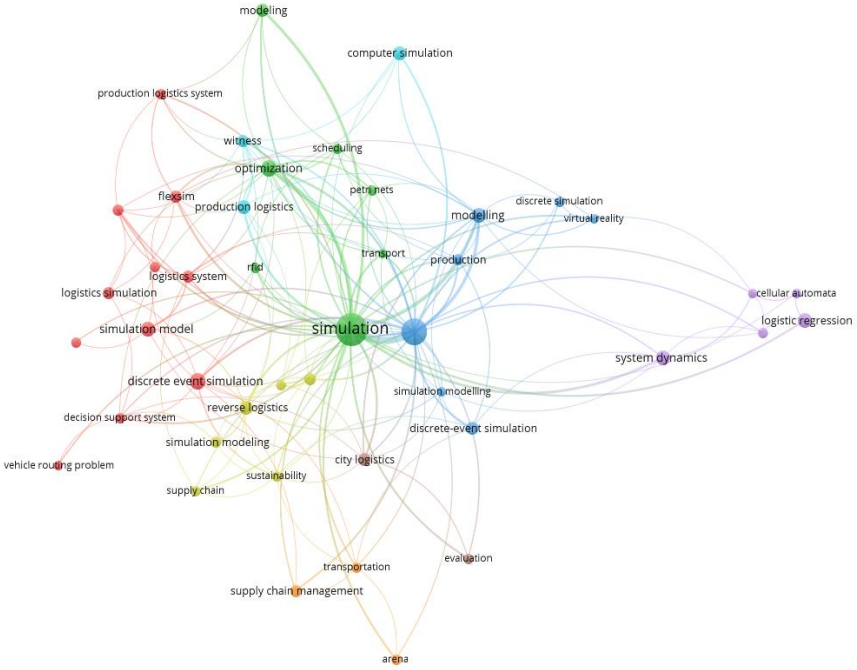
Cluster 5 (purple) 5 items: cellular automata, logistics, logistic regression, monte carlo simulation, system dynamics.

Cluster 6 (light blue) 3 items: computer simulation, production logistics, witness.

Cluster 7 (orange) 3 items: arena, supply chain management, transportation.

Cluster 8 (brown) 2 items: city logistics, evaluation.

Figure 8. Key words co-occurrence



Source: own research with the usage of VOSviewer software.

The bibliometric research presented in this paper describes the general trend for the topic where Simulation and Logistics are combined. As it has already been stated the analysis has several limitations that should be considered.

5. CONCLUSION

The aim of this paper was to investigate the combination of Logistics and Simulation in order to identify future research perspectives based on bibliometric research. As the importance of simulation for logistics has already proven itself and the interest is still growing following the trends of process optimization and savings, the combination of the notions of Logistics and Simulation should also be measured in order to provide authors with the necessary information for future research.

The bibliometric research provided data on the existing situation and trends connected with Logistics and Simulation. It was found that the most popular venue for discussion related to the mentioned topic is Winter Simulation Conference, as it has the highest amount of all the works published in this field. Moreover, the number of papers published during the Winter Simulation Conference proceedings is

incomparable to other sources connected with this topic. It was also noted that some authors specialize in this topic with the highest number of 9 publications per author and more than 20 % of all of the authors have several publications on the related topic. It was also assessed that the number of publications per year grew significantly in 2009 and remains high in the last decade, although with some slight fluctuations. This could also prove the stable interest in this topic. Considering all these trends it is possible to state that the interest in this field remains solid and future research in this field will continue to answer the research gaps connected with the fast development of modern technologies.

Further research in this field should consider the research limitations i.e. language of the research and type of document that was analyzed, moreover, possible analysis of the difference between countries and/or continents that could provide a better understanding of the focus of different parts of the world. As several research gaps were mentioned in the theoretical part of the research, such as data standardization for logistics processes, further development of technologies and their application, and influence on the simulation and optimization in logistics, these gaps can also be further investigated and assessed in the future. The lack of cooperation between authors and weak cooperation between countries that were identified in this research may also provide an impulse for future work, especially on the basis of comparison and sharing the experience.

Thus, the specialist, considering the implementation of Simulation for Logistics processes or researchers working in the field of Logistics and considering process simulation, should consider the results of the research as it proves the importance and efficiency of the application of simulation for logistics purposes.

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BULLWHIP EFFECT EVALUATION WITH INDICATORS IN USE

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Abstract

The bullwhip effect is a widely researched phenomenon. Its occurrence has a high impact on supply chain performance. Nonetheless, in practical environment a targeted analysis is less common. This results in a gap between scientific interest and practical application. Due to the high level of adaptation needed it is hard to apply the best practices.

Supply chains use multiple indicators. There are typical measurements that are used by several industries tailored to their own characteristics. These metrics are crucial to support customer service. They measure the quality of the service and the estimation's accuracy. Targeted analysis of the bullwhip effect is not that common due to limited capacity and the elusiveness of the phenomenon.

A deeper investigation of the bullwhip effect can be accomplished if the existing indicator set is used as a basis. Forecast accuracy, bias and service level value are influenced by the bullwhip effect. Using these indicators for - tracking bullwhip effect as well will raise awareness and understanding of the phenomenon. This means process improvement potential using the existing resources.

Key words: bullwhip effect, forecast accuracy, forecast bias, service level

1. INTRODUCTION

The bullwhip effect phenomenon is broadly researched in the scientific literature. The interest is not only significant from an academic perspective but also from a practical point (Wang & Disney, 2016). In the past 40 years several analyses researched the bullwhip effect but there is still no ready to use solution to avoid it. Its importance in business is mainly connected to the cost related impact that is generated as a consequence. The financial impact is not the only outcome, the effective operation

is also damaged. That results in further costs and requires additional attention (Disney & Lambert, 2008).

The business network and environment are complex and complicated. Focus needs to be divided between several relevant and important area (Simchi-Levi et al. 2008). The bullwhip effect is only one of the factors. The phenomenon is intangible, and it is hard to precisely define it in practice. As a result very limited capacity can be dedicated to only monitor the occurrence. Nonetheless the impacts are still harmful. Case studies present in the literature are mainly mathematical methods that needs resource investment. In addition, adaptability is also low due to the differences on sector and supply chain level. Literature also introduces the bullwhip ratio, but this is also a special metrics with the aim of the quantification of bullwhip effect. However, the adaptability of this metrics is good still application needs high investment on human and financial resources.

As the tracking of the bullwhip effect is essential (Fu et al., 2015) it is important to integrate the measurements in the set of indicators in use. It enables better understanding and detectability of the bullwhip effect. There are several metrics that are in use to keep under control the daily operation and to support the mid- and long-term improvement (Behzadi et al., 2020). Forecast accuracy, forecast bias and service level are basic measurements that are widely used in multiple industries and levels of the supply chain. The mention measurements are highly depending on demand parameter which is key factor also regarding the bullwhip effect. It worth to check if calculation of these measures can show the presence or impact of the phenomenon. Using existing tools from a different perspective would support to improve the performance of the supply chain without high level of investment. It could also deepen the understanding of the phenomenon.

The aim is investigating the potentials of the currently used indicators in analysis of the bullwhip effect phenomenon. This paper is checking the possibilities of extending the current operational usage of metrics with a new perspective.

2. METHODOLOGY

This paper consists of two parts. First the literature review is presented. It both introduce bullwhip effect phenomenon and selected indicators frequently used in practice. Bullwhip effect introduction focuses on the reasons and impacts of the phenomenon (Chapter 3.). The introduction of the indicators contains forecast accuracy, forecast bias and service level (Chapter 4.). These measures are the ones used in the extended supply chains which are typically affected by the bullwhip effect. The second part of the paper is the authors' analysis (Chapter 5.). It investigates how the presence of the bullwhip effect influence the introduced metrics. The analysis is separated to three levels based on the timing and purpose of the investigation: indicative, mitigative and analytic measures. The paper is looking for answer on below research questions:

- Does the occurrence of the bullwhip effect have impact on forecast accuracy, forecast bias or service level?

- Are these indicators applicable for bullwhip effect analytic purposes?
- How can we apply the mentioned metrics regarding the bullwhip effect analysis?

3. BULLWHIP EFFECT

Due to the malfunctions faced in the supply chain when the bullwhip effect occurs the analysis of the phenomenon is important. The research of the phenomenon has several approaches and directions. The main understanding of the phenomenon is still the same. The research of the phenomenon has a long history. It was known as the forrester effect based on the first researcher of the topic (J.W. Forrester, MIT Sloan School of Management). The term itself was defined in a 1997 study by Lee, Padmanabhan and Wang. From a practical perspective the first recognition is attributed to Procter and Gamble. The scope of their analysis was the causeless fluctuation of diaper demand and orders. Customer's needs did not explain the level of variability. The phenomenon was also present in other sectors and companies. The authors phrased the upcoming definition: "the phenomenon where orders to the supplier tend to have larger variance than sales to the buyer (i.e., demand distortion), and the distortion propagates upstream in an amplified form (i.e., variance amplification)." (Lee et al., 1997, p546) Another definition approaches from a different perspective. It is defined based on the difference between customer demand and the produced quantities. "The effect by which slow moving consumer demand creates large swings in production for the suppliers at the other end of the supply chain." (Wang & Disney, 2016, p691) Financially the bullwhip effect becomes crucial once the fluctuation of production leads to higher costs than the inventory holding (Wang & Disney, 2016). The occurrence of the phenomenon is also influenced by the market environment. Competition also needs to be considered as a factor. In addition, the structure of the supply chain is also impactful from the bullwhip effect perspective (Xuluo, 2021).

3.1. Reasons for the bullwhip effect

Traditionally the focus of the research is the operational consequences and causes of it. The solutions are also covering this perspective regarding influencing the lead time and increasing transparency (Lee et al., 1997; Yang et al., 2021). Lee et al. (1997) described the main operational reason groups behind the bullwhip effect: demand signal processing, rationing game, order batching and price variation (Lee et al., 1997). These reason groups have been complemented by the lead time parameter (Geary et al., 2006). This is due to the change in the lifestyle of the customers and the supply chain operations. Longer, international chains lead to an increase in lead time. The lead time element is still among the operational causes. Studies with a focus on operational reasons of the bullwhip effect assume the behaviour of the humans rational (Yang et al., 2021). Even if the described categories may seem outdated based on the time they were defined they are still valid. Digital technology has had a

significant impact on supply chain operation. The change is mainly visible in information, financial and material flow (Wiedenmann & Größler, 2019). In theory the tools available should support avoiding the bullwhip effect, but practical experience does not confirm this. These categories are still valid in practice.

As human factors have not been considered in these studies, it meant a potential improvement of the bullwhip effect research. As another aspect, irrational decisions and a stressful environment was also included as a behavioural reason for the bullwhip effect (Sterman, 2006). The number of studies considering the human factors have increased. The focus topics are information sharing, training and communication, trust in collaboration, human influence in forecasting and reactions on the bullwhip effect (Yang et al., 2021).

The aforementioned reason groups can be further broken down into sub-elements (Geary et al., 2006; Potter & Disney, 2006; Bhattacharya & Bandyopadhyay, 2011; Yang et al., 2021).

- Demand signal processing: inaccurate forecast; misunderstanding of the market information; the applied forecasting strategy; handling of stock-out; and lack of learning
- Rationing game: number of echelons; lack of transparency, control, and synchronization; fear of shortage; local approaches versus global
- Order batching: applied lot size; ordering timelines; lack of harmonization of replenishment strategies; limited capacity
- Price variation: planned and unplanned promotions; fluctuation of material price and finished goods price; change of other costs
- Lead time: impact forecasting strategy; delay in information flow
- Human factor: information sharing, trust, human influence on forecasting

3.2. Impacts of the bullwhip effect and reduction opportunities

The bullwhip effect can result in opposite outcomes - both overstock and stock-out can be the outcome. These results have a detrimental effect on the supply chain performance and have direct or indirect financial impacts. For example - cost impact can be realized due to lost sales opportunities or via increased warehousing costs. This impact can increase through the chain due to the multiplication effect. This leads to serious consequences at the chain level and mainly impacting the manufacturing level. In addition the cost information is also affected, becoming distorted due to the bullwhip effect. The impact is not only realized at a stock level but also highly influence the capacity utilisation. The production schedules are also impacted by losing the stability (Disney & Lambrecht, 2008; Wang & Disney, 2016).

There is research showing that collaboration has a supportive impact and it can strengthen the system measurements so the solution can be close to optimal (Tliche et al. 2019). Today's supply chains are considered complex networks rather than streamlined chains. The different chain and echelon level approaches can indicate different goals and expectations. Beside the global goals of delivering value or service to the customer they also try to maximize profits on a local level (Disney & Lambrecht 2008). Due to global and local differences and complex operations, cooperation became much harder. An ideal chain could be characterised by information

transparency, coordinated processes and common strategy. If these circumstances were realised, the bullwhip effect would be less likely to happen. However, the above characteristics are not likely to happen in real-life circumstances in the foreseeable future. The competitiveness of the industries of the real world results in incomplete information flow. As a consequence the customer demand information comes through the chain in a distorted manner (Zarandi & Moghadam, 2016).

For better forecasting processes and accuracy information sharing is needed. This would not be the final solution, just a first step. Highest peaks can be avoided in the long term. Beside the information flow lead time should also be considered. Analysation of the bottlenecks from this perspective can highlight critical processes. This can support having better control, more manageable processes, and lower uncertainty. Once the first steps through information sharing and analysation of the bottlenecks are made further synchronisation approaches can also be initiated. These can cover both batch sizes and processes (Towill et al., 2007) Based on case studies smoothing of the replenishment rule can result in a balanced solution between the bullwhip effect and the customer service level (Ponte et al., 2022). Although, transparency and information sharing seem to be supportive in decreasing the impact of the bullwhip effect, it has been demonstrated in various research that it does not always work (Haines et al., 2017). Even if the phenomenon does occur, an increased level of transparency and information is still important. It is easier to realize the bullwhip effect this way and it also supports the resolution of the problem.

4. INDICATORS USED IN PRACTICE

The harmonization of indicators can support the defined goals in the supply chain. This supports the harmonization of processes. These measurements can be personalized at each level according to the circumstances, but the calculations and basis need to be the same to be comparable. There are several performance measurement tools, frameworks and systems applied in the different industries. The metrics integrated in them are customised for the user company or the chain. Still there are some metrics that are typically used in practice. These measurements are integrated in the key performance indicator system in several industries and applicable at all levels of the supply chain. These metrics are the followings: forecast accuracy, forecast bias, and service level.

The common factor in the measurement below is that all of them can be measured in all levels of the supply chain. The scope of the measure can always cover two viewpoints. First is the comparison with the connected parties; second, the comparison to the final customer. The other common point is the scope of the measurement. Both of the three measurements consider forecasting as the basis with the calculation built on the demand value. For the calculation the following abbreviations can be used:

S actual sales quantity
Dc customer demand
D-1 demand of the previous echelon
F forecasted quantity
Fx fixed forecasted quantity (x month ago)

4.1. Forecast Accuracy (FCA)

The forecast accuracy aims to analyse the deviation between the actual- and the forecasted demand. This comparison gives information on the quality of the forecasting. The targeted value of the metric can differ based on the industry or segment. It can be influenced by frequently changing products and market requirement (e.g. fashion) or economical changes (e.g. COVID19). The calculation can be initiated in multiple different ways. It can be an absolute value of the difference, but it can also be calculated as a percentage (Moller et al.,2021).

Various calculation are in use to evaluate the forecast quality. The difference is mainly in the penalization of the errors. However, the negative and positive deviations of the same magnitude are assumed to result in the same loss, penalized symmetrically. The most widely used methods are the mean forecast error, mean absolute percentage error and the root mean squared error (Moller et al., 2021).

In several cases due to the length of the supply chain comparison of the current forecast and the sold quantity does not give sufficient information. Lead time can be two months or even longer (for example, sales in Europe with production in China). In this case the earlier forecast can be considered as the signal for the production. From a supply chain and production perspective the length of the chain also needs to be considered in the calculation. It is more informative with regards to the performance of the chain and/or echelon. In the case of these extensive chains forecast accuracy calculation can be based on a two months fixed forecasting period. The equation of the forecast accuracy based on Moller et al (2021) and practical applications is present below (Equation 1.): The customer demand is compared with a fixed forecast (fixed period depending on the supply chain characteristics):

$$FCA = \frac{D_c}{F_x} \tag{1}$$

As the calculation of the forecast accuracy is based on the forecasted quantities and the demand the value changes once the bullwhip effect is present. Both over and under forecasted periods will lead to oscillation of the metric. This phenomenon is first visible in the demand fluctuation. In cases of significant peak or drop of order the measure will move out of the targeted interval. If everything is sold according to plan bullwhip effect should not occur. Once the value of the FCA is out of the tolerated interval it means a significant drop or peak that is a signal of the bullwhip effect. The mentioned tolerated interval shows differences on industry level. Taking example of food industry, it is typically over 80%, in machinery industry it is 60%.

4.2. Forecast Bias (FB)

Besides the forecast accuracy it is also important to see how large the discrepancy is from the plan. Bias shows the trends if the forecasting is above or below the actual sales. It shows if the given product is over or under forecasted (Wan & Sanders, 2017).

Forecast bias and forecast error need to be separated. Forecast error is "the deviation of the customer forecast from the final order". Forecast bias means "structural or strategical deviation". In the case of positive bias, the customer, due to systematic or strategical reason, inflates their demand forecast; this is the result of the rationing gaming (Seitz et al., 2020). Therefore, analyzation of the bullwhip effect results can be highly supported with the bias results.

This metric is worth tracking on a monthly basis, it can show the sales trends of the selected product. It can also highlight monthly peaks and support reaction. Using forecast bias the product portfolio can be divided taking into consideration the tendencies of the market. A revision of the planning can be executed to improve quality. The higher product variety leads to an increase in complexity. Due to this the quality of the forecast cannot be kept on the highest level. To support the estimation process forecast bias that shows the tendencies can be used (Wan, Sanders, 2017).

Bias can be connected to operational performance and bullwhip effect elimination due to the results of the tracking. Tracking of tendencies can increase the quality of the forecast and it can also support the identification of the gaming behaviour (Seitz et al., 2020).

The calculation of forecast bias is a comparison of the actual volumes and the plans. The result can be both positive and negative. If the bias is positive the product is over forecast. In case of negative bias, it is under forecast. Equation 2. presents the calculation based on Seitz et al (2020) and practical applications.

$$FB = \frac{D_c - F}{F} \tag{2}$$

Due to the length of the supply chain, from a process improvement perspective usage of the latest forecast is not enough in several cases. Lead time needs to be taken into consideration in the case of long supply chains and supply networks. This can be supported by the fixed period for forecast. It can be, for example, two months: that can cover delivery time and reaction, also at the supplier and manufacturing level. In this case the fixed forecast needs to be used in the equation.

$$FB = \frac{D_c - F_x}{F_x} \tag{3}$$

Bias calculation is also based on demand and forecast. It has a targeted interval that shows acceptable level of change. Bias shows in the case of deviation also its' direction. This gives further information regarding the bullwhip effect. Once we know the direction, it is also known in the chain in which direction the first actions need to be done to eliminate harmful impacts.

4.3. Service level (SL)

The importance of service level is justified by the fierce competition of the market. Multiple replacement products are competing for the market share. Service level shows the availability that is crucial to reach the customers. Service level also

influences the demand, as products with higher service levels typically have a higher demand (Bhuniya et al., 2021). Through this forecast is impacted.

Service level shows the percentage of the fulfilled orders compared to the requested quantity. It can be introduced at all levels of the supply chain. Differentiation in calculation can also be introduced based on product classification or any predetermined criteria (Sereshti et al., 2021).

At the customer end of the chain, it also gives information on customer satisfaction (Customer service level (CSL)). At the same time it still shares information between the other members of the chain. It can point out where the problem occurred that resulted in poor performance. It can also potentially highlight gaps in the forecasting procedure. As this metric compares the requested and the supplied quantity only actual data can be used. Equation 4 and 5 shows the calculation method based on Buhniya et al (2021) and practical applications.

$$CSL = 1 - \frac{D_c - S}{D_c} \tag{4}$$

$$SL = 1 - \frac{D_{-1} - S}{D_{-1}} \tag{5}$$

The service level in practical use is attached with a target. The targeted service level can differ on an industry level. It is typically the highest in the food industry due to the short shelf life of the products. Once the value is out of the target the potential reasons behind need to be analysed. As the calculation shows peak demands that can lead to the bullwhip effect an immediate filtering option can be achieved if the occurrence is reacted to.

4.4. Combination of the indicators

In practice the aforementioned metrics are commonly used together. This combined usage can highlight additional information. If only forecast accuracy is used no information is obtained if the product is over or under-forecast. This information is added by the forecast bias.

The service level is primarily important due to the customer focus approach. It is worth checking the CSL (customer service level) and SL between other members. Checking the SL and FCA together can also give us information. Sufficient service level should be paired with proper forecast accuracy and positive or close to zero bias. There can be some exceptional cases (like sales of dead stock) but normally the values of the aforementioned metrics analysed together should answer product accessibility related questions.

Both aforementioned measurements aim to reach a better forecast. It is crucial to have proper inventory control. A lack of accurate planning results in lower effectiveness and quality (Moller et al, 2021). Supporting better demand planning can impact the bullwhip effect. As demand management is one of the core reasons behind the phenomenon, improvement of the field is very important. As all the aforementioned measurements are calculated based on the forecast, demand, and real sales value they can show the bullwhip effect. Using them in a targeted way to indicate

the phenomenon can increase the flexibility and decrease the level of negative impacts.

The FCA, FCB and SL are not only connected to each other but also reflect other areas such as inventory. Over or under forecasted products cannot be considered as optimal regarding the kept stock which can also be impacted by the presence of the bullwhip effect. The question is: Can any of the mention indicators be used to predict bullwhip effect? Can any of the indicators show the presence of the bullwhip effect?

5. INDICATORS TO MANAGE BULLWHIP EFFECT

The indicators used in the supply chain can be analysed during the investigation of the bullwhip effect. Those can initiate preliminary, on the spot and subsequent analysis. From this perspective metrics can be categorized into three different groups:

- Indicative

These metrics potentially show the occurrence of the bullwhip effect in advance or in the early phases. The aim is to take immediate action to reduce the probability of the occurrence with as many members of the supply chain as possible. It is also important to avoid impacting the customer.

- Mitigative

These metrics can be used to eliminate or at least decrease the impact of the bullwhip effect. They reflect the occurred phenomenon. Using these metrics the degree of oscillation can be reduced. Mitigative purpose can also help maintain a high level of the customer satisfaction.

- Analytic

These measurements support a deeper understanding of the phenomenon's background. They are mostly used for further investigation once the problematic period is over. They can be also the basis of process improvement actions.

5.1. Indicative measurements

Forecast bias and forecast accuracy can possible be used for indication of the bullwhip effect. In the calculation of these metrics current demand is compared to the historical forecast. The expectations and the realization are compared. The exact timing of the frozen period is adaptable based on the supply chain and industry's characteristics (number of echelons, geographical distances, etc.). As a result the indication can be realized in time. When the bullwhip effect is present forecast numbers do not cover the real demand. These two measurements indicate the deviation from the forecast. If the bullwhip effect is present forecast accuracy decreases and the absolute value of bias will be higher.

The change of bias and accuracy can be caused by other factors as well. These can be, for example, IT issues, so the forecasting system does not show realistic numbers or handling of returned goods. These cases can result in bias or accuracy change but the root cause can be identified, and the issue quickly solved.

These metrics are widely used due to their adaptability and scope. Based on the length of the chain, lead time, number of echelons etc. these are customized.

Meanwhile the indicators essentially remain the same. The planned and actual quantities are compared. This shows if customer demand has any unachievable fluctuation considering the flexibility of the chain.

When using forecast accuracy and forecast bias small deviations are noticeable. It allows a chance to check whether it is caused by something known or something unpredictable. It is also possible to take steps in advance if the bullwhip effect is predicted based on the investigation. These steps can reduce potential losses. It can shorten the range of the bullwhip effect and the number of effected echelons.

Using the aforementioned metrics, the bullwhip effect can be recognized before all members of the chain are impacted. It gives space for communication or compensation towards the customer. At the same time, it also enables modification of the forecast toward production to provide a much clearer and more transparent picture in all parts of the supply chain.

In addition to the indicative purpose forecast accuracy and bias can be used for analytic purpose with regard to the bullwhip effect as well. It can give information on the quality of the forecasting methodology used. This also has a significant impact on the bullwhip effect.

5.2. Mitigative measurements

Indicators used with mitigative purpose aims to eliminate the impact of the existing bullwhip effect. The widely used measure that can be applied for this purpose is service level. The metric reflects the existing situation. The low service level value can indicate the bullwhip effect if the stock level is not sufficient to cover the incoming orders. The measure cannot be applied as an indication due to the scope, but it can be used to reduce the negative impact. Service level is applicable when the demand is higher than the available quantity.

The realization of the presence of the bullwhip effect is important to reduce impact. It enables proactive approach instead of reactive. As a result, potential financial losses can be prevented and the degree of oscillation of the bullwhip effect can be decreased. Action can drive a positive result both at an echelon level and on chain level.

At an echelon level, for example, substitute products, a delay in promotional activity or compensative discounts can be offered to cover the sales gap generated. These activities will not terminate the bullwhip effect, but the sales results will be impacted less severely.

It can also support the chain level action. As the out of ordinary order can be handled in place, further parts of the chain do not need to be impacted. Exceptional information on the market situation can change manufacturing plans or orders sent to the supplier. Both are small steps, but at the end significant financial impact can be prevented. It can also support the non-financial areas.

The aforementioned example shows a case with information flow from the customer to the production. It can also work inversely. For example, production can communicate through the information chain regarding a missing part. This enables the distribution and retail level to develop solutions to decrease the impact.

The service level is highly monitored in most of the supply chains due to the importance of the customer focus approach. It is easy to extend the current way of using it with some additional check points. As the metric is present the task is to incorporate its usage into mitigation of the bullwhip effect. This metric is calculated by all echelons of the supply chain.

The service level is mainly useful for outstanding orders. If the order can be served from the available stock this metric does not show any difference. Nonetheless, this can still be problematic. For sales significantly under expectation forecast bias or accuracy can be used. It can also be highlighted using inventory management metrics.

5.3. Analytic measurements

Analytic metrics help to determine the impact of the occurred bullwhip effect. For analytic purposes it worth checking the aforementioned three KPIs first. It can show trends and tendencies. If reoccurring fluctuation of accuracy or bias is typical, we may face seasonality that is not considered in the plans. It also needs to be considered if SL, FCA or bias value is low in the long term for a given product or product group. This also show inappropriate forecast. To introduce corrective measurements the highlighted metrics can support select products, product groups or time periods.

Besides the performance indicators showing the presence of the bullwhip effect, there are ones which show the consequences. We can use them once it has been determined which product or area is impacted. These measurements cannot be used for indication or immediate action. The focus is rather at the echelon level than chain level. Metrics show cost and non-cost related impacts and do not focus on the cooperation of the supply chain members.

The fluctuation of these values can be caused by several other reasons besides the bullwhip effect. The measurements that can be used to justify that the bullwhip effect has happened are potentially used to precondition process improvement activities.

In this category example indicators are listed that can be impacted by the bullwhip effect. These are also important because the costs in the supply chain are increased by them as well. The supply chain and industry specific factors can be considered during the selection of the measurements. The critical areas are highlighted this way. Below some potentially impacted indicators are listed as examples.

- level of inventory and inventory turnover
- capacity utilization
- development of the safety stock
- lead time and delivery time of goods
- warehousing and transportation costs

The listed metrics are supply chain related impacts. Nonetheless, besides the immediate reflection on calculation the effect is more complex. It has financial consequences both immediately and in the long term due to the need for time and cost to return to the standard status.

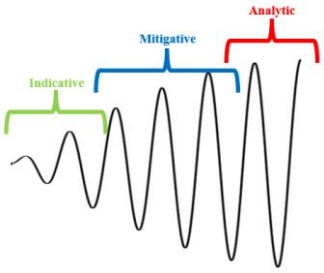
5.4. Time aspect

Time is a crucial aspect in respect of the bullwhip effect. As time passes the impact of the phenomenon becomes higher due to the increasing degree of oscillation. Based on the time passed the bullwhip effect can be split into three phases: early phase, intense phase, recovery phase.

In the early phase the first signals of the occurrence are present. The intense phase is already noticeable at multiple levels of the supply chain. The recovery period is once the phenomenon has already decayed; the consequences are appearing. By this time the impact has reached all levels of the supply chain.

The figure below shows in a timely manner the application of the aforementioned indicators and grouping. Moving from left to right indicates the time passed and the progress within the chain. In the early phases the signal is only present at the customer-retailer level of the supply chain. Forecast accuracy and bias can be used with indicative purpose. At the intense phase the phenomenon has already reached more actors of the chain and it is present in the service level metrics. Here the service level can be used together with the accuracy and bias to indicate the impacted products. The analytic purposes are in scope at the latest stage. By this point most of the chain members have already been impacted, recovery has started.

Figure 1. Time aspect of indicators analysing bullwhip effect



Source: Authors' edition

Integrating the targeted analysis of the bullwhip effect can increase the supply chain performance. As the indicators used are already applied no extra resource or process change is needed to be added. Only the perspective and approach change are needed. The measurements are already known and used; the task is to show the different method of use.

Identification of the presence of the bullwhip effect can show the relevant reasons of the phenomenon that are impacting a given chain. This support targets process improvement actions and in the long-term mitigation of occurrence. The most affected products can also be determined.

5.5. Application of the indicators

Table 1 shows the indicators that can be used for the different purposes. Regarding indicating the bullwhip effect forecast accuracy and bias are the

measurements. For this purpose, daily calculation is the most efficient which enables proactive approaches. In practice the calculation can show the value of these indicators on item level. Indication of the bullwhip effect can happen through filtering out the products with FCA or FB out of threshold. Once the problematic items are selected it can be simply checked if the difference is due to known reason (e.g., quality issue) or further investigation is needed. Recognizing the probability of bullwhip effect occurrence can prevent unnecessary productions and extra stock. On the other hand, it also can support to serve potential extra needs of the customers.

Table 1. Used indicators and application directions

	Indicative	Mitigative	Analytic
Forecast accuracy	X		X
Forecast bias	X		X
Service level		X	X
Application	Daily measure Threshold value	Daily measure Not sufficient availability	Big Data Patterns

Source: Authors' edition

For the mitigative purpose usage of service level is suggested. The value of this metric is also calculated on item level and daily basis. Here the application is also through analysation of the items with not sufficient availability. It enables reacting on the lost sales opportunities and preventing further supply chain echelons from unrealistic demand information.

Using these measures on analytic purpose is building on the technological development (such as Big Data) that enables long-term data availability. This approach has multiple application possibilities such as analysation of price increase, promotion, new product launches, seasonal products (in or out of season) etc. During the analysation, patterns are being researched. Cases from the historical data with similar discrepancies of measures. Processes can be improved through building in the learning of this analysation.

6. CONCLUSION

The bullwhip effect is a phenomenon of both scientific and business significance. Its occurrence leads to a decrease in performance and direct and indirect costs. The current competitive environment puts pressure on supply chain operations. To gain an advantage on the market, the supply chain needs to be competitive as well. At the same time the capacity to improve processes is also limited. Human and cost level limitations narrow down the possibilities.

Currently scientific and practical approaches are separated. There are several case studies and best practices to support handling the bullwhip effect. However, these are specialize in the studied environment and characteristics. Adaptability of these best practices is very limited.

Forecast accuracy, forecast bias and service level are indicators that are used in multiple industries at all levels of the supply chain. The aim of the usage is to improve the quality of the estimations to reach a higher level of customer service. These measurements compare the estimations with the real demand value.

The bullwhip effect influences the value of these metrics; as in all calculations demand plays an important role. The measurements show deviation from the targeted value. Forecast accuracy and bias currently mainly support exceptional cases, such as allocation planning when there is a shortage or a need to sell overstock. In daily use it is less in focus; they are rather used to evaluate the performance of the employees or systems. Service level is more commonly applied also in the daily operation, due to the customer focus approach. This measure is mainly used for local, echelon level purposes. The main purpose its usage is the monitoring of unexpected bottlenecks.

Targeted usage of these measurements can support conscious operation at a chain level. It can help in the early recognition and more successful handling of the phenomenon. As the metrics exist and are known in the chain additional resource requirement is not high.

This approach does not aim to solve all the negative impacts of the bullwhip effect in one step. The goal of this study is to present a solution to make the first step. This solution use existing resources and processes. It adds a new perspective to a tool in use. The requirement is a slight change in the way of reading and understanding the measurements and a higher awareness of the phenomenon. In the mid-term it can have a process improvement effect also, as it leads to better visibility on the bullwhip reasons of the examined chain or echelon.

In the continuously changing environment this subsequent analysis enables the process to be investigated from a different perspective. Additional information can possibly be explored. A combination of preliminary, on the spot and subsequent analysis allows the process to be evaluated taking all the perspectives into consideration. The analysis can be specified based on the characteristics of the given chain member and considering the main attributes of the chain. Easy adaptation is due to the measure's flexibility.

The conclusion reached by indicator and mitigative measurements should also be integrated into the subsequent analysis. It is supplemented by the potential listed metrics to view all the aspects. The investigation of the full picture allows process improvement actions to be initiated that target the reduction of the impacts caused by the bullwhip effect.

This research is focused on practices where the mentioned indicators are used. In multiple industries the application of these measures is typical. However, interpretation or calculation level can differ which limits the adaptability. The mentioned measures may not indicate all the instances when the bullwhip effect occurs.

As extension of the research, further frequently used indicators can be analysed. The impact of bullwhip effect is typically on stock fluctuation, inventory related measures (such as inventory turnover rate or days to sell inventory) can be used in analysis phase. Beside the extension of the scope of metrics also practical analysis is needed. The result should be tested in multiple industries.

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II. SUPPLY CHAIN AND LOGISTICS DIGITALIZATION

CONCEPTUAL MODEL FOR QUALITY ASSESSMENT OF DIGITAL COMPETENCIES IN HIGHER EDUCATION SYSTEMS – A CASE STUDY OF THE RESEARCH PROCESS

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Abstract

Digitalization is undoubtedly of high significance after three years. As professional logisticians and supply chain experts, who are mainly involved with IT and related digitalization, trends and challenges in aforementioned fields are researched frequently. Despite constant progress and development, determining the quality of digital competencies poses a significant challenge. The literature offers a variety of frameworks, guidelines and standards for teaching, selection, and use of technologies for educational purposes, as well as provisions on quality education. Due to the burning topic, the purpose of this paper is to present ongoing research, which was produced on the basis of the European Digital Competence Framework for Educators (DigCompEdu) and the document Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG). The DigCompEdu framework ensures that quality objectives are set and achieved by promoting improvement, while the ESG document provides a set of standards and guidelines for internal and external quality assurance in higher education. Based on the latter, questionnaires were prepared for both educators and students, who were interviewed on digital competencies quality provision in higher education. The objective of this research is conceptual model development, from which questionnaires were derived for the comprehensive assessment of provision and quality of educators' and students' digital competencies in the international higher education systems. This paper presents foundation for further research on digitalization within aforementioned

fields, as it provides insight into the perception of the digital competencies' quality and the identification of the existing gap between perception of educators and students. Logistics is the foundation of a well-designed supply chain and its smooth operations. This research topics' significance is heightened through its advantages and challenges. The latter should be thoroughly examined to obtain comprehension about errors' elimination and higher education optimization.

Key words: digitalization, supply chain and logistics, quality assessment, digital competency, higher education

1. INTRODUCTION

Digitalization has transformed the world in every aspect of life during the last decades (What is Digitalization?, 2020). The access to various information and communication technologies (ICT) other services, increase of smartphones, computers, tablets, and social media usage have changed the way people communicate and interact, learn, work, and do business (Schelenz & Schopp, 2018; Parviainen et al., 2017). Daily life nowadays involves extensive use of ICT, including searching for information, products or services, processing, communication, or production of information, both for work and private purposes. All the latter is enabled due to the rapid development of ICT for private, public, and business purposes (Hatlevik et al., 2012). The IoT has changed our perception about space and time, and about the relationships between people and machines – today, people and technologies appear as inseparable elements. (Martínez-Bravo et al., 2022) The relationship with technology implies the appropriation of systems and tools for their transformation into technologies meant for learning and knowledge, and technologies meant for empowerment and participation (Reig Hernández, 2016).

The rise and development of digital technologies and their educational applications increasingly requires the development of digital skills among educators (European Commission, 2013) since technology is now permeating the deliverance of teaching and learning, reflecting in students' experience and interactions (Carey, 2019). As a result, the concept of digital competencies has emerged, where the development of digital competency prioritizes the creative, safe, and critical ICT usage for different purposes, such as personal development and leisure, education and learning, participation and establishing connections in society and employment (Ferrari, 2012).

Due to the epidemiological situation in the recent few years, many schools and universities had to migrate their learning, teaching, and assessment activities to digital environments. Even though this was necessary, it was done without an agreed, appropriate, or even unified online pedagogical method, which consequentially created an imbalance between the educational quality and new, required approaches (Crawford et al., 2020). Logically, the impact of such a migration has left significant consequences on academic communities – faculty members had been facing diminished time for planning, preparation, teaching, and quality measures' implementation while tackling students' attendance reduction (O'Keefe et al., 2020).

Furthermore, faculty members were then compelled to coordinate newly default online education method, instructional design of effective online education deliverance and student learning, provide adequate pedagogical support for students, assure high-quality learning experience of students, while preparing for contingency plans to deal with unexpected events and needs, arising from the new default educational process (Bao, 2020).

Even though students are exceptionally willing to use various ICT, they should adopt new technologies as part of their educational process (Lamb & Arisandy, 2020). Regrettably, many of them lack online learning experience which causes technical operational obstacles. Even after the COVID-19 pandemic, educators and students still face the aforementioned challenges, including a lack of online teaching and learning experience and/or support from educational technology teams (Duarte & Rodríguez, 2021). Thus, educational institutions should make the necessary provisions to reinforce the digital competencies of both educators and students (Bao, 2020). Before educational institutions can provide such provisions, it is necessary to determine the (state of) knowledge of digital competencies among educators and students. To accomplish the latter, a conceptual model for digital competencies quality assessment in higher education was developed. The foundation of the model are principles of quality management by ISO 9001:2015 standard. The conceptual model was further composed on the basis of European Digital Competence Framework for Educators (DigCompEdu) and the document Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG). Based on the developed conceptual model, two questionnaires were prepared for both educators and students, who were interviewed on digital competencies quality provision in higher education. The main objective of this research was to develop a conceptual model, from which questionnaires were derived for the comprehensive assessment of provision and quality of educators' and students' digital competencies in the international higher education systems. The results of this ongoing research and associated project will enable the analysis and comparison of both aspects of the included groups of respondents, an insight into the perception of the digital competencies quality and the identification of the existing gap between perception in higher education.

The purpose of this model is that institutions could independently perform the digital competencies quality assessment, premised on which a proposal and implementation of necessary changes could be conducted in order to ensure the best possible educational process. Furthermore, digital competencies are extremely important for the field of supply chain management, where the advancements in digital competency could improve the flexibility and responsiveness of supply chains and logistics, which consequently become competitive through operational strategy with IT integration (Gunasekaran & Ngai, 2004). Meanwhile, a "tendency towards higher qualifications and acquisition of IT competency and process understanding" (Sapper et al., 2021) is desired in the logistics field. There are various reasons why digital competencies are a prerequisite in the fields of supply chain and logistics, mainly extensive sets of data and information, their analysis, and interpretation (Sapper et al., 2021). Therefore, the need for supply chain and logistics workforce is to have the ideal digital competencies to be efficient and effective logistics 4.0 workforce (Abdul Rahman et al., 2019). Analysing competencies allow professionals

to derive requirements for qualifications and developments in occupational fields, with possibility to reveal impacts on future forms of job profiles and organizations (Sapper et al., 2021).

2. THEORETICAL BACKGROUND

To comprehend the challenge, a lifelong cycle of learning and development of new skills is required to adapt to change and the systems' complexity (Martínez-Bravo et al., 2022). The continuous development of digital infrastructures, universalisation of faster and securer network access and interconnection is giving preference to configuration of the global digital ecosystem in which numerous complex and disruptive processes take place (Jorge-Vázquez et al., 2021). This teetering digitalization is challenging the traditional structures and balances of social and economic organization (European Commission, 2013), which also includes the education sphere. Digital transformation and the use of digital technology in educational institutions have grown exponentially in the last decade, especially during the COVID-19 pandemic (European Commission, 2013). Technology is now permeating the deliverance of teaching and learning, reflecting in students' experience and interactions (Carey, 2019). Furthermore, the growing number of learning management systems, online courses, communication platforms, and social media have enormous impact on embedment of online teaching and learning process (Barnes, 2013; Becker, 2010; Bell & Shank, 2004). This new default online education paradigm offers a wide pallet of opportunities to be explored and implemented in the teaching–learning process of higher education (Jorge-Vázquez et al., 2020).

2.1. Digital competency

The term competency represents "a high-level know-how, requiring the integration of multiple cognitive resources when it comes to deal with complex situations" (Perrenoud, 1995). It can be stated that a competency is a combination of knowledge, skills, and attitudes appropriate to the context (Ala-Mutka et al., 2007). The term competency is used more than the term skill, which reflects the need for a more profound and wider content of the term (Martínez-Bravo et al., 2022). The relation between competency and skills is defined as (Ilomäki et al., 2011): "a competency is more than just knowledge and skills. It involves the ability to meet complex demands, by drawing on and mobilizing psychosocial resources (including skills and attitudes) in a particular context". Key competencies can also be defined, that differ from the rest, because all individuals need them for active citizenship, personal fulfilment and development, social involvement, and employment (Martínez-Bravo et al., 2022).

The interpretations of digital competency differ from various academic literature, policy documents, teaching, and learning. The usage of ICT is intertwined with society – daily, more people are using technologies, for longer time intervals, for different purposes. The digitalization of society in general enabled the extensive ICTs use since many of the undertaken activities have a digital component. As society is

becoming digitalized, the necessary competencies are becoming diverse and multifaceted. (Ferrari et al., 2012)

There is still no mutual definition of digital competency among scholars; thus, the term has various interpretations, such as »internet skills«, »digital skills« and »abilities« (Van Deursen et al., 2009; Van Deursen & Hacker, 2003). Nevertheless, there are several examples of definitions of the »digital competency« concept:

- Digital competency is a confident use of electronic media for leisure, work, and communication associated with logical and critical thinking, information management and high-level communication skills (Bashkireva et al., 2020).
- Digital competency is a concept, describing technology-related skills (Ilomäki et al., 2011).
- Digital competency is the general term used to describe or explain the ability of a citizen, a student, an educator, etc., to use information technology (IT) in a specific context (Rizza, 2014).
- "Digital competency is the confident use of electronic media necessary to gain knowledge and skills in personal and professional development, due to a high level of logical and critical thinking aimed at managing the information and communication received" (Bashkireva et al., 2020).
- Professional digital competency is "the ability of the" educator "to work in the context of a digitally infused schooling education system, including teaching, manage the digital learning environment and the professional work of being a" (Starkey, 2020) educator.

Digital competency, as the key competency, goes beyond the operational use of technological tools and their application (Martínez-Bravo et al., 2022). It is assumed that all key competencies would immerse into the digital competency and the rest would represent its structural components (Bashkireva et al., 2020).

In preparation for professional activity and as a support for professional digital competency, digital competency should consider the age and psychological characteristics of students (Bashkireva et al., 2020). Being digitally competent today implies the ability to understand ICTs, search for information, be analytical about retrieved information and data due to widespread of the IoT, and to be able to communicate with others using various digital tools and applications (Ferrari, 2012).

At the institutional level, the European Union (EU) has promoted digital competencies' development in a variety of frameworks, including DigCompEdu (Redecker, 2017), which aims to cover educator-specific digital competencies. Other institutions have also expressed their views on the subject (Fallis, 2018): "it is essential that" educators "have the competencies to integrate ICT in their professional practice to ensure the equity and quality of learning".

Digital competencies are a fundamental key to students' and educators' ability to understand and use online method of applied education. Dahiya (2018) stated that the use of ICT in higher education was expanding quickly, is increasingly imperative and will proceed to develop, create, and be significant in the 21st century.

The use of ICT has brought inevitable changes in higher education systems: a) integration of ICT enabled endless possibilities in the education system; b) the use of ICT in education provides the facility of e-learning; c) traditional forms of teaching and learning were converted and diverted to online and virtual environments; and d)

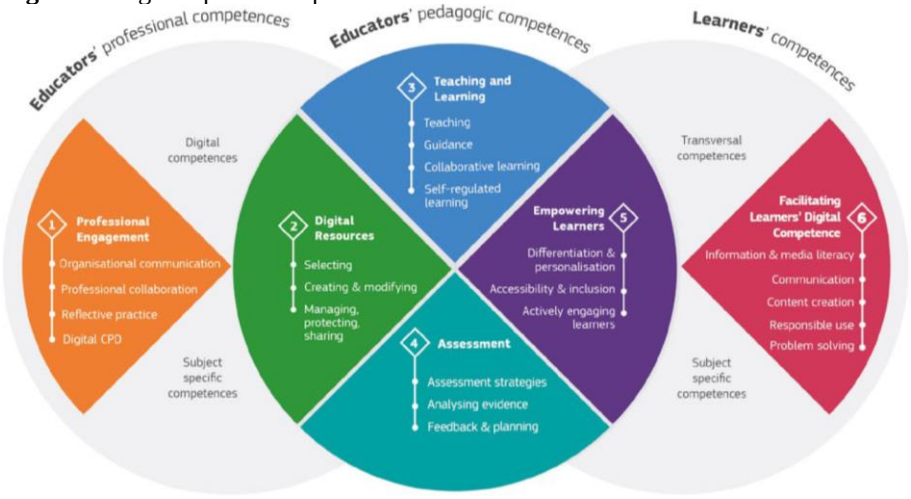
distance learning has been enhanced by the ICT implementation in the education systems. All the above is enabling quality enhancements in this century. (Richard, 2015) ICT infrastructure enables various benefits, such as: access to quality education; e-learning and virtual libraries (Fomunyam, 2020); enhancing the educational systems (Tamrat, 2022); ICT development is the main impetus of green growth (Li et al., 2022).

It is usually self-evident that higher education students and educators should have appropriate digital competencies, but this is not always the case. Many are unable to manage and cope with the required level of social, cognitive, and learning participation in a fully online education system. (Duarte & Rodríguez, 2021) This suggests that the development of digital competencies should and must be considered an educational priority (Blayone, 2018).

2.2. European Digital Competence Framework for Educators (DigCompEdu)

The DigCompEdu framework is a response to the growing needs of many EU member states, that are aware of the educators' need for a set of digital competencies, specific to their profession, which will enable them to exploit the potential of digital technologies to improve and innovate the education system (Redecker, 2017).

Figure 1. DigCompEdu competencies and their connections



Source: Redecker, 2017

The aim of the DigCompEdu framework is to display and describe a set of elementary digital competencies, which are divided into six areas and 22 competencies, specific to educators (Figure 1) (Redecker, 2017):

1. Area: Professional Engagement – refers to the wider professional environment and includes the use of digital technologies in professional communication.

2. Area: Digital Resources – includes the competencies needed for the efficient and responsible use of digital learning resources.
3. Area: Teaching and Learning – is intended for the management and organization of digital technologies' use in teaching and learning.
4. Area: Assessment – addresses the use of digital technologies to improve assessment.
5. Area: Empowering Learners – focuses on the potential of digital technologies for student-centred teaching and learning strategies.
6. Area: Facilitating Learners' Digital Competency – describes specific pedagogical competencies to assist students achieve digital competencies.

The core of the DigCompEdu framework is defined by areas 2 to 5. Collectively, these areas explain the digital competencies educators need to promote efficient, effective, inclusive, and innovative teaching and learning strategies (Redecker, 2017).

2.3. Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG)

The ESGs are used for internal and external quality assurance in higher education. This document does not represent quality standards (such as ISO 9001:2015), nor does it prescribe how quality assurance procedures are implemented, but it does provide guidelines and guidance, covering areas that are crucial for successful quality assurance and learning in higher education. The ESG focuses on quality assurance related to learning and teaching in higher education, including the learning environment and relevant connections to research and innovation. (ENQA et al., 2015) It describes quality as activities within the cycle of continuous improvement (assurance and improvement activities) and is thus in accordance with the principles of ISO 9001:2015 standard (ISO, 2015).

In the ESG, individual instructions are called »standards«, which are complemented by »guidelines«. Standards are defined, agreed, and accepted practices for quality assurance in EHEA and must therefore be observed and adhered to, in all terms and provisions for the higher education institutions' operations. The guidelines further explain why a standard (instruction) is important and describes how to implement a particular standard. Their implementation, of course, differs depending on the contexts in which they are implemented. The standards are divided into three groups (ENQA et al., 2015), amongst which the first set of standards were used (standards and guidelines for internal quality assurance) to conduct the research as they describe instructions and guidelines for internal quality assurance. They consist of ten standards, each described by guidelines. In the following, only the standards are presented, where the description has been redesigned for the purposes of conducting the research (ENQA et al., 2015):

(1) Policy for quality assurance – The institution has a policy for quality assurance that is made public and forms part of their strategic management. Internal stakeholders should develop and implement this policy, while involving external stakeholders.

(2) Design and approval of programs – The institution has processes for the design and approval of their programs. The programs should be designed so that they meet the objectives set for them, including the intended learning outcomes.
(3) Student-centred learning, teaching, and assessment – The institution ensures that the programs are delivered in a way that encourages students to take an active role in creating the learning process.
(4) Student admission, progression, recognition, and certification – The institution consistently applies pre-defined and published regulations covering all phases of the student "life cycle".
(5) Teaching staff – The institution assures itself of the specific digital competency of their educators.
(6) Learning resources and student support – The institution has appropriate funding for learning and teaching activities in a digital environment and ensure that adequate and readily accessible resources are provided.
(7) Information management – The institution ensures that they collect, analyse, and use relevant information for the effective management of their programs and other activities.
(8) Public information – Institutions should publish information about their activities ensuring digital competencies, which are clear, accurate and objective.
(9) On-going monitoring and periodic review of programs – The institution monitors and periodically review their programs.
(10) Cyclical external quality assurance – The institution undergoes external quality assurance on a cyclical basis.

3. METHODOLOGY

The implementation of digital training programs in higher education systems requires a reliable measurement of needs and proficiency levels of competencies. A vast number of scales are intended for this purpose (Duarte & Rodríguez, 2021), where various measurement tools can be classified into two categories (Calvani et al., 2009):

- objective assessments – include class or section performance testing and automated performance testing on assessments and online platforms;
- subjective assessments – include self-reporting tools for digital skills perception.

Objective assessments are commonly used for the practical assessment of digital competencies in a particular field or area but are often limited to specific software programs that can leave knowledge and skills untested. On the other hand, subjective assessments are less specific and allow users to assess their attitudes regarding digital competency. (Maderick et al., 2015) Although subjective assessment can be inaccurate and have little correlation with the objective measurement results (Fite et al., 2009), they are used because of their practicality and capability to solve the problem of software specificity (Ghomi & Redecker, 2019). It is therefore advisable

to apply both objective and subjective assessment types of measurement tools to enable users to receive complete feedback regarding their skills (Carrera et al., 2011).

Digital competencies also vary between different countries, education levels, and cultural contexts (Manos & Montoya, 2018). Given this challenge, it is highly advisable to design appropriate measurement tools or at least adapt them to the specific conditions and requirements of education systems (Midoro, 2013).

Due to the burning topic, this paper presents research, which was produced on the basis of the DigCompEdu framework and standards set by the ESG. The DigCompEdu framework is a scientifically sound framework describing what it means for educators to be digitally competent and ensures that quality objectives are set and achieved by promoting improvement. It provides a general reference frame to support the development of educator-specific digital competencies in EHEA. DigCompEdu details 22 competencies organised in six areas, where the focus is not on technical skills – the framework aims to detail how digital technologies can be used to enhance and innovate education systems.

On the other hand, the ESG are a set of ten standards and guidelines for internal and external quality assurance in higher education systems. The ESG are not standards for quality, nor do they prescribe how the quality assurance processes are implemented, but they provide guidance, covering the areas which are vital for successful quality provision and learning environments in higher education systems. The key goal of the ESG is to contribute to the common understanding of quality assurance for learning and teaching across borders and among all stakeholders.

The questionnaires were divided into two parts: one for educators and one for students. Both questionnaires have the same structure, where questions are composed based on the six areas from DigCompEdu, and the statements within the questions illustrate ten standards based on ESG. These questions present the majority of the questionnaires and are of closed type, with immense details and examples to further elaborate the questions and associated statements (more on this topic in the following chapter). The reasons for closed questions are in the benefits of simple comparison of answers from both questionnaires and their analysis, the respondents can answer the questionnaires faster and easier which leads to higher probability of cooperation; advanced statistical analysis is enabled. Open-ended questions were used only for one of the questions in the demographic sections – for the residing country of the respondent.

The research focuses on the issue if necessary digital competencies are being provided by the respondent's institution for smooth operations of educational system and students learning. Questions can be answered on a three-point scale: »Yes«, »No«, and »I do not know«. Thus, this research is focused solely on the provision of much required digital competencies for educators and students.

The data collected on the basis of this research will be examined on the basis of statistical analysis for the individual countries of the respondents, where the results will then be compared amongst: a) individual countries; b) the group of respondents (educators or students); and c) the group of respondents and the residing country in order to identify possible differences that could appear, if they even occur. The results will enable insight into the perception of the digital competencies' quality and the identification of the existing gap between perception of educators and students from

different countries. However, the data and results will be examined and interpreted as a part of further and future research.

The following chapter describes the elaboration of the conceptual model, the function of the ISO 9001:2015 standard, the use of the DigCompEdu framework and ESG standards for the preparation and construction of two questionnaires, and the conduction of the research to determine the provision and quality of digital competencies in the international higher education systems.

4. RESULTS

4.1. Elaboration of the conceptual model

To determine the provision and quality of educators' and students' digital competencies in the international higher education systems, a conceptual model was elaborated for digital competencies quality assessment in higher education. The model is primarily based on the principles of quality management by ISO 9001:2015 standard. The standard sets out a quality management system in such a way that a commitment to quality is a strategic decision of the institution, which can help the latter to improve its overall implementation and provide a solid basis for sustainable development initiatives. (ISO, 2015)

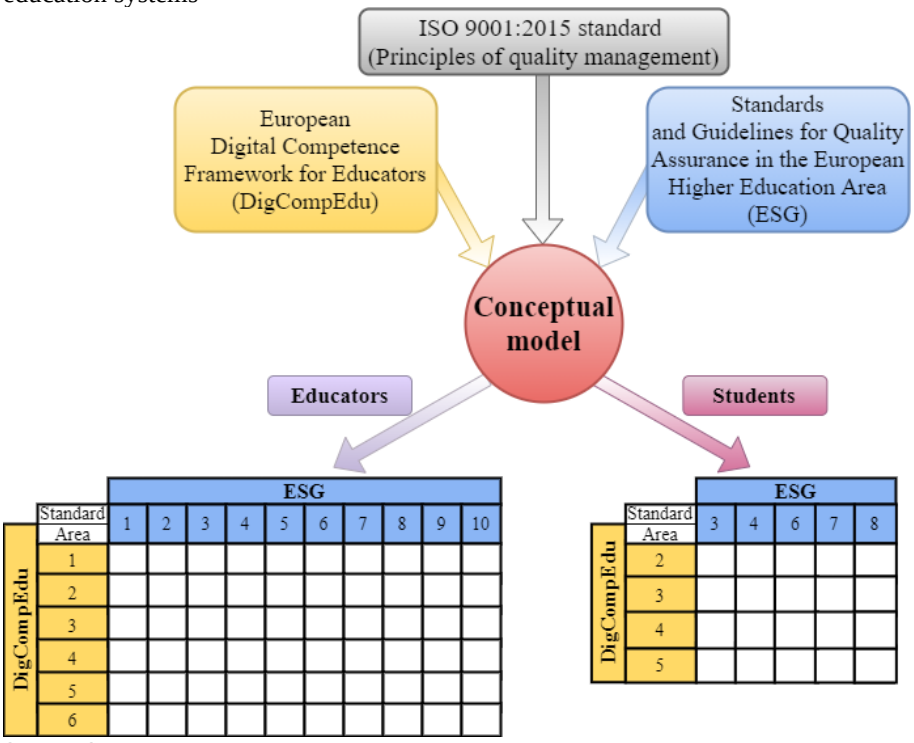
As predetermined, the targeted sector of this research is represented by educators and students of international higher education systems. As mentioned, the standard is based on the principles of quality management, and all the principles were followed in conduction of this research, as they are directly concomitant. Principles and their involvement in research are presented as:

- Engagement of people – the research is conducted with the aim of determining the state of provision and quality of digital competencies in international higher education systems.
- Customer focus – educational institutions must provide the necessary measures and knowledge for educators and students.
- Leadership – educational institutions, educators and students must be willing to participate in the research and make the necessary changes and improvements.
- Process approach – can be introduced as a PDCA cycle, where the degree of digital competencies' quality was assessed at a certain time interval, the corrections and advances were planned, necessary improvements were implemented, then the cycle was repeated.
- Improvement – are included based in the previous principle (improvements).
- Evidence-based decision making – is enabled with the results of the research.
- Relationship management – educational institutions must define and communicate the relations between individual entities and guide them in improving the current state of digital competencies' quality.

The figure below presents the composition and content of the digital competencies' quality assessment conceptual model in higher education. The conceptual model was based on all the above principles and their descriptions. The next step was to intertwine and implement the DigCompEdu framework and ESG

standards (Figure 2), based on which the questionnaire questions were designed. The questions are composed based on the six areas from DigCompEdu, presented vertically on the figure. The statements within the questions illustrate ten standards based on ESG, presented horizontally.

Figure 2. Digital competencies' quality assessment conceptual model in higher education systems



Source: Own source

The research was divided into two parts (ten ESG standards and six DigCompEdu areas), intertwined based on the foundation of principles of quality management from ISO 9001:2015. Consequently, two questionnaires were constructed, for the research' targeted sector: educators and student of international higher education systems.

4.2. Preparation and construction of questionnaires

Since the research is divided into two parts, the above figure also illustrates the composition and content of two questionnaires, one for educators (lower left figure part) and one for students (lower right figure part). The latter has fewer questions and statements presented, due to their relevance. To elaborate:

- Questions are based on areas from DigCompEdu – *Area 1: Professional Engagement* and *Area 6: Facilitating Learners' Digital Competency* refer exclusively to pedagogical competencies, which students cannot obtain.
- Statements are based on standards from ESG – *(1) Policy for quality assurance*, *(2) Design and approval of programs*, *(9) On-going monitoring and periodic review of programs*, and *(10) Cyclical external quality assurance* are standards that take place at the level of management, which is also cared for by the management.

The questions were designed based on the six areas from DigCompEdu framework. Thus, the first question was related to *Area 1: Professional Engagement*, where the considered area was shortly described with the help of corresponding areas' competencies. Afterward, the respondents were asked to assess whether their institution (faculty or university) is fulfilling the guidelines in correlation to considered competency. As an example, the first question that appears in the educators' questionnaire is presented:

*»**Professional Engagement** refers to the educators' use of digital technologies in professional interactions with colleagues, students, and other interested parties, for their individual professional development and the organization's collective good. (**MORE 1.1**) Assess whether the **Professional Engagement** competency is following the presented guidelines in your institution (faculty or university):«.*

The mentioned »guidelines« are formed based on the ten standards from ESG and the considered competency. Thus, the first question was related to guideline *(1) Policy for quality assurance*, where the considered guideline was shortly described with the help of some practical examples from the higher education sphere. As an example, the first statement that appears in the educators' questionnaire is presented:

*»Our institution has a policy for quality assurance for **Professional Engagement** (e.g., use of licensed programs, online quizzes, and assignments, online training) that is made public and is a part of their strategic management. This policy is developed and implemented through appropriate structures and processes involving external stakeholders. (**MORE 2.1**)«.*

All the resulting questions, both for educators and students are identical, with the difference that the number of questions for students is lower, as aforementioned. All the resulting statements were similar under the questions but are addressed from different aspects of individual competency. Thus, the respondents were posed with questions (six for educators and four for students) where they had to assess if their institution is providing the digital competency. Questions could be answered on a three-point scale (»Yes«, »No«, »I do not know«). The questioned educators were thus posed with six questions, ten statements each; and the questioned students were posed with four questions, five statements each. Questions about demographic data were posed at the beginning of the questionnaire, such as: age, gender, country of residence or education, the level of highest education attained, current employment status, and (for students) education level and field of study.

Within the question and statement, there is a word MORE written in parentheses and the number next to it. This indicates an additional document that contains a more detailed description of either the corresponding competency or guideline. Two

documents with more detailed descriptions were prepared: areas and competencies according to DigCompEdu, and standards according to ESG.

The research is ongoing since it is intended for educators and students of international higher education and represent a broader, complex research. Specific aspects and details about the questionnaires cannot be disclosed at this point, as it is part of ongoing research and project, where the disclosure of sensitive information could impair the results' significance. The duration of the research was set to approximately one year due to the desire to receive as many responses as possible. The questionnaires were shared with the respondents through the open-source web application for conducting online questionnaires.

As mentioned earlier, there are two types of competency measurement tools. In this research, a subjective measurement was used because the quality of educators' and student's digital competencies was being assessed – the respondents had to assess their attitudes regarding digital competency and the subjective measurement enables the respondents to receive complete feedback regarding their skills.

5. CONCLUSION

As a summary, the concept digital competency is an emerging concept and related to the development of technology as well as the political aims and expectations for citizenship in a knowledge society. It consists of a variety of skills and competencies, and its scope is on several areas: media and communication, technology and computing, literacy, and information science. Digital competency is regarded as a core competency in policy papers; in research, however, it is not yet a standardized concept. (Ilomäki et al., 2011)

Digital competency is essential in today's world, in which technological innovations are transforming the labour market and the skills employers are looking for. It is therefore vital that teaching practices and programs be adapted and include digital competency in order to prepare future workers for the challenges of tomorrow. Digital competency is closely tied to professional development for all 21st-century workers: everyone needs to be able to use available digital resources – such as communities of practice and online training or tutorials – in order to keep their professional skills up to date. (Bawden, 2001)

The objective of this research was to design conceptual model development, from which questionnaires were derived for the comprehensive assessment of provision and quality of educators' and students' digital competencies in the international higher education systems. The aim of the ongoing research is to determine the state of knowledge and to assess the quality of digital competencies of educators and students in higher education systems, with the degree of provision of these competencies by the respondents' institutions. The results of this international research will enable the analysis and comparison of both aspects of the included groups of respondents, an insight into the perception of the digital competencies quality and the identification of the existing gap between perception in higher education. Based on the final findings, suggestions can be made to improve the quality of digital competencies of educators and students in all fields, especially in the field of supply chains and logistics, where

the acquisition of digital competencies is a prerequisite and considered as an important factor in the technology environment that Logistics 4.0 is situated (Abdul Rahman et al., 2019). The digital competent workforce requires process of academic literacy, through which information and ICT literacies are developed (Guzman-Simon et al., 2017). In the education sphere, digital competency, digital literacy, digital technology, and standards of educational programs are interconnected (Javorský & Horváth, 2014), where the recipient is (virtually) the workforce of Industry 4.0 and Logistics 4.0. Furthermore, organizations constantly seek innovative practices, where the latter are dependent on innovative process and digital competencies degree of each individual workforce (Abdul Rahman et al., 2019).

Individual suggestions and solutions depend on the results and naturally vary and are limited to the requirements and needs of individual education institutions, educators, and their customers (students). The solutions also depend on the immediate environments' needs in which the education institution is located, and on the facilitation and encouragement (be it financial or general investments) they can receive from the immediate environment.

Many different models and frameworks have been presented in the past that specify, analyse, or interpret digital competencies in education systems: a) UNESCO ICT Competency Framework for Teachers, where the target groups are teachers in primary and secondary schools (UNESCO, 2011); b) ISTE Standards for Educators: A Guide for Teachers and Other Professionals represent an informative map for educators in different spheres of action (Crompton, 2017); c) beforementioned DigCompEdu framework, which defines key competency areas in a differentiated way, through competencies at different performance levels (Redecker, 2017); d) DigComp 2.1. Framework, which describes digital competencies as key competency for lifelong learning (Carretero et al., 2017); and many other national and international frameworks or models (Godaert et al., 2022).

In the future, this conceptual model could be applied to and implemented at all education levels (such as primary and secondary education), as it also includes parental involvement due to the integration of DigCompEdu framework, which is designed to be used at all stages of education. However, the focus of this research is on the higher education systems, which is why the (importance of) parental involvement was not emphasized, due to all students being adult citizens.

It is crucial to be aware, that the importance of the quality of acquired digital competencies and the quality of provided education is significant in order to acquire professional personnel in every field and sphere, even in supply chain management and logistics.

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POSSIBLE STRATEGIES AND BENEFITS OF INLAND WATERWAY TRANSPORT DIGITALIZATION IN HUNGARY

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Abstract

There has been an explosion of smart transport solutions and data sharing activities in recent years, focusing on seaports and inland (hinterland) gateways, as exceptional players in modern supply networks. Sharing the non-sensitive technical data amongst shippers, port and warehouse operators and transportation companies, transport authorities and other stakeholders as well can contribute to the establishment of a more resilient, effective and sustainable logistics system. In our paper, we investigate the available new solutions and techniques of port and inland waterway transport digitalization based on the literature and recent innovation projects. We are also presenting and evaluating local and national developments and findings. The goal of the research is to provide a conceptual framework for the evaluation and scenarios for the implementation to the Hungarian inland waterway transport sector, especially freight transport. Beside the prospective benefits we also identify critical factors (like trust, or the willingness of data sharing amongst partners), and form strategies for the first steps of supply chain digitalization.

Key words: inland waterway, freight transport, port digitalization

1. INTRODUCTION

Ports and waterways are playing a key role in modern economy and supply networks, and their smooth operation is crucial for the health of daily business operations.

Current trends and research directions towards wide-scale data sharing between transport partners lead to a fundamentally new type of logistics business model. As business excellence was previously based on exclusive information available to closed groups of supply chain participants, future trends show that information sharing

within the port and shipping communities is inevitable as the focus shifts to data management and operational excellence.

Even today, we see many examples of data sharing between neighbouring actors in the supply chain and the leading organization that plays the role of system integrator. In the new model, this data privilege will no longer be valid. The main factors contributing in the change are the ever-increasing freight demand, the energy crisis, the need for more resilient supply networks, and the constant pressure on transport and storage capacities (while at the same time capacity utilization of road transport vehicles in many cases is still low).

Value-added transport management decisions should be based on real-time, accurate information, in which the digitalization of ports and waterway transport activities are key components.

In the case of port and waterway digitalization the journey starts with the paperless communication between actors and authorities, and ends with digital data communities alongside the whole supply chain. In this organic evolution the first steps are the digitalization of the processes of participants, then exchange information at the port, later alongside the extended supply chain. Research results are showing that the digitalization is ongoing, whether the partners of the freight transport network favour or support it or not – their conservative attitudes are changing as they realize, that protest against sharing non-sensitive transportation data amongst partners and transport community members is not a competitive approach any more. They face the responsibility, whether they contribute and actively create the framework of cooperation, or leave it to other actors.

2. THE DIGITAL TRANSITION

One of the European aims is the technological-digital transition of the whole society, including administration, businesses and citizens. This digital transition is based on key enabling technologies such as big data, the IoT, cybersecurity and more.

The goal of the EU is to generate a common European data space to contribute in the acceleration of digital transformation, to lead to a genuine European space respecting the rights of individual persons and business over data. Data is a non-rival good, in the same way as streetlight or a scenic view: many people can access them at the same time, and they can be consumed over and over again without impacting their quality or running the risk that supply will be depleted. The volume of data is constantly growing, and - as an untapped potential - 80% of industrial data is never used. The new rules of the Data Act will make more data available for reuse, which aims to make the EU a leader in our data-driven society (EC, 2022).

In this respect, many research projects are willing to support public administrations in improving data policies making use of actions and cases deployed in the specific sea port environments. The objectives of these seaport and inland waterway port digitalisation projects are to implement pilot actions for reusing the data generated with port authorities and companies, ensure fairness in the allocation of data value and co-generated IoT data. According to the aims to be able to establish data communities in transportation it is necessary to benefit all partners and

stakeholders in each region by sharing innovative solutions and policies, and strengthen the blue circular economy among them contributing to the Green Deal objectives with focusing on policy instruments to support the data exchange through the implementation of data spaces.

3. DIGITALIZATION OF PORTS AND WATERWAYS

Regarding the waterway infrastructure, a clear distinction can be made between digitalisation measures that are intended to optimise the physical waterway infrastructure (assets) and traffic management ('digital infrastructure'), and those measures that relate to information concerning the current availability (transport route) and current use of the infrastructure (ongoing transports) ('digital information services') (Sys et al, 2020):

- Digital infrastructure (main users: infrastructure operators): infrastructure (asset) management systems (maintenance and expansion of the waterway infrastructure, bedload management), automation and remote control of lock and weir facilities, lock management (optimised chamber utilisation), marking of waterways (remote monitoring of shore-side and water-borne fairway signs), generation of basic data (bathymetric survey, gauges), compilation and visualisation of the data in geographic information systems.
- Digital information services (main users: boatmasters, fleet operators, logistics specialists): Fairway information services as part of the River Information Services (water levels, information on shallow sections, route and lock availability, vertical clearance under bridges, Notices to Skippers), digital Aids to Navigation (virtual fairway signs in electronic navigational charts), berth occupation and berth booking systems (current availability).

The role of data sharing is becoming more and more critical in multimodal, intermodal and especially in the new, innovative synchromodal solutions:

- In multimodal transport, which is characterised by the transport of goods using two or more different transport modes (e.g. change from waterway to rail) the availability of loading infrastructure is critical regarding not only the operations, but the planning phase as well, because in order to change the means of transport, transhipment of the goods is required. In doing this, the strengths of the several individual transport modes can be used and the cheapest and most environmentally friendly combination can be chosen. Since each transhipment involves additional time and causes additional cost, multimodal transport is often used for long-distance transport where delivery time is not an important factor.
- In intermodal transport – as a special form of multimodal transport - the goods are transported in the same loading unit or with the same road vehicle on two or more modes of transport. Supporting the process with actual data is especially important when changing transport means, where only the loading units or the road vehicles are switched, while the goods remain in the same transport receptacles (such as containers or swap bodies). Since only loading units or the road vehicles (and not the goods themselves) are reloaded, this method saves time

and cost. In addition, the risk of damage to the goods during transhipment is minimised. As these solutions require special loading units and loading infrastructure, the additional investments are feasible only when the quick mode change is reliably supported by information technologies. Combined transport is a special type of intermodal transport in which the major part of the trip is performed by inland vessel or railway and any pre- and end-haulage carried out by truck is minimised. When rail or waterway transport is used for the main leg, combined transport represents an environmentally friendly transport alternative.

- Synchromodality comprises several elements and enables efficient and eco-friendly transport chains with switches in transport mode in real time. Synchromodal transport chains allow real-time switches in transport mode; consignors book their transport regardless of the mode, which means that they only define the framework conditions, but not the means of transport that will be used. Horizontal cooperation is another important aspect of synchromodality; it describes collaboration between companies that could actually be competitors. The aim of synchromodality is to improve capacity utilisation of transport modes and to increase the quota of transports conducted by rail and inland waterway.

The synchromodality platform created in the Netherlands with participation of logistic companies and supported by national institutions, defines synchromodality as "the optimally flexible and sustainable deployment of different modes of transport in a network under the direction of a logistics service provider, so that the customer (shipper or forwarder) is offered an integrated solution for his (inland) transport" (Solvay, 2018).

The European technology platform ALICE (Alliance for Logistics Innovation through Collaboration in Europe) encourages the integration of synchromodal services in intermodal transport by "synchronizing intermodal services between modes and with shippers, aligning equipment and services on corridors and hubs and integrating these into networks".

In the current transport network, a lack of services' synchronization between multimodal operations continuous to exist. Therefore, within the H2020 research programme of the EU promoting of a smart, green and integrated transport, synchromodality is one of its research and implementation priorities. The creation of a synchromodal transport in Europe is already covered in some current EU H2020 projects. Most relevant ones contributing to the synchromodal field are SELIS - Shared European Logistics Intelligent Information Space, AEOLIX - Architecture for EurOpean Logistics Information eXchange, and SYNCHRO-NET - Synchro-modal Supply Chain Eco-Net. (Solvay, 2018).

Within the Alice Roadmap for future European logistics the following research areas were indicated: Development of data analytic in logistics, predicted methods for connecting demand and supply, the definition of synchromodal operation principles, define hub business model principles and ITS Logistics architecture for connected applications - operational (ITS), tactical (service design) and strategic (business intelligence).

As Solvay (2018) summarize (based on the research of Putz et al. and Phoser et al.) the main research areas for synchromodal transport developments are interdependent:

1. network cooperation and trust,
2. sophisticated planning and simulation,
3. information, data and use of ICT and ITS,
4. physical infrastructure,
5. legal and policies issues,
6. awareness and mental shift and
7. cost, service and quality.

Brunila et al (2021) are giving a broad overview about the road towards smart ports and inland waterway developments, and state that it is vital that the ports carefully decide and compare, which technologies are to be integrated or newly installed into the daily operations. The transition towards a 'digital' or 'smart' port is difficult and complex process. In the end, digitalization will evidently improve operational efficiency and productivity, increase safety, reduce emissions, and improve sustainability. However, in the initial phases of digitalization, disadvantages of digitalization are likely to emerge. According to several authors, the processes and operations in port communities are often quite conservative, when it comes to applying and collecting data driven operation solutions in the case of shipping. The level of digitalization varies between ports according to their size as well. Large ports often have more resources in their disposal, and they tend to be more active in development programs and collaborative research and innovation actions. The three generations of digital transformation in ports are: (1) paperless procedures, (2) automated procedures, and (3) smart procedures. In practice, and sadly, in too many (port) cases, 'going digital' simple means small transitions on the first step (moving to paperless procedures). These are early steps in digitalization but too often particularly small ports satisfy to stay on the first early adoption level (paperless procedures). The Digital Maturity Model (DMM) of ports (developed by Buck et al.) identifies four port maturity levels. They indicate the functional maturity of digitalization with the following categories: 1. Digitization of individual parties in the port; 2. Integrated systems in a port community: paperless data flows; 3. Logistics chain integrated with hinterland; 4. Connected ports in the global logistics chain resulting into digitalized port networks.

As a conclusion of current research activities it can be stated that the need for digitalisation emerges alongside the whole supply chain, the interconnected ports can only be competitive on the transportation market if the transition to become digital is evenly distributed.

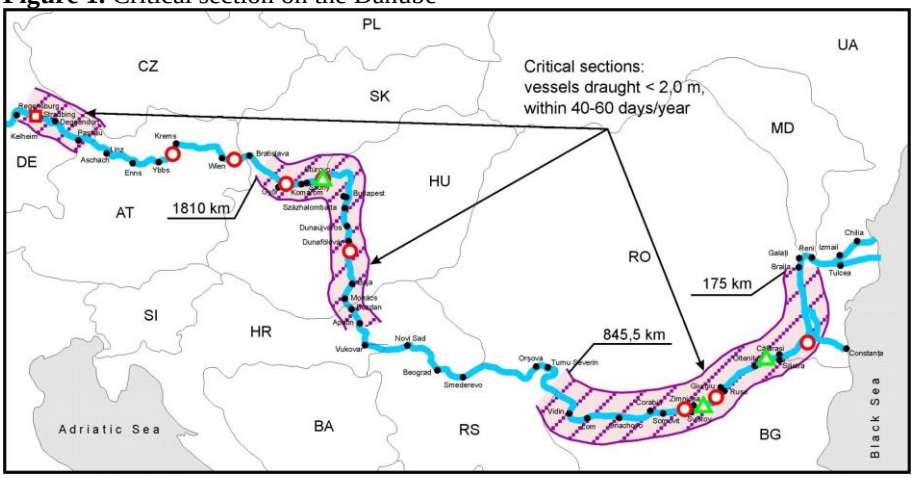
4. CHALLENGES IN FREIGHT TRANSPORT ON THE DANUBE IN HUNGARY

The navigable Danube River in Hungary is about 378 km long and represents 15,6% of the total 2415 km navigable river length. The whole Hungarian section is a

free flowing stretch, characterized by very dynamic river bed formations consist of mainly gravel and raw sand (Danubeportal, 2022).

The Hungarian section of the river as inland waterway is vulnerable to climate change because river navigation depends on precipitation and water levels for its operations. Droughts and floods have the most disruptive impacts for inland waterways because low water levels impose limitations to navigation services. Besides the environmental factors emerges the technical difficulty occurring at the Gabcikovo locks, why recent years the sector faced unexpected and short termed announced closure of the daily traffic. These closures severely impacted the reliability and functioning of the sector, both freight and passenger carrying.

Figure 1. Critical section on the Danube



Source: National Directorate of General Water Affairs (2018) Danube Navigability Map

At the current stage, where the lack of navigable waterway determine the whole shipping industry the transported goods are mainly the less time-sensitive agricultural products – to be able to involve more, high value-added supply chains in inland waterway shipping it is inevitable to solve the problems of low water situations (waterway development by building the proper infrastructure helps not only the shippers, but mainly the agriculture sector and the power sector – in the same time no efforts have been made on this field by any government since the successful protest against dams on the Danube more than forty years ago).

As harnessing the potential of intelligent transport systems has strategic importance for a resource-efficient economy the National ITS Strategy of Hungary was prepared in 2015 and it has a separate chapter which is dedicated to inland waterway navigation. Digitalization and the share of mass transport data is one of the fundamental objectives of this ITS Strategy. An Action plan of Intelligent Transport Systems was also prepared in 2015, which is an integral part of the Hungarian ITS Strategy and defines measures to develop ITS services of inland waterway navigation. Both the Strategy and Action Plan need to be revised as they based on the technological environment 7 years ago.

The Hungarian ITS Strategy addresses ITS services by transport modes and horizontal focus areas (e.g. sustainability and environmental protection, transport safety, interoperability). One of the transport modes is inland waterway navigation. Status quo analysis of the ITS Strategy recognizes that ITS service deployment in inland waterway navigation is at different levels. Elements related to safe navigation are relatively widespread and comprehensive while other information systems that could e.g. support more efficient navigation are often the result of cutting-edge researches however their usage and integration are not fully resolved and there are many remarkable but rather isolated ITS solutions. The Strategy defines 3 strategic measures for inland waterway navigation:

- maintaining, improving and expanding the current River Information Services (RIS)
- developing and harmonising integrated international and national information systems supporting multimodal passenger and freight transport.
- defining quality of service levels and ensuring their sustainability

Based on the National ITS Strategy the KIR system - National port management system of Hungarian Danube ports - was established, developed and continuously managed since by RSOE (financed by the CEF project). To deliver on the overall objective, the project develops, tests and validates an integrated inland port information system. In addition, they analyse cross-border options and opportunities for interconnection. The main activities of KIR project are the design and operation of the pilot system, pilot system implementation and testing in various ports and exploitation of the results.

The central information system will capture all automatic and manual data inputs, including the planned and current entry into port of various water and inland transport vehicles (ship, lorry and rail) and freight traffic (loading and unloading). The central system aggregates and processes the data and serves users in the form of appropriate notifications and queries based on their eligibility levels. It informs the carriers about their exact point of loading within the port, helps the freight forwarder to keep track of the merchandise and provides general port statistics to the ministry.
The pilot integrated port information system will monitor the incoming and outgoing transport flows into and from the port, record the volume of cargo loading and unloading, contribute in port traffic management, modernize the registration system of port terminals and the port management supervision, and automatize the port charges and electronic invoicing. It will also provide electronic data to ministries, national statistics office and EUROSTAT, an enhanced security system and monitor the implementation of port rules and licenses.

5. THE NEED FOR CULTURAL CHANGE

On the workshop held by KTI Institute for Transport Sciences, Department of Transport Management and Hungrail Hungarian Railway Association on 12th of September 2022, the experts (17 persons) present from various representative rail and waterway transport companies and organizations were surveyed in the frame of

pairwise comparison related to the necessary action should made to shift freight from road to rail and waterway:

- Creating labour mobility for train drivers plays a key role in increasing the service level of cross-border rail freight traffic and ensuring faster border crossing, this would ensure progress in increasing the competitiveness of rail freight transport at a cost level appropriate for technological developments (100 on the normalized scale)
- Ensuring the navigability of the Danube is a necessary and essential condition for inland waterway transport - as long as this is not done in accordance with international expectations and previous domestic commitments, we cannot expect a significant increase in inland waterway freight transport (83,67 on the normalized scale)
- The improvements and modernizations on the vehicle and track side in themselves, even without significant development of the domestic storage and loading infrastructure, provide adequate conditions for diverting road freight transport to rail and waterways (63.27 on the normalized scale)
- Renovation and modernization of the existing sidings, which are used to a limited extent or not at all, could also result in a significant increase in the diversion of road freight traffic to the railway (26,53 on the normalized scale)
- The development of the necessary infrastructure for the rail transport of non-craneable semi-trailer stock preferred by road carriers is in the national economic interest (26.53%)
- Increasing the number of semi-trailers that can be craned can effectively contribute to shifting road freight transport to rail (16,33 on the normalized scale)
- Reviewing, modernizing and fully digitizing the complex railway regulatory environment and technical-economic operating model, as well as providing appropriate IT support and data sharing for supply chain partners can greatly contribute to increase the competitiveness of rail and waterway freight transport (0 on the normalized scale!)

While the statement about the necessity of waterway infrastructure development got 83.67 on the normalized scale (2nd place after cross-border rail process development) the need to establish data communities (towards advanced multimodal and synchromodal transport systems) got the last place (after all “hard” infrastructure development needs).

In spite of the fact that data community developments are still considered “less-expensive” solutions compared with physical infrastructure developments, in the background of this priorization order there can be independent and strong reasons identified:

- experts directly face these physical barriers in their daily work, so they feel stronger than the virtual collaboration system that has not yet been developed
- experts still represent the conservative approach of the competitive (and not yet cooperative) viewpoint of transport modes
- benefits of transport data communities are considered less to be able to overcome the risk and trust issues

6. CONCLUSIONS

Establishing data communities in transportation is inevitable to successfully overcome recent challenges on the field of energy and climate crisis and the ever-growing logistics needs. Inland waterway transport has an important role in the future inter- and synchromodal distribution of goods, but it is achievable only if besides the IT infrastructure development the cultural change happens between supply chain partners. It is necessary to invest more resources in sharing the best practices of international ports and research centres and form the frame of knowledge transfer solutions.

In the case of Hungarian inland waterway digitalisation there are promising results in port digitalisation, but the need for physical waterway infrastructure developments are considered more critical in shifting road freight to rail and waterway.

Regarding to the recent low-water crisis in 2022 one of the possible and feasible data sharing pilots – based on the results of the KIR system development - can be an integrated barge-and-truck management system, which supports the cooperation between the port warehouse and loading operator and the road transport company from the side of the product (grain) owner. It is necessary for the efficient management of the road transport to get notification of the forecasted arrival of the barge, the availability of the loading infrastructure and the planned amount of products (depending on the actual water level on the Hungarian Danube section, strongly connected to weather conditions). With an efficient management of the shared information the timing of the truck fleet is becoming easier and cheaper, which makes the whole loading process less time-consuming (there will be less time wasted on allocating enough trucks, in the meantime the truck fleet can provide other shipments at the case of barge delays, etc).

The demonstrative projects can extend the shipper-authority data interchange approach towards the digital port community solutions, as many partners can benefit of sharing the technical data, and none of the business or trade sensitive data is becoming available to non-authorized actors.

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DATA DIGITISATION IN TRANSPORT PROCESSES

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Abstract

The digitalisation of logistics processes is accelerating and technology and innovation are entering every part of the supply chain. The changes brought about by pandemics have accelerated data digitisation processes, also in logistics processes. Despite this, the exchange of information between transport participants still often takes place in a chaotic and inefficient way, using various means: telephones, various communicators, paper documents or e-mail. This organisation of the information flow no longer meets the challenges posed by the market and modern supply chains. In the logistics market, there is a need for electronic data and document exchange, reducing errors and increasing the reliability of exchanged information. It causes, that from the level of state administration, authorities, branch organizations and finally carriers themselves, the need of data digitalization and transfer of transport documents in a standardized digital form comes up. These changes are visible in every branch of transport, both at the level of the road, rail and sea transport, as well as in inland waterway transport. In this article, special attention will be given to the digitalization of data transmitted in the road transport process. An analysis will be made of data digitalization at the level of national and international transport in Poland, where in recent years dynamic changes have taken place to standardize and legalize the circulation of electronic transport documents in road transport. The initiatives supporting the development of digital documents in transport will be analysed, both from the state administration level as well as the solutions created by commercial providers.

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Key words: transport, electronic consignment note, e-cmr, documents digitisation

1. INTRODUCTION

The analysis of the impact of digitalization on transport processes raises the issue of initiatives within the Polish market that affect the digitization of transport documents. Given the interpenetration of the transport area from the countries of the European Union, and the mutual impact that changes and innovations in the countries of the Union have on each other, the study also outlines an overview of implementation activities in countries neighbouring Poland, implementing or assuming concepts corresponding to the Paperless initiative. The focus was then on technical implementation with the participation of Polish administrative bodies, organizations, and companies offering commercial solutions in line with the assumption of digitization of documents linked to the realization of logistics processes (Wahab et al., 2021). The cross-border impact of logistics from EU countries and the mutual impact of changes and innovations in EU countries suggest that innovation and digitization of transport documents in neighbouring countries will also affect the Polish market, and can serve as an example and model for initiatives in the future, Implemented in countries not yet involved in research work (Giyasidinov et al., 2020). The work also analysed and attempted to assess the processes in terms of how information flows, in a selected medium Polish transport company, which is engaged in high-quality international transport.

2. DIGITALIZATION OF TRANSPORT DATA AND DOCUMENTS

Various initiatives are being undertaken in the Polish market to digitize documents in the retail and TSL sectors. The transport environment notes the need to digitize documents, particularly in the area of transport letters, both in the area of road and rail transport (Heines, Rütttimmann, Jung, 2021; Wycislak, 2022). A wide field of use of electronic communications in the transport process also exists in the port area, where initiatives are being taken in both the B2G (Business-to-Government) and B2B (Business-to-Business) relationship to digitize the document flow.
The need to digitize documents in the TSL sector is recognized both in the European and Polish markets. Electronic documents are produced in accordance with EDI data exchange standards (Dębicki, Kolinski, 2018). R&D works initiated by public administrations, EU and commercial projects coming from the business environment are being undertaken. However, it should be pointed out that, despite the creation of document standards**, these standards are not always used in the development of electronic solutions**, and there are legal restrictions that prevent the full use of electronic transport document formats by transport. The process of digitizing transport documents is slow in all modes of transport. Each mode of transport may extract the basic transport documents in force for the transport, the digitization of which is essential and at the same time must comply with the provisions of the relevant conventions. Table 1 provides a summary of the basic transport documents to be digitized, together with information on the status of implementation work.

Table 1. A summary of the transport documents to be digitized, depending on the mode of transport, taking into account the state of play and existing data exchange standards

Type of transport	Digitized documents	Is there an elaborate standard?	Status of work in the European market	Status of work on the Polish market
Road transport	CMR	CRM standard developed by UN/CEFACT	Commercial solutions exist on the market or are being developed	Developed solutions in Diginno project
				Commercial IT solutions are being developed
Rail transport	CIM, CIM/SG MS	eCIM/SGMS standard developed by CIT	European projects are taking action on implementations	There are commercial solutions providing electronic waybill (ELP) individually by each carrier
		ORFE US standard	Commercial solutions exist in the market or are being developed.	Work is underway to adapt the ELP to the requirements of the SGMS shipping law
Sea transport	EMSWe	There are standards for data exchange in the port environment	Ratified protocol regarding establishment of EMSWe-	Work is underway to create and adapt the National Single
	eManifest			
	A range of documents used in port traffic.		Many European ports have had a Port Community System (PCS) in place for years	Work is underway to develop the Polish Port Community System

Source: own research

The recognition of the TSL (Transport, Shipping and Logistics) market for initiatives similar to Paperless in the field of road transport confirms the high need for digitization of documents in the TSL industry, especially for the digitization of international shipping letters. The need for the digitization of transport letters concerns both road and rail transport, but most of the initiatives for the digitization of documents in the TSL sector have been developed in the field of road transport. The top-up initiative, the European project DIGINNO, has brought together the activities of both the state administration and business organizations and entities, from both the international and Polish environment. At the same time, several commercial e-CMR initiatives have been developed, but all identified commercial initiatives are not standardized – the lack of cooperation – the obstacle to the dissemination of e-CMR; these solutions are potential users of the product of the DIINNO/DINNOCUP project. It is important that there is already a standard for the exchange of e-CMR data on UN/CEFACT, but among all the initiatives examined in the market, it is only used in research validation, and it is preventing the full functionality of electronic e-CMR documents from being hampered by inadequate legal regulations in Poland and neighboring countries

2.1. e-CMR

In Poland, many initiatives are being undertaken in the field of road transport. **The additional protocol of CMR**, adopted by the Polish authorities in 2019, allowed the start of work on the implementation of the electronic consignment note on the Polish transport market. The process of digitizing a CMR document is concerned with the whole road transport environment, bearing in mind the **advantages of digitization**, such as:

- Save time
- Reduce paper document errors

- Ability to monitor the execution of the order on-going
- Collection of documents in electronic form
- Ability to share documents in real-time B2G and B2B relationships
- The ability to invoice for the service immediately after confirmation of service delivery.

Commercial initiatives have been launched in IT services market to provide the TSL industry with e-CMR (Tomicová, Poliak, Zhuravlava, 2021). These solutions, however, are mostly in the test phase and face serious legal obstacles to full functioning in the Polish market. The main obstacle is **the lack of solid legal legitimacy for the e-CMR solution**, which requires paper documents from the carrier carrying out the goods (Poliak, Tomicová, 2020). The problem of insufficient legislative solutions to the Polish TSL market was also recognized in the Dinino project, which, as a top-up initiative, the European project, brought together public administrations and business entities to implement e-CMR on the Polish haulage market. The following steps propose the creation of a working group involving mainly the public administration, which is to work on solving the administrative problems facing the introduction of the full functionality of e-CMR in the Polish transport market. The final result is **the e-CMR format, which complies with the UN/CEFACT e-CMR standard**, and is intended to be made available free of charge to all transport users.

2.2. Digitization in rail transport

The market investigation carried out for this report has shown that **there is also market demand in the area of rail transport for the digitization of transport documents**. It has been concluded from the studies carried out that, although there is a need for the digitization of railway transport letters, there has been no top-up initiative in Poland to digitize railway transport documents. However, major railway operators offer their customers the possibility to send electronic railway letters, each in its format and system. **Rail freight transport** companies create electronic mail formats for their customers, thus eliminating the need to trade paper documents (Casado, Funes, García-Doncel, 2021). Railway R&D initiatives are directly involved by carriers and have not yet been established in Poland with a top-down initiative taken by the state administration or industry organizations to introduce a single standard for data exchange in the rail waybill. The data provided by PKP cargo S.A. shows that the current use of the electronic consignment note by customers transmitting shipments in domestic traffic amounts to 76%, while in international traffic 50%. It can therefore be seen that the electronic form of document transmission meets with customer approval and is likely that, with greater support for the availability of this solution in international traffic, the degree of use of this form of data exchange would be greater. However, it should also be noted that the electronic railway bill offered by carriers on the Polish market is created by each carrier separately, but no data is available to indicate whether railway waybills are being built according to the data exchange standard, e.g. those defined by CIT. At the initiative of CIT, the standard of the International Electronic Railway Letter CIM/SMGS has

been developed, but no data is available as to whether this format is used by carriers on the Polish market.

2.3. Digitization in the Polish port environment

In the process of digitisation in transport, **the environment of Polish maritime transport was also analysed in terms of initiatives for electronic documents and it was observed that in the area of maritime transport**, the most important initiative undertaken on the Polish market is the polish Port Community System (PCS) conception. The Polish PCS conception is intended to cover both the integration of business entities in B2B and B2G relations with the target integration of PCS with the National Single Window, the national maritime transport contact window operating in the B2G relationship. The scope of work to digitize the data flow is large and the Polish PCS does not provide detailed data on which documents will be digitized in the system. The work also observed that the port trading environment partially uses the UN/EDIFACT, IMO, and WCO electronic data exchange, but it is not clear in which state these standards will be implemented in the Polish Port Community System

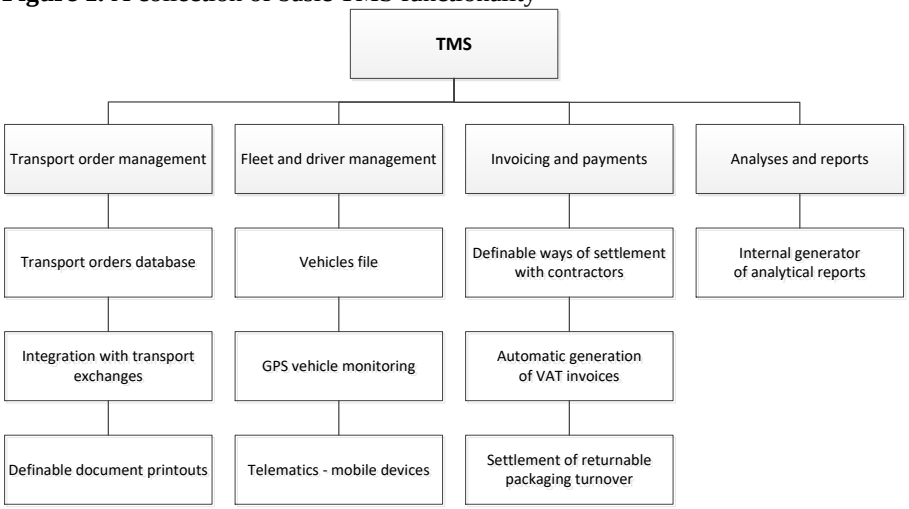
2.4. Other solutions providing electronic documents in road transport

When examining the area of electronic documents on the Polish transport market, mention should also be made of documents for everyday use in transport processes that do not require regulation. Such documents, which operate in the supply chain, are often in paper form, as e-mail, as pdf messages, or messages exchanged by telephone (Kleedorfer, Huemer, 2017; Tmerge, Avramović, 2021). The most commonly exchanged messages during the transport process include:

- Transport order
- Load Disposition
- Vehicle authorization
- The status of the order
- Confirmation of unloading
- Freight Invoice.

For many years, the Polish market has been operating with TMS (Transport Management System), which aims to eliminate paper documents. Many solution providers offer TMS systems that offer electronic data transfer functionality, including transport order exchange, order acknowledgement, or transport invoice generation, providing an overview of TMS functionality.

Figure 1. A collection of basic TMS functionality



Source: own research

TMS can be integrated into enterprise operating systems and used as stand-alone tools. The main work area in TMS is the ability to manage mail orders, fleet management, invoice handling, and analysis and report modules. Most of the documents that can be generated and transmitted via the TMS do not require compliance with special regulations such as CMR (international consignment note), so there are several TMS solution providers whose solutions and document format can be tailored directly to the needs of a particular customer. TMS can also use standardized messages in the data exchange process. These messages may include both the order preparation process, the dispatch of the transport order, and the issue of an invoice. However, the level of standardization of individual components of TMS and the use of standards in individual databases requires interviews with suppliers and system users.

3. E-CMR AS A SIGNIFICANT DOCUMENT IN THE DIGITALIZATION OF TRANSPORT PROCESSES

Implementations aimed at the digitization of transport documents in the field of road transport focus mainly on the possibilities of digitization of the International des marchandises par route (CMR). The digitization of CMR, unlike the national waybill, requires compliance with the provisions of international law and recognition by public authorities, including customs and control services (Baublys, Batarlienė, 2015). This is a key document, both in transport and in the final settlement of the transport service, hence the need to digitize it and increase the accuracy of the data transmitted to the parties and control authorities. This need is clearly apparent in the transport environment, as demonstrated by the numerous initiatives taken in this respect by operators implementing or seeking to promote international transport.

An important document often linked to the consignment note, at least at the level of national road transport, is the WZ document (external edition). A WZ document is an important document issued in connection with the removal of goods from the trader's warehouse. This document is important in the marketing of goods and is also necessary for transport, as it will, for example, be used to check transport based on the document (and possible weights of the goods being dispatched). In order to avoid any problems, both accounting and transport, it is necessary that the document contains all the necessary information, is accessible and does not contain errors. The electronic form of this document is also desirable in the context of trade in goods, but the various initiatives do not focus on international trade.

The digitization of CMR in Poland was made possible by the ratification by the legislative authorities in 2019 of the additional Protocol to the 1954 CMR Convention. Despite the signing of the additional Protocol in September 2019, there is still a lack of specific legislative requirements, as well as some resistance in an international environment in which the relevant international partners do not allow the use of digitized documents (Bazina, 2022). In the case of Polish carriers, until recently it was important that e-CMR was not able to use e-CMR in Germany, which, as one of the few European countries, alongside Italy, had not ratified the protocol of the additional CMR Convention. The argument put forward by the Federal Ministry of Transport and digitization was that there was little interest in carriers to be able to use electronic transport documents and that other paper transport documents (e.g. dangerous goods transport documents) were required, which would undermine the reasonableness of holding the consignment note as the only electronic form.

On the other hand, however, a significant part of the international environment, including entrepreneurs, operating in Germany, recognizes the strong need for the market to abandon paper records. In this context, national administrations, the European Union and private companies are undertaking design, design and implementation activities to digitize the transport area and allow the transition to electronic documents. The German Transport and Logistics Association (DSLV) also called for the introduction of an electronic waybill in the country, noting the global trends in the digitization of documents, in a letter to the Federal Ministry of Justice and Consumer Protection, and the Federative Ministry of Transport and Digital Infrastructure

4. THE BENEFITS OF DIGITALIZATION OF TRANSPORT PROCESS AND DOCUMENTS

The letter of carriage, in both paper and electronic form, shall, from the point of view of legal applications, have, inter alia, the following functions:

- Proof of acceptance of the consignment for carriage and of receipt of the consignment
- Proof of the condition of the consignment in transit
- ID function - gives you the right to dispose of the shipment
- An instruction function to inform about the required conditions of carriage

The above uses of the consignment note make its use very important for the interests of the supply chain. The cessation of the use of waybills in certain areas would prevent the parties from achieving certain legal effects. Even in those areas where it is legally possible to withdraw from the consignment note (e.g. on evidence), its absence would mean less convenience for the participants in the entire freight transport process and would negatively affect confidence in the circulation.

At the same time, it is clear that the current rate of movement of goods makes the use of traditional waybills in many cases burdensome and sometimes even prevents the use of legal institutions designed in times when the maximum reduction in transport time was not so high as to be a priority. Therefore, allowing the electronic presentation of the consignment note and the affixing of the same form of registration at the various stages of transport could have a very positive impact on both the legal security of the freight operators.

In addition to purely economic considerations resulting from the reduction in the cost of operations generated by the need to print a significant number of documents and the subsequent marketing of these documents, the studies show different benefits detailed in the table below. The survey was carried out in the first half of 2022 among the 68 supply chain-link companies. This test sample was assessed as representative under the test methodology set out in the publication (Domanski & Kolinski, 2020). The study aimed to identify the importance of the benefits of digitization of the supply chain. The present research was carried out as part of the research work of the PLANET project, in the field of standardisation of the digitisation of supply chains.

Table 2. Analysis of the importance of the benefits of supply chain digitalisation

Potential benefit	Importance						Average value
	0	**1**	**2**	**3**	**4**	**5**	
Reduce the flow of documentation	1	1	2	5	27	32	4,235
No negative consequences for lost documents	1	2	2	4	21	38	4,294
Identification of persons involved in the transport	1	1	2	10	20	34	4,191
Reduce fraud opportunities	0	3	4	14	15	32	4,015
The date of acceptance of the consignment note shall be clearly specified	2	2	3	8	25	28	4,000
Limitation of refusals by insurers to pay compensation	2	2	4	9	18	33	4,029

Source: own research from PLANET project

Each of the benefits analysed was rated at a high level of importance (mean above 4 on a Likert scale, supplemented by a level of 0). This indicates the need to consider all potential benefits in further research.

Reduce the flow of documentation

The standard in the transport industry is to make the payment deadline for the transport service pay. Often, transport contracts also include contractual penalties for late delivery of documentation. Where drivers are often on the road for several weeks,

it is necessary either to send letters by mail to the carrier or to wait for up to a few weeks for the transport documentation to flow. The introduction of e-mail would allow for immediate verification of the end of the journey and reduce the time after which transport services would be paid.

No negative consequences for lost documents

The contracts in the TSL industry regularly contain provisions which allow the payer to avoid payment of the remuneration for the carriage or to limit it significantly in the event of loss of transport documents even where the performance of the carriage is beyond doubt and is not the subject of a dispute between the parties. Part of the contracts of carriage contains even clauses whereby the main part of the carrier's remuneration is payable for the supply of documents and only a small part for the carriage itself. Electronic waybills could eliminate the effects of such clauses, which, although contrary to the substance of the contract of carriage and therefore regularly challenged by the courts, have in practice an impact on the relationship between carriers and their customers (Antonov, 2020).

Identification of persons involved in the transport

The practice of road transport both domestic and international shows that, in the vast majority of cases, the signatures on the waybills alone do not allow the identification of the persons who issued the consignment note, accepted the consignment on behalf of the carrier or removed it from the consignee. This constitutes a significant impediment to disputes arising from the proper performance of the carriage and the signature on the document without the relevant stamp often prevents the party from showing that the person concerned has actually received the consignment. However, even if the issue of the consignment itself is not disputed, it is in many cases difficult to determine which specific individuals have participated in, for example, the receipt of the consignment or the delivery of the consignment to the carrier and which should be heard in court for instance on the condition of the consignment. These negative developments would not occur in the case of the use of electronic waybills, where an appropriate digital signature would allow a clear identification of the person who made it.

Reduce fraud opportunities

The transport industry is used to commit high-value fraud in two basic ways. First, criminals pretend to be honest carriers to obtain a transport order and then disappear with loads. Secondly, criminals pretending to be well-known companies and ordering goods with deferred payment dates (which are what vendors are getting in the recognized reputation of buyers) lead to shipments in places that do not allow them to be identified later. The use of electronic waybills could allow this phenomenon to be reduced. The need to send the digital data of the carrier necessary for the issue of the electronic consignment note would reveal cases where a transport order would be received by a person who does not have such data but merely tries to impersonate a carrier. Similarly, criminals pretending to be other companies that order merchandise would in many cases not be able to effectively confirm receipt of the

shipment, as they would not have the digital signature of the people who allegedly ordered the item.

The date of acceptance of the consignment note shall be clearly specified

The time at which the consignment note is accepted by the consignee is extremely important in determining the person entitled to claim from the carrier. With this point, the right of the consignor to dispose of the consignment is transferred to the consignee. Most often, this moment is clear, but there are situations where it is a disputed situation. This is particularly the case in cases where the consignee refuses to accept the consignment. Such acceptance is often accompanied by the inclusion of entries in the consignment notes, but in the course of the dispute it is difficult to determine who made those entries. The digital signature on the electronic consignment note would make it clear whether the consignee has accepted this letter or not and thus resolved the issue of the identity card for the recovery of the carrier.

Limitation of refusals by insurers to pay compensation

The practice of Polish insurers, as described above, making the existence of insurance cover in the carrier's liability insurance contracts conditional on the inclusion of insured data in the transport list, will no longer be an important problem for both carriers and the entities commissioning them. The negative effects of this practice may be limited where the electronic system of circulation of the transport documentation is organized in such a way that it will require all carriers involved in the carriage of the consignment to be added to the consignment note.

5. CONCLUSION

So far, many initiatives have been set up to digitize transport documents, including international e-CMR letters, but mostly from the business environment. The opening of the national market to the use of CMR's electronic document, by signing the additional Protocol to CMR in 2019, has increased the interest in the use of the document and many companies have taken steps to create a commercial solution for the provision of e-CMR to carriers and their customers.

As yet, the solutions offered, according to the information obtained from their suppliers, are not standardized solutions and, despite compliance with legal requirements as to the format of the document, do not rely on any data exchange standards previously developed, such as the UN/CEFACT e-CMR format.

There was an initiative in the Polish market involving public administrations and industry organizations in the field of road transport – a project DIINNO. This research takes a reverse approach to e-CMR's commercial suppliers and assumes, above all, the integration of international public administrations in order to allow control bodies to operate e-CMR, and then to allow business operators to use the standardized e-CMR format.

The benefits of digitization of documents, including CMR documents, encourage economic operators and public organizations to move toward the implementation and promotion of such solutions. Industry organizations and road transport associations

follow the market and demonstrate their willingness to engage in the development of an environment favourable to the operation of electronic road transport documents (Ismailiva, 2020).

Commercial e-CMR suppliers consider that cooperation discussions are of interest to shipping companies, but there is a perceived legal barrier. The lack of legal certainty about the feasibility of the e-CMR document is also highlighted by the researches, who place a strong emphasis on the involvement of administrative authorities in the process of exchanging and sharing data in the B2G, G2G relationship. However, the legislative problem is not solely on the part of the Polish services. In the European Union (the EU currently has 27 Member States), work is still being done to clarify the legal framework for e-CMR in the countries that have ratified the additional CMR Protocol (the Protocol has been ratified by 23 countries). It should be stressed that not all the countries of the European Union have accepted and enabled, at least in theory, the use of an electronic waybill. For Polish carriers, for example, the failure of the German administration to use e-CMR in Germany to date is a major restriction, which in the case of international transport, to a large extent using German road infrastructure, is a clear and substantial restriction, even preventing the switchover to electronic transport documents.

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DIGITALIZATION MODEL OF INFORMATION AND DOCUMENTS FLOWS IN GOODS MOVEMENT PROCESSES IN SUPPLY CHAINS - DETERMINANTS OF IMPLEMENTATION AND MEASUREMENT EFFICIENCY

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Abstract

Companies along the supply chain are increasingly adopting digitalisation solutions to improve the flow of goods and accompanying information. Among other things, the digitisation of supply chains aims to eliminate traditional paper documents and move towards Electronic Data Interchange (EDI). Electronic documents provide a standardised and automatic exchange of information necessary for e.g. ordering or delivery processes and enable a direct link between the flow of goods and the information concerning this flow. Ultimately, companies can achieve several benefits such as eliminating errors in manual data entry, eliminating delays in information processing, shortening the time of operations, and thus reducing their costs. In the paper, the authors present a model describing the digitisation of key documents in the process of order and service in supply chains and the concept of measuring the efficiency indicators of the implementation of the developed model.

The research carried out in this area is the result of cooperation between Lukasiewicz Research Network – Poznan Institute of Technology and Poznan School of Logistics. The research was conducted in 2021 and the first half of 2022 with a conceptual approach, pilot implementation and ultimately a benefits analysis. The research was performed as part of a research project carried out for GS1 Poland.

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Key words: paperless, information flow, supply chain digitalisation, supply chain efficiency

1. INTRODUCTION

Digitization of supply chains is a complex problem described in the academic literature at both the strategic (Canhoto et al, 2021; Ritala, et al, 2021; Wen, Zhong, Lee, 2022) and operational levels (Wiedenmann, Größler, 2019; Grooss, Presser, Tambo, 2022; Peschl, Schüth, 2022). Due to its complexity, it comprehensively touches on all aspects of supply chain business operations (Gray, Rumpe, 2015), from streamlining workflows in accordance with the Paperless concept (Šuleř, Machová, 2019), to integrating IT systems among supply chain business partners (Siagian et al, 2021), to applying digital technologies to improve logistics processes (Dujak, Sajter, 2019; Parhi et al, 2021; Wahab, Rajendran, Yeap, 2021; Fahad Anwar et al., 2022). Digitization of supply chains is also very often focused on improving the efficiency of individual logistics processes, i.e. optimizing transportation (Marchenko, Babyr, 2021; Palkina, 2022; Gaponenko, Hvoevskaya, 2022; Wycislak, 2022), streamlining production processes (Birkmaier et al, 2021; Thürer, Li, Qu, 2022; Sapel et al, 2022), optimizing warehouse processes (Borisova, Taymashanov, Tasueva, 2019; Winkelhaus, Grosse, 2022; Sgarbossa et al, 2022) and distribution (Burroughs, Burroughs, 2020; Parfenov et al, 2021).

Regardless of the complexity of the problem, digitalization is based on automating and streamlining supply chains and the flow of information between business partners. A way to affect the efficiency of logistics processes from a Paperless perspective is the use of Electronic Data Interchange (EDI). Among the basic EDI messages that affect the application of the Paperless concept in supply chains are:

- order (ORDERS),
- delivery advice/dispatch advice (DESADV),
- electronic transport order (e-CMR),
- delivery receipt (RECADV),
- invoice (FV).

There have been conceptual and implementation studies using EDI messages to streamline logistics processes and reduce errors affecting supply chain operations. The present research aims to start a scientific discussion on the benefits of digitizing logistics processes in supply chains.

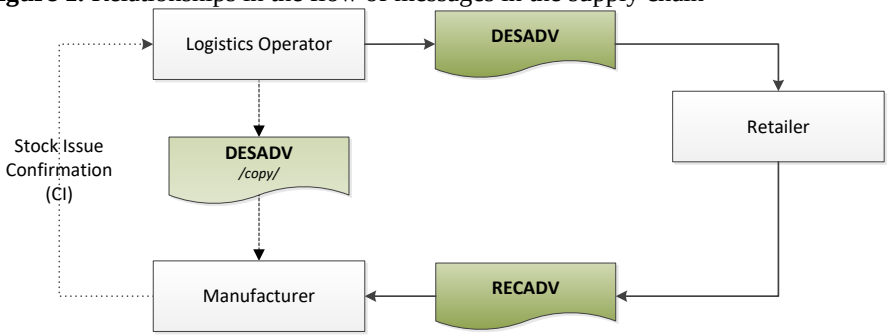
2. RESEARCH METHODOLOGY

The Paperless model developed as part of the research work had the character of a target model, taking into account the full digitization of document workflow in the processes of goods movement in supply chains. The research work carried out in this regard was aimed at identifying the benefits of implementing EDI messages as a solution in line with the Paperless concept.

In the first phase of the research work, a specific business case (supply chain) was defined, within which the implementation was to be carried out, and specific

documents were defined to be digitized. According to the research methodology, the pilot implementation covered the supply chain: Manufacturer - Logistics Operator - Retailer, and within this chain the DESADV and RECADV messages (Figure 1).

Figure 1. Relationships in the flow of messages in the supply chain



Source: Ł-PIT research

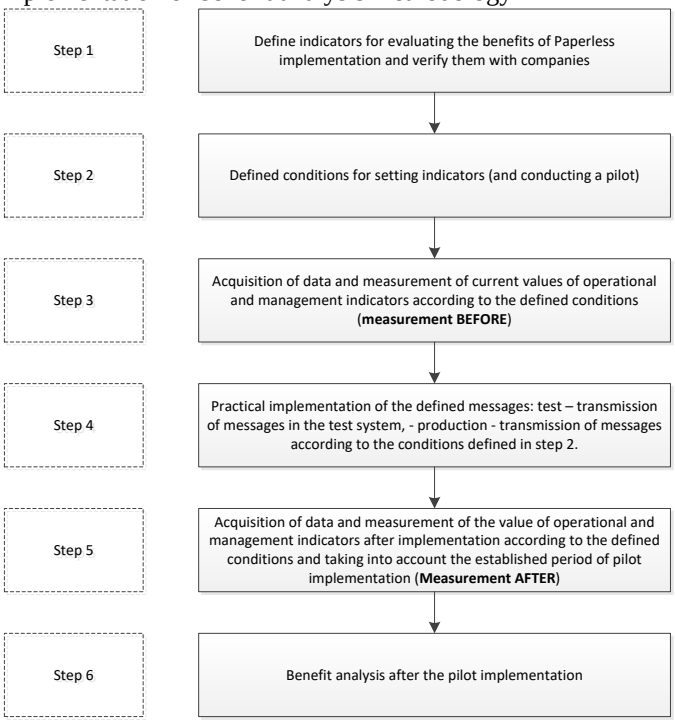
In doing so, it should be noted that the key document that was subject to implementation was DESADV. The RECADV message was also implemented in the relationship in question, however:

- The Retailer sends only a simplified structure of the RECADV electronic document, which does not allow for a full recording of discrepancies in delivery; the expansion of the information structure of the document will be able to be implemented only after the implementation of the WMS system in the Retailer,
- The manufacturer is carrying out work on its side to upload the RECADV document, to finally enable the automatic generation of FV for orders that have 100% fulfilment confirmed in RECADV.

Establishing the basic assumptions of the scope of the pilot implementation allowed us to define the methodology for analyzing the benefits of implementation, as shown in Figure 2.

This methodology is the basis for conducting analyses of the impact of using the Paperless concept on the efficiency of logistics processes in the supply chain. Benefit analysis by comparing the pre-implementation state and the post-implementation state in the same period allowed minimizing the risk of comparing different current states, caused, for example, by the seasonality of supplies from a given manufacturer, or sales peaks. The proposed benefit analysis methodology makes it possible to multiply this method of analysis to further partners in the supply chain.

Figure 2. Implementation of benefit analysis methodology



Source: own study

3. MEASURING THE SUCCESS INDICATORS OF THE PILOT IMPLEMENTATION

The pilot implementation refers to DESADV and RECADV messages, according to the established information structures, shown in Figure 1. The pilot covered all delivery orders executed by a given Logistics Operator (on behalf of the Manufacturer participating in the pilot implementation) during the established period (related to orders of the Retailer to the Manufacturer) and delivered to the Distribution Center of the Retailer. For each delivery order, related DESADV and RECADV messages will be generated, in the relationship:

- Logistics Operator→ DESADV →Retailer,
- Commercial Network→ RECADV→ Manufacturer.

Pilot implementation period (first indicated period of implementation of established messages, in established information structures):

- launch in the test system: 17.12.2021 - 01.02.2022
- migration from the test system to production: 02.02.2022

- production launch: 01.03.2022 - 30.03.2022:

Period of data for measuring indicators:

Taking into account the seasonality of commodity deliveries, it was agreed that the period for data collection BEFORE implementation should be analogous to the period during which the pilot is implemented (and from which data for OP measurement are taken) with a yearly offset. This approach will enable comparative analysis of results obtained at the same point in the seasonal cycle both before and after implementation.

Given this assumption and the realistic periods when the pilot was implemented, the following periods were defined for measuring indicators:

- measurement BEFORE implementation: March 2021 (01.03.2021 - 31.03.2021),
- measurement AFTER implementation: March 2022 (01.03.2022 - 31.03.2022).

Measurement risks:

The first period of pilot implementation may be a time when the full picture of benefits cannot be achieved due to the need for the company to adapt to the implemented solution and potential inefficiencies in the flow of implemented messages. Therefore, it is planned to repeat the pilot and measure its efficiency in an indicative manner after a longer period of application of the solution (e.g., in a sequence of 30 - 60 - 90 days after the initial launch).

This benefit analytics approach is due to potential process disorganization after the implemented deployment, the effects of which have a direct impact on the efficiency of the deployment. Conducting additional measurements in later periods will enable a comprehensive analysis of implementation efficiency, including the aspect of adaptation of the implemented solution to the implemented processes.

4. BENEFIT ANALYSIS OF THE PILOT IMPLEMENTATION

The benefit analysis of the pilot implementation was based on the indicators shown in Table 1.

Table 1. Indicators measured in the pilot implementation

Indicator	Manufacturer	Logistics operator	Retailer
Indicator of the use of EDI messages in the advancement of deliveries	X	X	X
Indicator of saving root of handling delivery from supplier			X
Indicator of delivery acceptance efficiency			X
Indicator of invoices issued based on RECADV	X		
Indicator of driver's stay at the recipient in the delivery process		X	

Source: Lukasiewicz-PIT research

The tables below include data provided by the Manufacturer and the Retailer. Data was obtained only from the two companies involved in the implementation process, the Logistics Operator was not able to provide data (e.g., monitoring the driver's time at the recipient in the process of delivery), in addition to the actual list of completed deliveries.

Following the accepted logic, monthly data were obtained after the implementation (March 2022) and data from the corresponding period in 2021 (March 2021), to realistically compare the results and assess the potential benefits of the implementation. The companies provided the aggregated monthly data needed to determine the defined performance indicators of the pilot implementation. The following summaries show the comparative results for each company.

Table 2. Data for deployment efficiency analysis - Manufacturer

Data type	Data from **BEFORE**	Data from **AFTER**
	March 2021 01.03.2021 - 31.03.2021	March 2022 01.03.2022 - 31.03.202
total number of deliveries for a given customer	110	99
number of returns	2	0
total number of deliveries for a given customer	110	99
monthly number of DESADV messages	0	99
monthly number of total advising documents	0	99

Source: Lukasiewicz-PIT research

Table 3 shows the aggregate results of the indicators generated for the Manufacturer.

Table 3. Implementation Efficiency Analysis - Manufacturer

Index	**BEFORE implementation**	**AFTER implementation**
Analysis of returns in deliveries*	1,82%	0,00%
Indicator of FVs issued based on RECADV*. /totalled to all FVs/	0	98,18%
Indicator of the use of EDI documents in the advancement of deliveries	0,00%	100,00%

Source: Lukasiewicz-PIT research

The primary benefit of implementing DESADV at a Manufacturer is the digitization of data flow and information about the timing and completeness of customer orders. The integration of the despatch advice with orders, sent by EDI message, allows us to suggest that the manufacturer can optimize the level of stock to be released, guided by the application of the Just in Time concept in stocking the warehouse with stock to be released, thereby reducing the cost of keeping the stock ready for release. However, the information obtained during the initial post-implementation phase does not allow to explicitly confirm this thesis, but in the future, it is worth keeping such a context in mind.

A very important conclusion was identified, pointing to the very high potential of implementing an expanded RECADV message as a consequence of the completed DESADV implementation. The RECADV message, which is an acknowledgement of receipt of delivery, will ultimately be the basis for invoicing for all deliveries. In the current situation, the Retailer only sends a simplified message that does not allow for the recording of discrepancies in the delivery, so the automatic issuance of an FV about RECADV is possible only for fully compliant deliveries, where there is no return. Both before and after implementation, a very low rate of non-conforming deliveries (return rate) was recorded in the Manufacturer - Retailer relationship: about 2% returns before implementation, and 0% returns after implementation. Translated into the billing process, this means about 98% of FVs are issued automatically, as soon as PZ is generated at the recipient and RECADV is sent. This generates significant time savings in the process of settling order fulfilment at the manufacturer (efficient and fast issuance of FV without the need to enter additional data and scanned documents into the system) and gives the potential to improve financial flows between the recipient and the supplier (faster issued FV = faster payment).

Table 4. Data for deployment efficiency analysis - Retailer

Data type	Data from **BEFORE**	Data from **AFTER**
	March 2021 01.03.2021 - 31.03.2021	March 2022 01.03.2022 - 31.03.202
total number of deliveries from a given supplier	152	133
average time spent accepting delivery from a given supplier [minutes]	55	31
number of EDI messages (DESADV) in a month	0	83
number of advising documents per month	152	133
the annual cost of handling the acceptance of deliveries	47 730,90 zł	18 017,00 zł

Source: Lukasiewicz-PIT research

Table 5 shows the aggregate results of the indicators generated for the Retailer.

Table 5. Implementation Efficiency Analysis - Retail

Indicator	BEFORE implementation	AFTER implementation
Indicator of incorrect deliveries from a supplier	43,42%	38,35%
Delivery acceptance efficiency rate [minutes]	55	31
Indicator of the use of EDI documents in the avowal of deliveries	0,00%	62,41%
Indicator of cost savings in handling deliveries from a supplier	5 244,00 zł	3 227,92 zł

Source: Lukasiewicz-PIT research

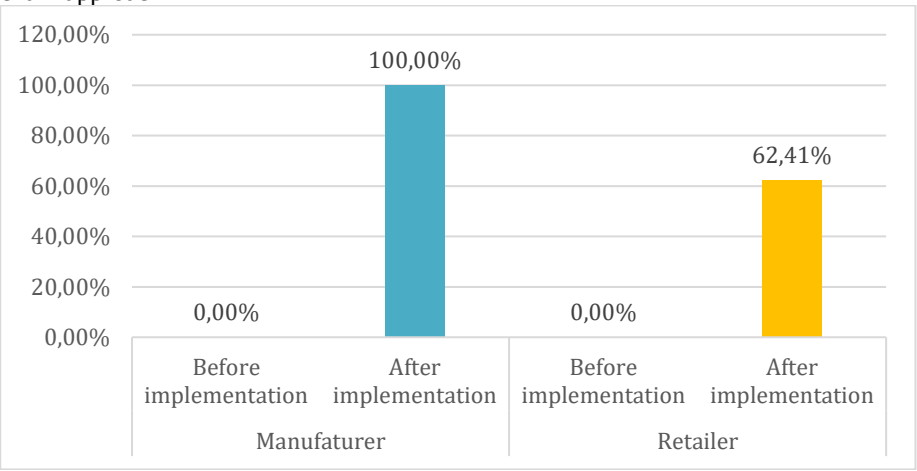
An analysis of indicators based on data from the Retailer shows that the rate of incorrect deliveries from the perspective of the Retailer has improved by about 5%, which should be considered a good result, but not directly conditioned by the implementation of DESADV. This is mainly due to a reduction in the rate of untimely deliveries. This rate, according to the Retailer, in March 2021 was about 12%, and in March 2022 it was already only 3%. It is worthwhile in further stages, after stabilizing the flow process and the use of electronic documents in the analyzed supply chain, to investigate whether there is a correlation between electronic communication and on-time delivery.

By far the key indicator from the perspective of the recipient's benefit from receiving electronic messages advising delivery is the rightfulness of acceptance of delivery. Admission efficiency has improved due to a 44% reduction in delivery acceptance lead time per supplier. This is very concrete and also the biggest benefit of implementing the DESADV message from the recipient's perspective. DESADV message containing full information on the structure of the delivery, enables its automatic acceptance (scanning of logistics labels from the delivery, concerning DESADV, automatic generation of PZs regarding DESADV), without the need to manually enter data into the system.

It should be stated that a significant reduction in the time of acceptance of delivery on the part of the recipient, can also positively affect the total time of the driver's stay at the recipient, which in turn can be a significant benefit for the logistics operator. This benefit, unfortunately, could not be fully dimensioned, due to the lack of full-time records of the driver's stay at the recipient. This is because several different activities and actions are carried out in the delivery process, not all of which are directly linked to the use of EDI communications.

The indicator to be analyzed in terms of the supply chain (comparing the data of different entities) is the rate of use of EDI documents in the avowal of deliveries. The discrepancies in the data on this indicator reported by the Manufacturer and the Retailer are shown in Figure 3.

Figure 3. Analysis of the rate of use of EDI documents in the dispatch advice - supply chain approach



Source: Lukasiewicz-PIT research

A potential reason for these discrepancies may be the act that the Manufacturer may have provided data on all DESADV messages sent, while the Retailer may have provided data on DESADVs that, once stored in the IT system, had no discrepancies in terms of the message content (e.g., in terms of the Retailer's internal data) and thus enabled automatic acceptance of the delivery.

As a summary of the study of the benefits of the pilot implementation, it should be stated that it is necessary to conduct complementary studies at the logistics operator, as well as to obtain data from all companies from later periods after the pilot implementation.

Regardless of the suggestion to supplement the indicator analysis with data from a longer period after the implementation, and to complete the data by the Logistics Operator, to obtain complete information in terms of the supply chain, it is worth noting that the conducted implementation of the DESADV message, and the indication of a legitimate rationale for the implementation of the expanded RECADV, indicates several benefits of using a complete Order to Cash (O2C) solution in the supply chain, such as:

- Reduction in the number of incorrect deliveries,
- faster order processing by automating the ordering process and being able to start the delivery process quickly,
- faster ability to respond and inform customers when suppliers cannot deliver the products ordered,
- efficient monitoring of inventory levels helps suppliers know exactly when an order will be delivered,
- streamlining the order forecasting process and increasing product availability,
- efficient unloading planning, by reducing delivery queues,

- improved accounting and billing processes, due to the ability to track and store all communications exchanged with suppliers.

5. CONCLUSION

Digitization of the supply chain is a highly topical issue both in terms of business practice and ongoing research work. Identification of the benefits of supply chain digitization solutions is at an early stage and the conducted research should be considered a pilot study, subject to the risk of error. Nevertheless, the analysis of benefits carried out in accordance with the adopted methodology allows for generalizing the following conclusions:

- The pilot implementation of the DESADV message carried out reduced delivery handling costs on the recipient side by 38%,
- Delivery acceptance efficiency on the recipient's side has improved due to a 44% reduction in delivery acceptance lead time on a single supplier (Manufacturer),
- For 98% of deliveries, there is the potential to significantly improve the process of billing for deliveries on the Producer side, by way of automatic issuance of an FV about the RECADV sent by the recipient. This means not only a streamlining of the FV generation process but also a positive impact on cash flow related to delivery payments.
- Due to the significant reduction in the warehouse-level lead time, as a result of the realization of receptions about DESAV, there is a high potential to reduce the total time of the driver's stay at the consignee's premises, in the process of making deliveries. Due to the lack of complete data, this potential could not be measured.
- The indicated conclusions about the benefits of implementing electronic DESADV and RECADV messages, in the main, show a measurable benefit from the perspective of the retail network. However, it should be borne in mind that the measurements are based on data obtained shortly after the implementation, and thus may be subject to some risk of error, related, for example, to the inconsistency of source data at the level of individual partners or the different way in which master data is recorded in the systems of individual companies. It is expected that in the further period after the implementation, the value of the benefits of the implementation may increase and it will be possible to measure more indicators (e.g., as a result of improving the process of generating data on the time of the driver's stay at the recipient's premises).

To confirm the identified benefits and expand their measurement, re-measurement and re-collection of data should be carried out 60 and 90 days after

implementation (stabilizing the EDI process on each side). It is also suggested that further research work be carried out in the analyzed supply chain to expand the content of the RECADV message so that a full record of any delivery discrepancies can be made.

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III. DISTRIBUTION LOGISTICS ANALYSIS

EFFICIENCY ANALYSIS OF TRADE COMPANIES IN SERBIA USING THE ARAS METHOD

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Abstract

The research of company efficiency can be quite challenging when using different methods of multicriteria decision-making. This paper looks into the efficiency of trade companies in Serbia using the ARAS method, with the aim to achieve improvements in the future. The empirical results of efficiency evaluation of trade companies in Serbia for 2020 using the ARAS method reveal that the most efficient company is MERCATA VT. It is followed by DELHAIZE SERBIA, NELT CO., PHOENIX PHARMA, LIDL SRBIJA, KNEZ PETROL, AGROGLOBE, MERCATOR-S, MOL SERBIA, and LUKOIL SRBIJA. This ranking of trade companies in Serbia was influenced by economic climate, but even more significantly by management efficiency as regards human resources, assets, capital, sales and profits. Obviously, this efficiency differs in these companies, depending on the skills and competences displayed by their management. Another important aspect is full digitalisation of operations. Those who had embarked on e-commerce early enough were able to avoid some of the negative consequences of COVID-19 pandemic. As is the case elsewhere in the world, e-commerce has significantly alleviated the negative impact of the pandemic on the performance of trade companies in Serbia.

Keywords: efficiency, factors, ARAS method, trade, Serbia

1. INTRODUCTION

In recent years, various multi-criteria decision-making methods or combinations thereof are fast becoming a key instrument for measuring the efficiency of trade companies (Nguyen, 2020; Karcıoğlu, 2022; Görçün, 2022). Against this background, the paper seeks to perform a complex analysis of the efficiency of trade companies in Serbia using the ARAS method aimed at determining, as close as possible, the

efficiency of trade companies in Serbia and making suggestions for improvements in the future (through application of effective relevant measures).

Recent years have seen a proliferation of studies on efficiency evaluation of trade companies using multi-criteria analyses (Saaty, 2008; Ersoy, 2017; Gaur, 2020; Lukic, 2011, 2019, 2020a, b, c, d, 2021a, b, c, d, e, f, g, h, i, j; Lalic, 2021; Berman, 2018; Levy, 2019; Lovreta, 2021; Tsai, 2021). In particular, the ARAS method appears to be gaining in popularity. However, when reviewing the available literature, we could not find a comprehensive work dedicated to evaluating the efficiency of trade companies in Serbia using this particular method, especially for 2020. The paper addresses this gap thereby adding to the existing scientific and professional research in the field.

The hypothesis that will be tested in this paper is that a careful analysis of the efficiency factors of trade companies is a key prerequisite for future improvements through timely implementation of effective relevant measures. This can be easily achieved by using various methods of multi-criteria decision-making or combinations thereof, including the ARAS method as well as DEA models (Banker, 1984; Lukic, 2019).

The empirical data needed for the research presented in this paper were collected from the Serbian Business Registers Agency (SBRA). The data are internationally comparable as they are produced in accordance with relevant international standards.

The paper has been organised in the following way: in addition to the introduction and conclusion, it contains sections describing the basic characteristics of the AHP and ARAS methods, and an analysis of empirical results of efficiency evaluation of trade companies in Serbia using the ARAS method. The authors acknowledge the limitations of the research and make recommendations for improving the efficiency of trade companies in Serbia in the future.

2. ARAS METHOD

The ARAS (Additive Ratio Assessment System) method is a multi-criteria analysis technique developed by Zavadskas and Turskis (Zavadskas and Turskis, 2010). Unlike other multi-criteria decision-making methods, the alternatives are ranked based on the utility function value (Chatterjee and Chakraborty, 2013; Sliogene et al. 2013; Rostamzadeh, 2017; Koc, 2017; Dahooie, 2019; Jovčić, 2020). The ARAS method procedure includes several steps (Zavadskas et. al., 2010):

Step 1: Create a decision-making matrix (DMM)

The decision-making matrix is created as follows:

$$X = \begin{bmatrix} x_{01} & \cdots & x_{0j} & \cdots & x_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix}; i = \overline{0,m}; j = \overline{1,n} \qquad (1)$$

where m – the number of alternatives, n – the number of criteria describing each alternative, x_{ij} –the value representing the performance value of the i-th alternative in terms of the j-th criterion, x_{01} – the optimal value of the j-th criterion.

If the optimal value of the *j*-th criterion is unknown, then

$$x_{0j} = \max_i x_{ij}\,, if\ \max_i x_{ij}\ is\ preferable;$$
$$x_{0j} = \min_i x_{ij}^*\,, if\ \min_i x_{ij}^*\ is\ preferable \quad (2)$$

Step 2: Normalise the values of the criteria

In this stage, the initial values of the criteria are normalised - by defining the values $\bar{x}_{ij}$ of the normalised decision-making matrix - $\bar{X}$.

$$\bar{X} = \begin{bmatrix} \bar{x}_{01} & \cdots & \bar{x}_{0j} & \cdots & \bar{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \bar{x}_{i1} & \cdots & \bar{x}_{ij} & \cdots & \bar{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \bar{x}_{m1} & \cdots & \bar{x}_{mj} & \cdots & \bar{x}_{mn} \end{bmatrix}; i = \overline{0,m}; j = \overline{1,n} \quad (3)$$

If a maximum value is preferable, normalisation is done as follows:

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} \quad (4)$$

If a minimum value is preferable, the procedure consists of two phases:

$$x_{ij} = \frac{1}{x_{ij}^*};\ \bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} \quad (5)$$

Step 3: Define the normalised-weighted matrix - $\hat{X}$

Weights are usually determined by the expert evaluation method. One should use only well-founded weights because they are always subjective and affect the solution. The sum of weights is limited (i.e. equal to 1):

$$\sum_{j=1}^{n} w_j = 1 \quad (6)$$

$$\hat{X} = \begin{bmatrix} \hat{x}_{01} & \cdots & \hat{x}x_{0j} & \cdots & \hat{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}_{i1} & \cdots & \hat{x}_{ij} & \cdots & \hat{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}x_{m1} & \cdots & \hat{x}_{mj} & \cdots & \hat{x}_{mn} \end{bmatrix}; i = \overline{0,m}; j = \overline{1,n} \quad (7)$$

The normalised-weighted values of the criteria are calculated as follows:

$$\hat{x}_{ij} = \bar{x}_{ij} w_j; i = \overline{0,m} \quad (8)$$

where w_j is the weight (importance) of the *j*-th criterion and $\bar{x}_{ij}$ j is the normalised rating of the *j*-th criterion.

Determining values of optimality function:

$$S_i = \sum_{j=1}^{n} \hat{x}_{ij};\ i = \overline{0,m} \quad (9)$$

where S_i is the value of optimality function of the *i*-th alternative. If S_i is the largest, the criterion is the best.

The utility degree (K_i) of an alternative a_i is calculated (using the previous equation) as follows:

$$K_i = \frac{S_i}{S_0}, \qquad i = \overline{0,m} \qquad (10)$$

where S_i and S_0 are the optimality criterion values.

The value of K_i is in the interval $[0, 1]$. The relative efficiency (position, rank) of an alternative is determined according to the utility function values. The best alternative is the one with the greatest value.

3. ANALYTICAL HIERARCHICAL PROCESS (AHP) METHOD

Considering that, when applying the ARAS method, the weights of criteria are determined using the AHP method, we will briefly look at its theoretical and methodological characteristics.

The Analytical Hierarchical Process (AHP) involves the following steps (Saaty, 2008):

Step 1: Construct a pairwise comparison matrix

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \qquad (11)$$

Step 2: Normalise the pairwise comparison matrix

$$a_{ij}^* = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, i, j = 1, \dots, n \qquad (12)$$

Step 3: Determine the relative importance, i.e. the weight vector

$$w_i = \frac{\sum_{i=1}^{n} a_{ij}^*}{n}, i, j = 1, \dots, n \qquad (13)$$

Consistency index - CI is a measure of deviation of n from λ_{max} and can be represented by the following formula:

$$CI = \frac{\lambda_{max} - n}{n} \qquad (14)$$

If CI < 0.1, the estimated values of the coefficients a_{ij} are consistent, and the deviation of λ_{max} from n is negligible. In other words, this means that the AHP method accepts an inconsistency of less than 10%.

The consistency index is used to calculate the consistency ratio CR = CI/RI, where RI is a random index.

4. MEASURING THE EFFICIENCY OF TRADE COMPANIES IN SERBIA USING THE ARAS METHOD

The following criteria were used to measure the efficiency of trade companies in Serbia based on the ARAS method: C1 - number of employees, C2 - assets, C3 - capital, C4 – operating income (sales) and C5 - net income. The selected criteria adequately measure the efficiency of resource use and financial performance of trade

companies which are key factors in the efficiency of trade companies (Lukic, 2011, 2020a,b,c,d, 2021a-j). Adequate control over these factors can enable trade companies in Serbia to achieve their target efficiency (Lalic, 2021). These variables fully correspond to the nature of business operations of trading companies, i.e. of using resources in order to achieve the target profit (Berman, 2018; Levy, 2019; Lovreta, 2021). Based on them, a strategic model can be constructed (Berman, 2018; Levy, 2019):

$$Return\ on\ assets = \frac{Net\ profit}{Sales}\ x\ \frac{Sales}{Assets} \quad (15)$$

relation

$$Return\ on\ net\ worth = \frac{Net\ profit}{Sales}\ x\ \frac{Sales}{Assets}\ x\ \frac{Assets}{Net\ worth} \quad (16)$$

By effectively controlling the return on sales and asset turnover, the target return on assets can be achieved. Likewise, effective control of the return on assets (that is, the return on the sale and turnover of assets) and financial indebtedness (financial leverage) can achieve the target return on net worth.

For these reasons, among other things, the mentioned variables are used in the literature when evaluating the financial performance and efficiency of trading companies.

The trade companies whose efficiency was analysed are the alternatives: A1 – Nelt Co., A2 – Phoenix Pharma, A3 – Mercata VT, A4 – Knez Petrol, A5 – Agroglobe, A6 – Delhaize Serbia, A7 – Mercator-S, A8 – Lidl Srbija, A9 – Mol Serbia, and A10 – Lukoil Srbija.

Table 1 shows the initial data for measuring the efficiency of trade companies in Serbia for 2020 using the ARAS method.

Table 1. Initial data

		Number of employees	Assets	Capital	Operating income	Net income
		C1	C2	C3	C4	C5
A1	NELT CO. DOO BEOGRAD	2,037	26,799	13,326	77,376	783
A2	PHOENIX PHARMA DOO BEOGRAD	512	25,082	5,928	55,983	1,004
A3	MERCATA VT DOO NOVI SAD	754	9,605	1,015	55,487	650
A4	KNEZ PETROL DOO ZEMUN	1,129	8,467	2,809	39,351	791
A5	AGROGLOBE DOO NOVI SAD	286	24,481	6,390	32,380	50

A6	DELHAIZE SERBIA DOO BEOGRAD	12,889	72,196	42,305	111,485	3,931
A7	MERCATOR-S DOO NOVI SAD	8,031	55,477	0,000	79,966	-5,478
A8	LIDL SRBIJA KD NOVA PAZOVA	2,483	53,999	28,806	57,014	1,138
A9	MOL SERBIA DOO BEOGRAD	98	16,040	13,215	44,691	1,381
A10	LUKOIL SRBIJA AD BEOGRAD	150	6,271	3,027	29,200	1,036

Note: The data are expressed in millions of dinars. The number of employees is expressed in whole numbers. The first five companies are from the wholesale sector and the rest are from the retail sector. Capital = Net worth. Net worth = Total assets – Total liabilities. It is noted that the company A7 MERCATOR-S DOO NOVI SAD has no capital and is operating with a loss above the capital.
Source: Serbian Business Registers Agency

The influence of the wholesale and retail trade companies on the performance of the Serbian economy is significant. More specifically, wholesale companies (21 in total) accounted for 4,7% (Nelt Co., 0.7%, Phoenix Pharma 0.5%, Mercata VA 0.5% Knez Petrol 0.3% and other companies 2.0%) and retail trade companies (14 in total, including Delhaize Serbia 1.0%, Mercator-S 0.7%, Lidl Serbia 0.5% and other companies 2.0%) accounted for 4,1% of the total operating revenues of the 100 largest companies in Serbia in 2020 (source: Serbian Business Registers Agency). Thus, it is essential to continuously investigate the efficiency factors of trade companies in Serbia using various multi-criteria decision making methods or a combination thereof, including the ARAS method, with the aim to achieve improvements in the future by taking effective relevant measures and through effective control of their implementation.

The criteria weights shown in Table 2 and Figure 1 were determined using the AHP method. (The calculation was done using AHP Software for Excel)

Table 2. Criteria weights

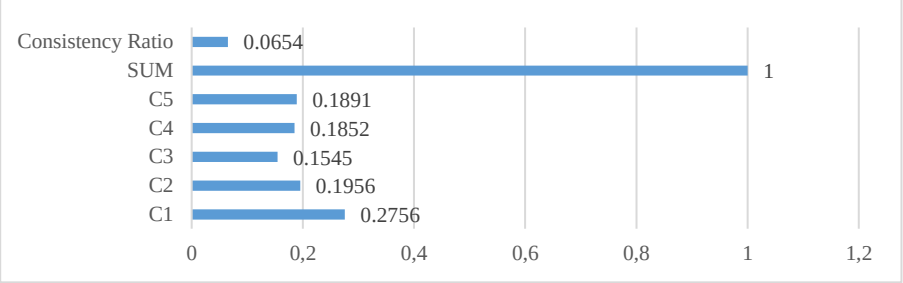
AHP With Arithmetic Mean Method					
Initial Comparisons Matrix					
	C1	**C2**	**C3**	**C4**	**C5**
C1	1	2.5	1	2	1
C2	0.4	1	2	1.25	1
C3	1	0.5	1	0.5	1
C4	0.5	0.8	2	1	1
C5	1	1	1	1	1
SUM	3.9	5.8	7	5.75	5

Normalised Matrix						
	C1	**C2**	**C3**	**C4**	**C5**	**Weights of Criteria**
C1	0.2564	0.4310	0.1429	0.3478	0.2000	0.2756

C2	0.1026	0.1724	0.2857	0.2174	0.2000	0.1956
C3	0.2564	0.0862	0.1429	0.0870	0.2000	0.1545
C4	0.1282	0.1379	0.2857	0.1739	0.2000	0.1852
C5	0.2564	0.1724	0.1429	0.1739	0.2000	0.1891
					SUM	**1**
Consistency Ratio	**0.0654**	**COMPARE WITH 0.1; IT SHOULD BE LESS THAN 0.1**				

Note: Authors' calculation

Figure 1. Weights of criteria



Source: Authors

In terms of their importance, the selected criteria are ranked as follows based on the results of evaluation using the AHP method: The most important criterion is C1 - number of employees. It is followed by: C2 - assets, C5 - net income, C4 - operating income, and C3 - capital. These results suggest that by improving human resource management (through training, flexible working hours, flexible employment, career advancement, and rewards), the efficiency of trade companies in Serbia can be significantly improved. In addition, there is a need to improve the efficiency of financial capital management (by increasing sales revenues, reducing costs, and increasing profit). Furthermore, full digitalisation of operations plays an important role in achieving higher efficiency.

The empirical results of the research into the efficiency of trade companies in Serbia using the ARAS method are shown in Tables 3, 4, 5, 6, and Figure 2. (The calculation was done using ARAS Software for Excel)

Table 3. Initial matrix

Initial Matrix					
weights of criteria	0.2756	0.1956	0.1545	0.1852	0.1891
kind of criteria	1	1	1	1	1
	C1	**C2**	**C3**	**C4**	**C5**
A1	2.037	26.799	13.326	77.376	783
A2	512	25.082	5.928	55.983	1.004
A3	754	9.605	1.015	55.487	650
A4	1.129	8.467	2.809	39.351	791
A5	286	24.481	6.39	32.38	50

A6	12.889	72.196	42.305	111.485	3.931
A7	8.031	55.477	0	79.966	-5.478
A8	2.483	53.999	28.806	57.014	1.138
A9	98	16.04	13.215	44.691	1.381
A10	150	6.271	3.027	29.2	1.036

MAX	754	72.196	42.305	111.485	791
MIN	1.129	6.271	0	29.2	-5.478
0-Optimal Value	754	72.196	42.305	111.485	791

Note: Authors' calculation

Table 4. Normalised matrix

Normalized Matrix					
weights of criteria	0.2756	0.1956	0.1545	0.1852	0.1891
kind of criteria	1	1	1	1	1
	C1	**C2**	**C3**	**C4**	**C5**
0-Optimal Value	0.2922	0.1948	0.2659	0.1605	0.2574
A1	0.0008	0.0723	0.0837	0.1114	0.2548
A2	0.1984	0.0677	0.0373	0.0806	0.0003
A3	0.2922	0.0259	0.0064	0.0799	0.2115
A4	0.0004	0.0228	0.0177	0.0567	0.2574
A5	0.1108	0.0661	0.0402	0.0466	0.0163
A6	0.0050	0.1948	0.2659	0.1605	0.0013
A7	0.0031	0.1497	0.0000	0.1152	0.0000
A8	0.0010	0.1457	0.1810	0.0821	0.0004
A9	0.0380	0.0433	0.0830	0.0644	0.0004
A10	0.0581	0.0169	0.0190	0.0420	0.0003

Note: Authors' calculation

Table 5. Normalised weighted matrix

Normalised Weighted Matrix					
	C1	**C2**	**C3**	**C4**	**C5**
0-Optimal Value	0.0805	0.0381	0.0411	0.0297	0.0487
A1	0.0002	0.0141	0.0129	0.0206	0.0482
A2	0.0547	0.0132	0.0058	0.0149	0.0001
A3	0.0805	0.0051	0.0010	0.0148	0.0400
A4	0.0001	0.0045	0.0027	0.0105	0.0487
A5	0.0305	0.0129	0.0062	0.0086	0.0031
A6	0.0014	0.0381	0.0411	0.0297	0.0002
A7	0.0009	0.0293	0.0000	0.0213	0.0000
A8	0.0003	0.0285	0.0280	0.0152	0.0001
A9	0.0105	0.0085	0.0128	0.0119	0.0001
A10	0.0160	0.0033	0.0029	0.0078	0.0001

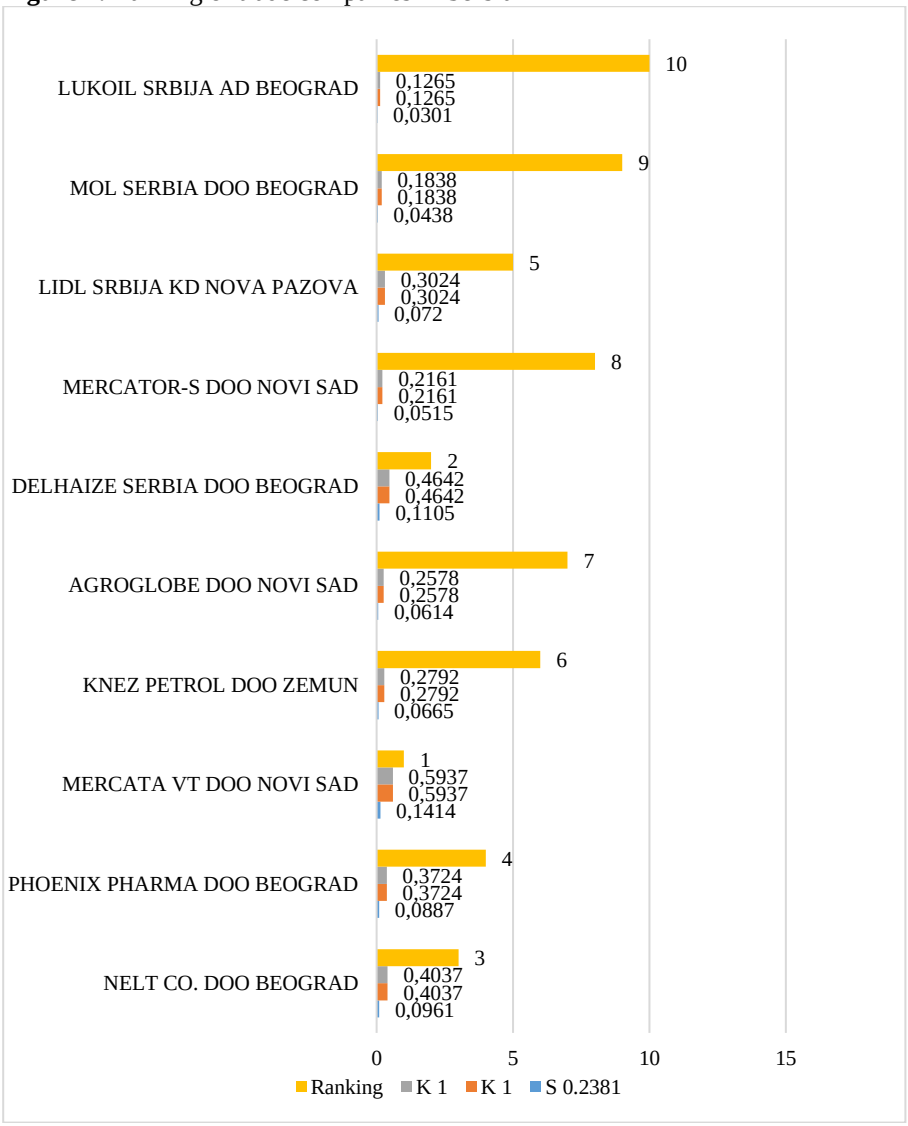
Note: Authors' calculation

Table 6. Ranking of alternatives

		S	K	K	Ranking
	0-Optimal Value	0.2381	1.0000	1.0000	
NELT CO. DOO BEOGRAD	**A1**	0.0961	0.4037	0.4037	3
PHOENIX PHARMA DOO BEOGRAD	**A2**	0.0887	0.3724	0.3724	4
MERCATA VT DOO NOVI SAD	**A3**	0.1414	0.5937	0.5937	1
KNEZ PETROL DOO ZEMUN	**A4**	0.0665	0.2792	0.2792	6
AGROGLOBE DOO NOVI SAD	**A5**	0.0614	0.2578	0.2578	7
DELHAIZE SERBIA DOO BEOGRAD	**A6**	0.1105	0.4642	0.4642	2
MERCATOR-S DOO NOVI SAD	**A7**	0.0515	0.2161	0.2161	8
LIDL SRBIJA KD NOVA PAZOVA	**A8**	0.0720	0.3024	0.3024	5
MOL SERBIA DOO BEOGRAD	**A9**	0.0438	0.1838	0.1838	9
LUKOIL SRBIJA AD BEOGRAD	**A10**	0.0301	0.1265	0.1265	10

Note: Authors' calculation

Figure 2. Ranking of trade companies in Serbia



Source: Authors

As can be seen from the results of efficiency evaluation using the ARAS method, the company MERCATA VT is ranked first. It is followed by: DELHAIZE SERBIA, NELT CO., PHOENIX PHARMA, LIDL SERBIA, KNEZ PETROL, AGROGLOBE, MERCATOR-S, MOL SERBIA, and LUKOIL SERBIA.

The ranking of trade companies in Serbia was influenced by favourable economic climate, but even more significantly by management efficiency as regards

human resources, assets, capital, operating income and profits, which depends on the skills and competencies of trade company management. Another important factor is the application of new business models (multi-channel sales – online and offline, organic product sales, private label, etc.). Full digitalisation of operations also plays an important role. As is the case elsewhere, e-commerce has significantly mitigated the negative impact of the COVID-19 pandemic on the performance of Serbian trade companies.

To obtain a better insight into the efficiency of trade companies in Serbia with the aim to improve it in the future through effective relevant measures, it is essential to use other methods of multi-criteria decision making (TOPSIS, DEMATEL, WASPAS, etc.) and DEA models (Banker, 1984; Lukic, 2019) in addition to the ARAS method (Banker, 1984; Lukic, 2019).

To our knowledge, similar empirical research has not been conducted elsewhere in the world. It would be desirable to undertake similar research in other countries in the future. The results would enable international comparison and thus shed light on the position of trade companies in Serbia in terms of efficiency relative to trade companies in other countries.

5. CONCLUSION

Based on the results of the empirical research into the efficiency of trade companies in Serbia using the ARAS method, the following conclusions have been reached.

According to the AHP method, the importance of the selected criteria is as follows: (1) the most important criterion is C1 - the number of employees. (2) It is followed by: C2 - assets, C5 - net income, C4 - operating income, and C3 - capital. By improving human resource management (through training, flexible working hours, flexible employment, career advancement, rewards), the efficiency of trade companies in Serbia could be significantly enhanced. Moreover, the efficiency of financial capital management should be significantly increased (by increasing sales revenues, reducing costs, and increasing profits). Full digitalisation is also an important contributing factor.

The ARAS method has revealed that the most efficient company in the trade sector (both wholesale and retail) is MERCATA VT. It is followed by: DELHAIZE SERBIA, NELT CO., PHOENIX PHARMA, LIDL SERBIA, KNEZ PETROL, AGROGLOBE, MERCATOR-S, MOL SERBIA, and LUKOIL SERBIA.

The ranking of trade companies was significantly influenced by the favourable economic climate in Serbia, but even more significantly by management efficiency as regards human resources, assets, capital, operating income and profits, which depends on management skills and competencies in individual trade companies. Full digitalisation of operations also plays an important role in this respect as does the application of new business models (multi-channel sales – online and offline, organic product sales, private label, etc.). As is the case elsewhere in the world, e-commerce has significantly alleviated the negative impact of the COVID-19 pandemic on the performance of trade companies in Serbia.

To provide a better insight into the efficiency of trade companies in Serbia with the aim to improve it in the future by implementing effective relevant measures, other methods of multi-criteria decision making (TOPSIS, DEMATEL, WASPAS, etc.) and DEA models should be used, in addition to the ARAS method. A comparative international analysis is also needed.

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SEARCHING FOR AI SOLUTIONS TO IMPROVE THE QUALITY OF MASTER DATA AFFECTING CONSUMER SAFETY

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Abstract

The quality and completeness of the master data has a direct impact on the accuracy of purchasing processes in supply chains. Today, manufacturers and retail chains have both centralized catalogue solutions and distributed repositories supported by appropriate standards at their disposal. Despite the popularization of digitization of the synchronization processes of data describing products, research conducted around the world indicates basic errors that concern packaging at various levels, from the basic item, through cartons, to pallets. Therefore, incompleteness and unreliability of the data force the parties involved in the processes to remove errors, which leads to a deterioration of the sales economic parameters. However, the master data used in both B2B and B2C relations are not only the identifiers, classifiers, and dimension and weight information, but also a set of information on the composition and content of products, e.g. food products, which may affect the safety of consumers.

Therefore, a detailed verification of the information content provided by suppliers and producers for individual participants in the supply chain is required. Such activities require the work of specialized teams of expert auditors who must deliver a verdict on timeliness, quality, and completeness. The elements of Artificial Intelligence (AI), which can take over most of the controlling activities, are the perfect solution for this role. This paper identifies important factors as the places where important decisions are made regarding the approval or rejection of product/master data.

AI will be an important element of content verification in terms of consumer safety. The role of these mechanisms is particularly important in the context of the sale of food products and cosmetics, i.e. items that come into contact with the human body. Automation of these processes using this methodology and self-learning mechanisms will enable mass checking of entire databases in search of places that do not meet user safety requirements. The implementation of such mechanisms, whether in catalogue systems or distributed systems, will improve the substantive quality of product descriptions, and thus increase their usability and safety and build customer trust in the brands of individual manufacturers.

Key words: AI; Artificial intelligence; Supply chains; Catalogues; Master data synchronization; Security; GDM; Global Data Model;

1. INTRODUCTION

Master Data is a key element in commercial processes between suppliers, wholesalers, and retailers. Correct product information ensures proper identification. Previous research indicates that incorrect input data cause errors in the further part of the sales process (GS1 UK, IBM, 2009). According to this report, even 80% of the master data in the UK are incorrect, despite the use of modern techniques of electronic data exchange. This has a direct impact on sales losses (e.g. £ 300 million over 5 years). This affects the overall cost of handling transactions. That is why it is so important to use appropriate IT tools and standards for data synchronization in supply chains.

One of such standards is GS1 - GDM - Global Data Model, which indicates the most important elements from the point of view of B2B and B2C cooperation and what is needed to close product registration, regardless of location. In addition, it indicates which data should be completed in individual countries. It is important that the standard of the Data Model is independent of the adopted technology, which means Technology Agnostic. This means that it can be used both in typical Excel files and in advanced database systems.

The current practices of sharing and exchanging product data via IT systems have become an indispensable part of the business, proving the high maturity of the chain. However, the problem arises when the data are not fully standardized (Tagliabue, 2021) or when each supply chain partner expects something different (Whitehead et al., 2019). This situation is observed, for example, in e-commerce, where data is used not only for electronic exchange (Niemir & Mrugalska, 2021). Regardless of whether companies use Data Models or exchange information beyond any standards, the problem of their quality remains. It often happens that information is incorrectly compiled or incomplete.

Quality can be controlled. It is done by both the authors of product data, i.e. producers, brand owners, or suppliers, as well as retailers or specialized companies

from Data Capturing. The question arises of what to do to reduce the risk of errors or incompleteness of data, especially in those places that are important from the point of view of end-customer security.

The authors of this study point to the importance of using not only organizational and technical environments or standards, but also the mechanisms of AI - Artificial Intelligence. Here, AI is an independent element that supports control activities. Additionally, based on the experience gained, the most important places were defined that should be verified using the above-mentioned techniques to maintain the safety of the final consumer.

Only the combination of the use of product data synchronization standards and AI - Artificial Intelligence techniques in control processes makes it possible to improve data quality. This can have a measurable impact on the cost of servicing the supply chain.

2. METHODOLOGY OF RESEARCH

In the lack of reports from the literature related to the use of AI in the field of master data quality improvement (specially customer safety), the focus was on determining the method of evaluating product data for goods in modern supply chains and methods that would enable the automation of the data quality control process.

Its authors decided to divide the research work into three aspects:

- Theoretical, identifying the problem of AI and the possibilities of its application in logistics processes,
- Previous business experience in the field of applied standards such as GDM - Global Data Model in the field of proper shaping of product data and identification of places that would require additional control,
- Practical, presenting the possibilities of using solutions treated as a forward-looking proposition of AI implementation in the control of data crucial for consumer safety.

The research process presented in the article results from the logic of the structural analysis of the identified research problem. The adopted research methodology assumes theoretical research, including the identification of similar, but not the same AI solutions.

According to the authors, the above-mentioned aspects are intended not only to confront research, concepts and practical considerations, but also to organize the existing knowledge on the analysed topic. Ultimately, the specificity of the research problem requires comprehensive research at every level and carrying out the so-called proof of concept. This applies in particular to those algorithms that have been indicated as recommended for the described applications, i.e. improving master data quality control.

3. LITERATURE REVIEW

3.1. The importance of product data

Modern trade requires participants to efficiently use product data to allow proper identification of the subject of sale. Today, the easier it is to promote a product, the more knowledge the market has about it. This confirms the theory that a product is treated as incomplete without adequate information.

There are many definitions of master data in the literature. For example, (Schäffer & Stelzer 2017) defined it as a set of representing data. Such a data set can describe different types of product features or properties - both physical, structural, and compositional (Schäffer & Stelzer, 2017; Niemir & Mrugalska, 2021).

Additionally, product data can be divided into areas such as identification, classification, and description (Legner & Schemm, 2008; Vandic et al., 2018). Undoubtedly, the key attributes of the product data are:

- Product name that uniquely and fully identifies a specific product, taking into account its variant and brand, without having to know other product attributes and without having to browse photos or physically view the product,
- Unique identifier - unambiguously representing the product in the supply chain, created in one standard and interpreted in the same way by all IT systems. A well-known and widely distributed number that meets these requirements is the GTIN (Global Trade Item Number – late EAN Code) issued by the GS1 organization.

Before starting cooperation with wholesalers or retail chains, producers and suppliers prepare the so-called product cards. These are still very often Excel files. Moreover, in parallel, data recipients use independent catalogues or their own data collection tools.

Ideally, the market would expect free access to structured information prepared similarly for the entire market. Access to such information should be available not only to the authors of the content, i.e. producers, brand owners or suppliers, but also intermediaries, wholesalers, retailers, logistics operators, and consumers. This would make it possible to maintain adequate homogeneity and consistency of these data in all the above-mentioned market participants, while guaranteeing unambiguous interpretation. Hence the search for organizational and technical solutions that would enable synchronization of data describing products.

In connection with the above, catalogue systems such as GDSN classes - Global Data Synchronization Network, which is treated as central databases. GDSN is a team of global cooperating product catalogues that meet the requirements of GS1 standards. Thanks to this, the data can be transparently transferred from the supplier to the retailers, regardless of who uses which GDSN catalogue. Additionally, there are also

distributed environments based on individual internet resources of individual brand owners (Osmólski & Muszyński, 2020).

Another element in the fight for data quality, are standards, the purpose of which is to unify and simplify the rules for collecting, processing, exposing and transferring the above-mentioned data. They also shorten the processes of goods exchange by eliminating errors related to the correct identification of products. Consequently, it improves the economic parameters of sales.

Since trading occurs across multiple channels simultaneously, product information is needed to support all key supply chain processes. Product information, also known as master data, is also the foundation of proper product identification. This is especially important in the era of the omnichannel, in which all commodity participants should simultaneously have access to correct and high-quality data that describe products. Here, Omnichannel should be understood as sales carried out with the use of integrated content coordinated and available everywhere (classic stores, online stores, mobile applications, social media, and AR - Augmented Reality).

To identify the information scopes needed to support data exchange, the authors of the study divided the key attributes into sections. The most important of them are presented in Table 1.

Table 1. List of the most important groups of attributes describing FMCG products (Fast Moving Consumer Goods = Food and Near Food products)

Attribute sections	Sample content
Supplier and product / package identification	Vendor Identifier - GLN - Global Location Number Product identifier - EAN / GTIN - Global Trade Item Number
Product name and description	Product name / Short name on the receipt
Marketing information	Marketing communication regarding the product
Legal requirements	Regulated product name; Is the price indicated on the product?
Tax classifications and rates	Product classification, eg. - General Classification - GPC; CN code; VAT rate
Information based on Regulation 1169 / EU	Nutritional information; Allergen content; Breeding place; The place of fish catch
The origin of the product	Country of manufacture of the product
Dimension and weight information	Height / width / depth; Net weight; Net content; Weight after draining
Product durability / warranty storage information	Use by / use by date Maximum and minimum storage temperature

Package type	Unit package / Carton / Pallet
Information on palletizing	Number of pieces on a layer / Gross height of the pallet
Packaging material	Cardboard; Foil; Glass bottle
Safety information	Dangerous product marking; The presence of batteries in the product
Complementary attributes for controlling the data publication process	Date of data publication; Is the unit intended for shipping?; Is it an invoiced unit?

Source: own study

In the case of selling food products, the manufacturer should provide information on the composition with particular emphasis on substances that may be dangerous to the health or life of the consumer (e.g. allergens by the EU Regulation - EU 1169/2011). However, when selling through the Internet, it is important to meet the requirements of the Consumer Directive - EU 83/2011. The buyer/customer may return the goods if he deems that the description was too limited and was thus misled by the seller.

Therefore, as you can see, the completeness and quality of product data have a significant impact not only on building brand loyalty, but also on customer safety.

The global standardization, organization GS1 conducts intensive initiatives aimed at structuring product data, which in turn has an impact on the improvement of the quality of information flowing between all participants of the supply chains. One of them is the implementation of the GDM Global Data Model. This organizes the sets of attributes applicable to particular industries. It is also a starting point for the implementation of technical platforms and other standards related to the quality of information about products (Muszyński, 2021).

Today, suppliers, retail chains, Logistics Operators and Catalogue Providers associated with international GS1 Working Groups have developed Data Models that accurately describe data in the following sectors/industries:

- Food,
- NearFood,
- PetFood,
- Alchohol&Beverages,
- Tobacco,
- From 07/2022 also DIY – Do It Yourself.

It should be clarified here that the description of typical FMCG products is a result of at least two Food and NearFood Models.

GDM defines not only what the scope of information should be broken down by industry, but also indicates which of the attributes are required. This is the important

factor, which additionally indicates which of the attributes are absolutely mandatory. It means that without this it will not be possible to properly close the registration of the product in the supplier-recipient relationship (e.g. Retailer).

Regardless of the described standards and EU regulations, a business carries out its sales mission in its own individual way. Important elements used in B2B and B2C relations are, first of all, the connection of the GTIN identifier (Global Trade Item Number) with the name of the product, then with its detailed description, and in the case of e-commerce with a photo.

Data catalogues often use validation rules that allow you to catch basic errors such as:

- Incorrect GTIN syntax - wrong GTIN number/duplicate existing GTIN,
- Arithmetic errors, e.g. incorrect number of unit packages in the box,
- Logical errors - wrong assignment of product categories.

However, the above-mentioned solutions do not provide certainty of entering data of appropriate quality in all cases. Hence the need for a deep connection of several factors. And here comes the place to implement AI methods to better control the shared data.

Examples of problems related to the identification and interconnection of relations between the attributes are presented below.

In the example cited above, in traditional trade, the key attribute of a product is GTIN, which uniquely identifies the product, while in e-commerce, product identification begins with its name (Niemir & Mrugalska, 2022). For example, in a stationary store, the customer identifies the product by its packaging, and the purchasing process begins with scanning the bar code - that is, GTIN identification, the IT system uses it to determine the price, inventory, etc. In the case of online purchases - the product is identified and searched for by name. At this stage, the GTIN does not matter and the purchase is made at the level of the internal online store ID associated with the name. This shows why the product name is so important. Unfortunately, it turns out that just as the GTIN number is a permanent element, given by the manufacturer, the name of the product is interpreted by everyone in their way.

Using one of the local purchasing platforms, research was conducted on a product with the same GTIN number entered for many names of offers and categories. This is a classic example where a buyer searches for different products and consequently receives multiple offers with the same product. Platforms are currently trying to solve such problems by creating their own product catalogues, and aggregating such data by GTIN.

This is only possible if the platform has reference data. This solution is not 100% effective. In the discussed case, as many as 771 pairs were created for the set: offer name (product) + product category. The product appeared in 10 different categories and 283 different names. Instead of the name of the product, the offer contained various information - from the common name to the description of the client's needs. This demonstrates the seller's approach of using an offer description to attract

attention at the expense of sound product information, only to increase sales. This is an example of the so-called wrong combination of attributes.

Another multi-criteria problem may appear when we match the name of the product with its photo. The study analysed all stores in detail to confirm the selected word about the name, to eliminate situations when the search engine retrieves data, e.g. from the description on the product page.

There are many reasons for this, such as an incorrectly entered product name by the operator of an on-line store database or a badly loaded photo that does not represent the real product, or even a poor-quality photo, e.g. a photo, distorted colours, the wrong colour definition.

Another problem is the photo itself - the shot, background, number of products in one photo etc. In the traditional channel, such situations are extremely rare, as the consumer can physically touch the product and verify his own experiences/feelings. Given the above examples, it seems that, AI algorithms and methods will significantly improve the data entry process and eliminate discrete errors that cannot be detected using the classic validation methods. The above reports prove that, as a user, we have some data, but they are "dirty". In addition despite we use of standards, electronic catalogues, etc. The numbers cited above, as well as the types of problems, and the fact that standard guidelines, validators, best practices, and software vendors' security are far too high-quality data. By analysing the literature on the subject, we found no relevant publications on how to improve the quality of product catalogues. Therefore, we decided to analyse the publications in terms of AI algorithms available to improve the quality of the data.

4. DISCUSSION - LOOKING FOR A SOLUTION

In this chapter, the authors try to select information areas to be controlled and the best potential algorithms currently available on the market. The work does not examine their details, but only indicates the potential in their application.

4.1. Description of the problem to be solved

From the point of view of product data security, the following issues should be taken into account, in particular:

- Key attributes determining consumer safety,
- Current and future data verification methods.

Among the attributes presented in this study, the authors rejected those that do not have a direct impact on consumer safety. These are, among others, product identifiers, manufacturer and product names, and dimension and weight information. These data are important mainly for handling B2B relations between the supplier and the retailer. There remains a group of attributes related to the characteristics of the

product, such as composition, nutritional requirements, suitability, and information on hazardous materials.

Finally, from among the group of attributes, the most error-prone were selected. It is behind them that the safety of consumers stands. These are:

- Classification of the product,
- Name of the product,
- Regulated product name,
- Functional name,
- Product description (details of the product),
- Does the product contain substances dangerous to health and life,
- The content of allergens,
- Maximum date for consumption,
- Nutritional information / calorific value,
- Nutritional information / content of protein, sugar salts, etc.,
- Allergen warning on the product packaging.

When using electronic master data synchronization methods, the data pools often use simple validation rules. They consist of checking the arithmetic values and the logical presence or absence of some descriptive fields.

As it turns out, such a cursory check is not always sufficient. A content check is required. It is most often done by a man who verifies and allows the description of the data for further use. This means that the data will be in a retailer or an online store. The human factor is the possibility of a mistake. In addition, there is an effect of scale. How to efficiently control the base of 40 thousand items (typical index list amount in retailer)? What about the situation at the data pool, when there are millions of GTIN-s. Here, self-learning methods derived from AI algorithms are needed. Therefore, it is suggested to use Artificial Intelligence mechanisms for faster and more efficient identification of defective data in order to release for use only those that meet the control conditions.

4.2. Indication of AI algorithms and methods needed to verify product data

Focusing on consumer safety, a group of the most important attributes was selected. They also form the core of the information defined in Regulation 1169 / EU. They include: Product names, Detailed descriptions, Classifications, Information on hazardous material content, Nutritional information, Shelf life, and Allergen warnings. The literature in the area of broad Artificial Intelligence supporting data analysis including text and images was then analysed in search of possible algorithms that could improve the quality verification of these attributes. As a result, several ideas for verification were selected that potentially offer a chance for effective implementation of solutions of this type, as presented in Table 2 in the combination: idea - detailed description.

Table 2. AI and detailed information on selected attributes important for consumer safety

Idea	Description
Correctness of product classification in the context of the name and description	A model learned from the data could determine the correct classification of the product. If the classification differed significantly from that assigned to the product, it could be reported as a data error.
Cross-validation of name and description in the context of safety and allergen attributes, key characteristics, and net content	Algorithms in the area of text transformation and natural language processing could extract data recorded in descriptive form, such as in the name or marketing description, and then compare it with data contained in the form of lists or yes/no information. Deficiencies or differences could be reported as errors.
Missing ingredient and allergen data	Assuming the product dataset is sufficiently large, it could be possible to predict missing elements of multi-element attributes (e.g., ingredient or allergen lists), non-matching data, or non-existent data.
Incorrect numeric data in attributes	In large product datasets, it is possible to observe some recurring rules between product attributes in the same categories. Using appropriate machine learning algorithms, deviations from the norm could be detected.
Incompatibility of product image with text attributes	Using techniques such as computer vision (CV), machine learning (ML), optical character recognition (OCR), and natural language processing (NLP), it is possible to effectively extract data from a product label, classify it, and compare it with data stored in individual attributes.

Source: own study

4.3. Correctness of product classification in the context of the name and description

Correct product classification is significant for consumer safety. With proper product classification, product management systems, sales platforms and other IT solutions can require additional fields dedicated to certain product groups, limit accessibility for underage consumers, etc. The classification problem is generally known, and research in this area on the use of Artificial Intelligence has been carried out for many years with good results (Lee et al., 2021). However, the authors propose a different approach to this topic, the goal of which would be not to find the correct classification of the products in question, but to find an error in the product data that has already been described and return the information to the data controller. The benefit of such a solution would be a reduction in data preparation costs. This solution could be used to improve the quality of data classified using GS1 GPC (Global Product Classification), as well as any other classifications, provided the data used to learn the algorithm is large enough and sufficiently fills each branch of the classification.

The choice of model for text classification is not a trivial task. There are many classical machine learning approaches for classification (Kowsari et al., 2019). The basis for the operation of any such algorithms, is first to properly convert the words of the input text into corresponding numbers or multidimensional numeric vectors, the so-called "word embedding". Classical embedding methods, such as TF-IDF ("Term Frequency - Inverse Document Frequency"), work by counting words and assigning corresponding weights to them, which, however, has major drawbacks - the order of words in the text is ignored, the algorithms are unable to capture semantic information, and they have high dimensionality. This limits their application to effective text classification tasks (Naseem et al., 2020). Novel, but more computationally expensive approaches are based on transformer architectures. They use a pre-trained encoder on large text datasets, e.g., BERT ("Bidirectional Encoder Representations from Transformers") enhanced with a classification head (Devlin et al., 2019). Studies show that such solutions are significantly better than classical methods (Gasparetto et al., 2022).

Text classifiers require training. Training of such an algorithm is usually carried out on correctly prepared labelled data, which is prepared by a trained team of so-called annotators. If the classifier is large, hundreds of thousands of data need to be annotated, which may not be cost-effective in relation to the business benefits. However, if one were to run the learning of the classifier on real, dirty data and perform data training using stratified cross-validation (Bates et al., 2022), which should minimize the adverse impact of errors on the model, there is a chance that with a large scale of data the results will be sufficient enough to achieve the desired goal. This is because the solution is not about the correctness of the classification prediction, but about alerting the database administrator to a possible error present in the data. Success, therefore, would already be the narrowing of the search for errors by the database supervisor to, for example, 10% of the entire database, which still saves 90% of the time. Of this 10%, some of it would certainly be an error in the operation of the algorithm, whereas a properly set up information system could retrain the model by using the information resulting from the administrator's final corrections.

4.4. Cross-validation of name and description in the context of safety and allergen attributes, key characteristics, and net content

Computer systems usually do not validate the content of fields if they contain free text. As a result, data discrepancies are observed between product data attributes. Various algorithms from the field of natural language processing (NLP) trained and tailored to the particular language in which product data are stored could help extract relevant and useful information for comparison with other product attributes (Srinivasa-Desikan, 2018). In this way, information about the content of a given ingredient (e.g., active ingredient, allergen, hazardous substance) or the net content of a product could be extracted from product names stored in the database (Javed Akhtar et al., 2020; Zheng et al., 2018). This information could be used to verify that the name matches the actual data recorded in detailed product attributes. This concept applies to various product names: the functional name - describing how the product is used by the consumer, the regulated name – it means the recommended, regulated or

generic name or term of the product describing its true nature. This is all, the basic field, which is the product name (Niemir & Mrugalska, 2022), sometimes referred to as the label description, as a consumer-friendly short description of the product suitable for compact presentation. Similarly, a product description, regardless of its form (e.g., a marketing description), should contain full information about the product, including restrictions on use due to allergens or hazardous substances, which various data extraction methods can be used to control (Wang et al., 2020a;, Wang et al., 2020b). On the other hand, if the product information database contains yes/no information, and extracted lists containing ingredients, allergens and hazardous substances - these completely must coincide with the description. Describing the issue more broadly - Artificial Intelligence by cross-referencing product textual data such as name, product description, lists with ingredient and allergen information could verify their correlation and automatically detect potential anomalies, and report these to the data manager.

Data consistency is very important for consumer safety. Often the name, description, and detailed attributes of a product come from different sources, are incompletely aggregated, or entered by other people. While inconsistencies in numerical values between a product's name and its description or detailed parameters can be mainly a cause of consumer confusion, already false, unconfirmed, or contradictory textual information can lead to serious health consequences. For example, when a product whose name includes the statement "gluten-free" will have the information "may contain gluten" in the description and no warnings in the allergen fields, while in fact it actually contains such an ingredient.

The subject area of this type of field validation is very broad and can include many effective solutions worth testing. One of the simpler methods here may be the extraction of net content from the product name. With the use of appropriate regular expressions and a well-described dictionary of entities, along with synonyms and abbreviations, the effectiveness of such a solution can be assumed to be high. As a result of the operation, missing extracted data, inconsistent units or values, would be a reason to report an error to the data manager. A parallel approach could be a more high-tech algorithm that examines text consistency at the level of specific words, programmed to recognize standard phrases - that is, the basic context of use, such as: "contains [...]", "does not contain [...]", "may contain traces of [...]", and other cross-contamination problems. Using appropriate methods that perform lemmatization, i.e. reducing each word in the text to its base form, and a programmed dictionary of synonyms (Latin descriptions, regulated food additives described as E, etc.). The solution could also be characterized by high efficiency. In this case, the data manager could be informed of both missing information and inconsistencies, especially with the phrases: does it contain or does not contain.

The most high-tech solution worth testing and promising good results would be, as in the previous consideration, to perform calculations on text data after converting them into vectors of numbers. There are a number of embedding methods, such as Glove Embedding - but the method does not encode the context information that is crucial here, the ELMO method ("Embeddings from Language Models"). This encodes bidirectional context information (Peters et al., 2018), and finally the most interesting and noteworthy - the aforementioned BERT method (Devlin et al., 2019),

which best encodes context using the attention mechanism (Vaswani et al., 2017). Several calculations can be performed on such a transformed dataset: calculating the similarity of a given, e.g., allergen to a single word in a text using Cosine Similarity (Gomaa & Fahmy, 2013). It gives similarly to the aforementioned method with a classification head - to determine whether, e.g., a product contains allergens, information about warnings, usage restrictions, etc. or not. A slight similarity of a word, e.g. allergen to a product description, or a different response from the system in the category of yes/no fields would result in sending the information to the data manager. Unfortunately, such algorithms require training on tagged data. The better the quality of the data - the better the final results of prediction effectiveness, although, again, tests can be performed on dirty data knowing the consequences of shifting the training process to the data admin in the initial period of operation of such a system.

4.5. Missing ingredient and allergen data

Another problem of data quality is missing parts of the information. If the data in the product catalogue do not have extensive descriptive information including, for example, product ingredients or allergens, and the list with ingredients or allergens is not complete either, the cross-validation algorithms described in the above paragraph will not work. When verifying such information, an experienced data manager is likely to point this out, but due to the large amount of data or inexperienced staff, the fact of missing data may be bypassed. It turns out that the process can be automated. Assuming the product dataset is sufficiently comprehensive, it is possible to predict missing elements of multi-element attributes (e.g., ingredient or allergen lists). This is known as data imputation (Lin & Tsai, 2020). In this case, the data would not automatically be entered into the database, but information about possible deficiencies would be forwarded to the data manager for verification. In this way, it would be possible to alert the data manager to a possible oversight in product data, potentially reducing the risk of a missed issue. This is particularly important where a lack of information could have consequences in terms of endangering the life or health of the consumer.

One of the preferred solutions to the problem could again be the use of text classification based on BERT transformers, as described in the first issue ("Correctness of product classification in the context of name and description"). In this case, the classifier would be, for example, a list of ingredients and allergens created using the One Hot Encoder technique (García et al., 2016). A text classification would then be performed, with the difference that on top of the architecture would be a multi-classification head with the ability to select more than one class for a single product, since a product may contain more than one allergen or ingredient. The result of such an algorithm would be a list of likely items that should be listed, in terms of percentages, which, after comparison with the actual data, could be sorted and evaluated by the data manager.

4.6. Incorrect numeric data in attributes

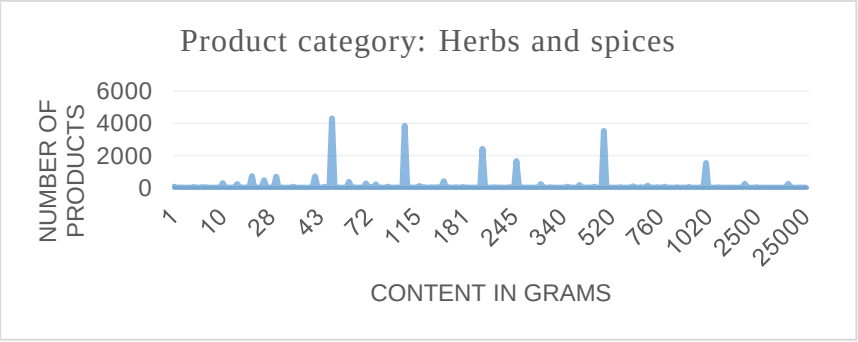
In product databases, one often encounters anomalies in numerical data that "meets the eye." This is the kind of data that the information system records because the value is within a preset range, but a human can identify it as "illogical" at a glance. These are the results of not only human mistakes in terms of figures or units but also wrong data conversions between IT systems. Although some attributes, such as those related to logistics, do not directly affect consumer safety, errors in some data can have more serious effects. Consumer safety is affected, for example:

- Allergen content - the value / amount of the allergen,
- Maximum date of consumption / use from delivery,
- Maximum date of consumption / use from production,
- Nutritional information / caloric value,
- Nutritional information / content of protein, salt sugar, etc.

When defining extreme numerical values of given parameters, values can be estimated from experiments, but this is a time-consuming operation given that the permissible parametric ranges also depend on units, as in the case of net product content. It is much easier to use algorithms from the field of statistics and perform calculations on existing data sets. The easiest way - you can calculate minimum and maximum, or, with a large dataset, the median from the set of all minimum, and maximum values on the products, and thus determine threshold values, beyond which the data manager will get information about a potential error. Such a solution will reduce anomalies, but will also introduce additional false positive errors on extreme values incorrectly identified by the system as potentially erroneous.

Analysing the issue in more depth, the ranges of correct figures can vary from one type of product to another. Moreover, on a large dataset of packaged products, some recurring rules were also observed depending on the classification to which the product was assigned.

Figure 1. Number of products / net content in the category of herbs and spices



Source: own study

9Figure 1. shows the specific sizes of the number of products (from different companies) for a specific value of the number of grams. It can be seen that certain values are preferred by manufacturers. This, in turn, gives an introduction to consider the possibility of using advanced machine learning algorithms in anomaly analysis (Poon et al., 2021) and detecting not only extreme numerical values, but also data that occur inside the range. It is possible to detect such correlations and draw the attention of the data manager to deviations from the norm. Unfortunately, the quality of such prediction depends on the already accumulated data in the database.

There are various models that can be used to detect anomalies. Poon et.al. (2021) list as many as 11 of them in their research on this type of detection, without identifying the best one. It is worth mentioning one of the simpler and older K-Nearest Neighbours models - KNN (Guo et al., 2003) which stores all available cases and classifies new ones based on a similarity measure, an algorithm using density level estimation based on a threshold of the number of neighbours - Density-Based Spatial Clustering of Applications with Noise - DBSCAN (Hahsler et al., 2019) and Isolation Forest, which identifies anomalies using a decision tree algorithm (Hariri et al., 2021). All should be verified at the case study stage.

4.7. Incompatibility of product image with text attributes

In the last idea discussed, it is worth considering the possibility of cross-validation between product packaging images and the product description and other text attributes. This could be the ultimate validation of data quality, especially important given that in large corporations, the responsibility for product label design and country compliance undergoes a completely different quality control than the process of publishing textual data. What is more - you can be sure that the data placed on a product photo come from the manufacturer, while text data have no such guarantee. Verification of data using images is fundamentally dependent on their quality, including resolution and coding, and cannot be carried out if the product packaging images do not depict the product label - which often requires analysis of several images, such as each side of the carton separately. However, there is a big improvement in both the quality and completeness of images, due in part to e-commerce requirements. A photo-description cross-analysis solution could at the same time verify deficiencies in textual data, but also examine whether the posted photo is appropriate and corresponds to the described product, and thus unequivocally assess the consistency and reliability of the data, taking into account the data determining product safety.

The process of extracting information from product images would have to start with computer vision (CV) issues, i.e. analysing the image and extracting blocks of background-free text (Gundimeda et al., 2019). One of the more effective usable solutions could be the EAST model - "Efficient accurate scene text detector" (Zhou et al., 2017), one of the best for detecting text in natural scenes. Then, a ready-made, learned OCR (Optical Character Recognition) text recognition tool, such as "Tesseract Open Source OCR Engine" (Smith, 2007) could be used to extract text in previously detected text blocks from product images. The extracted text, could be used for semantic similarity analyses using BERT transforms and cosine similarity, as

presented in the idea "Cross-validation of name and description in the context of safety and allergen attributes, key characteristics and net content ". In this way, the collated and compared data would give full information about the correlation of the photo with the description, and the completeness of both. Any discrepancy would be grounds to alert the data manager to potential quality problems.

5. CONCLUSION

The constant emphasis on the use of digital media, and the need to satisfy the specific appetite for data on the part of informed consumers are the basic determinants defining the current trends in the field of product information exchange/synchronisation. Therefore, you can see that there is no turning back from the current practice.

The observations and experiences of the authors described in this study allow us to conclude that to maintain the high quality of the product data, it is absolutely necessary to implement two mechanisms in all market participants:

1. Organizing product information, eg. by the GDM standard - Global Data Model. This standard will ensure not only the systematization of data, but most of all it will affect the presence of key attributes, i.e. it will provide a complete set of data. Here, all information critical to maintaining consumer safety is particularly important.
2. Implementation of control procedures for data collected electronically, using AI. It will allow to eliminate of many errors related to incorrectly compiled information or even the lack of some data. This should be seen as automating data verification procedures. Until now, verification was done manually or with the use of simple validation rules.

Global Data Models unify and systematize the information scopes necessary to conduct efficient sales. Thanks to them, all trade participants have sufficient knowledge about what data are globally important and what are important to meet the legal requirements of the European Union. The implementation of the aforementioned order in the form of a Data Model translates into an improvement in the cost parameters of several activities related to the preparation and transfer of product data. Information supplemented according to this pattern enables full control over their quality. This, in turn, is related to the improvement of further parameters such as consumer safety or creating a consistent policy of trust in the brand.

The concepts mentioned in the study are the starting point for building product data exchange systems that will independently take care of storing high-quality data, i.e. building modern and trusted sources of information about products.

To sum up, the group of attributes regarding e.g. composition, content and durability of the product should be controlled not only manually, but with the use of selected AI methods/algorithms. The review of the recommended methods and

algorithms is described in detail in the previous chapter. This guarantees the improvement of data quality and, consequently, the possibility of influencing several key parameters:

- Consumer safety,
- Brand trust,
- Eliminating errors and improving the economics of sales.

By extrapolating the conclusions described in this study, Artificial Inteligence can also be ultimately used for the processes of automatic information improvement. Thus, AI deep learning systems would enable the completion and refinement of data. This, in turn, fits in with the concept/trend of an ideal market in which all its participants would have access to the same qualitative information describing products.

This article indicates the areas for optimizing the quality of product data, i.e. a group of key attributes for customer safety. Recommendations regarding the selection of AI methods and algorithms were also presented. All the elements gathered above are theoretical considerations. Now it is necessary to carry out the implementation and test whether the described indications are sufficient to meet the requirements of full quality control of master data or not. Therefore, it is suggested to carry out the proof of concept on a sufficiently large set of real data. Real data, means, obtained from the market (B2B and e-commerce data). This will certainly give answers to whether the selected AI methods are closely related to the type of base, or whether methods and experiments can be easily transferred to any set.

In the initial phase, each of the methods/algorithms requires manual control of the test moderator, i.e. the process annotator. Only in this way will it be possible to evaluate the effectiveness of selected solutions, and it will also be possible to carry out tests of AI resistance to disruptions in the processes of improving/enriching of product data.

The last task that should be carried out as part of the proof of concept is to test the profitability of the implementation. That is, indicating the optimal volume of the data set for which it is worth paying the cost of implementing AI technology and the personnel cost of the implementation team. Only such a set of information will give the data pool provider a complete picture of what AI algorithms are to be used, how to do it and when to do it. It means, at what point in the development of the database system.

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EXPLORING THE RELATIONSHIP BETWEEN SUSTAINABLE PUBLIC CATERING AND SHORT SUPPLY CHAINS - DEVELOPING AND PRESENTING A SUPPLY CHAIN MAPPING METHODOLOGY THROUGH A HUNGARIAN CASE STUDY

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Abstract

Our study deals with an exceptional area within the food supply chain, the relationship of sustainable public catering and short supply chains. We aim to examine sustainable school food systems. The definition includes not only the operations, ingredients, and stakeholders in connection with the value creation activities (e.g., farming, food manufacturing, catering, consumption, and reverse logistics), but the well-prepared communication about the processes to stakeholders belong to the core values of sustainable school food systems. The research methods include both primary and secondary data analysis. First, we conducted a literature review focusing on supply chain mapping methodologies with a special focus on school food systems. In order to provide a structured interpretation of the topic we present a mapping methodology, and its application demonstrated by a Hungarian school food system sample. The results of the mapping are shown in a case study. The results suggest that our mapping methodology is suitable for school food systems analyses. It seems to be important to detect the focal entity at the beginning of the mapping process to be able to have a comprehensive analysis of the school food system. Limitations of the introduced methodology can be that the interviewed stakeholders have a too narrow focus on their own operations and roles within the very extended food supply network, which cannot be easily tracked. Further research may focus on testing the methodology at other supply chains to gain a comprehensive view. This study should contribute both to the academic sphere and practitioners who are interested in emerging methods supporting the efficient and sustainable operation of school food systems.

Key words: public catering, short supply chain, sustainability, supply chain mapping

1. INTRODUCTION

In the 21st century, sustainability has been becoming increasingly important in many areas of life (Filippi & Chapdaniel, 2021; Kamble et al., 2020; Lavelli, 2021) and the literature on food security issues (Krishnan et al., 2021; Naik & Suresh, 2018) also increasingly addresses sustainability.

In our study, we focus on a prominent food sector, namely public catering. In Hungary, the social perception of public catering is often seen as negative, which is commonly discussed by local media platforms (Munk, 2022a, 2022b), but it has a high potential in terms of sustainability (Vincze, 2022). Sustainability impacts include both environmental and socio-economic aspects. The environmental impacts seem to be the most evident in the choice of raw materials, the mode of transport, processing and the use of water and energy. In addition, the group of socio-economic impacts includes short supply chains, indirectly supporting the economy through relationships with suppliers, job creation, food culture, healthy eating and support for disadvantaged people.

First, we outline the theoretical framework for food supply chains based on the literature. After, we will discuss the links between the value chain, the food supply chain, food systems and regional food hubs, which will be used to formulate a definition of a "sustainable public catering system" that best fits the characteristics of public catering.

Furthermore, methods for mapping supply chains used in other industries are presented. These methods will be adapted to the specific supply network of public catering, with the aim of creating a mapping methodology to analyse different public catering systems. The aim of the analyses is to identify different models of public catering systems, identify areas to be improved, problems to be solved and give recommendations for environmental, social and economic sustainability.

The qualitative methodology developed as a result of the literature analysis, based on in-depth interviews, was tested in a public catering system in a Hungarian location. Our results and the practical usability are presented in the form of a case study, focusing on the task of mapping a public catering system.

2. LITERATURE REVIEW

The literature review chapter focuses on the concepts dealing with the relationship between the actors operating in the food industry (relevant for public catering) and in the second part the possible analysis methods are presented.

2.1. Concepts Describing The Relationships Between Food Industry Actors

The relationships between food industry actors should be discussed and explored along the lines of value creation. For example, the flows of goods, supply chains, financial and contractual relationships between them may function as the fundament of the observation.

The concepts in Table 1. describe the possible relationships between food industry actors. *Value chains* can be understood as strategic alliances between farmers and other supply chain partners. The concept implies customer focus, direct contact between producer and customer, all activities required for the product, full transparency. The focus is explicitly on the added value of the product and the relationship between the actors (Devaux et al., 2016; FAO, 2019). Food value chains are specific in terms of the characteristics of the products. Their value depends to a large extent on the natural environment (humidity, soil mineral content, water quality, etc.), the professional knowledge and know-how of the individual actors, and the length of the supply chains (KPMG, 2013).

Table 1. Framework for describing the relationships between food industry actors

	Value chain	Supply chain	Food hub	Food systems
Focus of relationship	stakeholders	business transactions	operation	operation
Emphasis	socio-economic	economic	social (microenvironment)	socio-ecological
Industry-specific	not	not	yes	yes

Source: own editing, 2022

The *food supply chain* is composed of all actors (producers, suppliers, retailers, and buyers) and all functions within each organisation that are directly or indirectly involved in meeting customer needs (Gelli et al., 2012). Food supply chains can be understood as a set of transactions along the path from producer to consumer (Filippi & Chapdaniel, 2021). The more complex the food product is, the more stakeholders are involved in the production and distribution processes. For this reason, supply chains are typically driven by the final product, but also rely on data from actors in the chain (Van der Vorst, 2006)

Regional food hubs are businesses or organizations that actively manage the collection, distribution, and marketing of labelled foods from primarily local and regional producers to enhance their ability to meet wholesale, retail, and institutional demand. Their necessity lies in the fact that many farmers, especially small and medium-sized farms, are often unable to access trade channels independently. By offering a combination of aggregation, distribution and marketing services at affordable prices, food hubs enable many producers to enter new, larger-scale markets that increase their incomes and provide them with the opportunity to expand production (Horst et al., 2011; Matson & Thayer, 2013).

Based on these three concepts, it is worth exploring the notion of *food systems*, which integrates the three different approaches to interconnectedness in some aspects. Food systems have been considered as social–ecological systems (Berkes et al., 2003; Ericksen, 2008b). In general, the activities in food production, processing and packaging, distribution and retail, and consumption are involved (Ericksen, 2008a). The constant change of the condition of the Earth let us focus on its current

manifestation. Food systems depend on natural resources, not only by value added processes (e.g., production), but also by supporter processes (e.g., distributing (packaging) or consuming (boiling water while cooking) (Westhoek et al., 2016). According to experts not only "in-house" operations, like production, handling, storage, processing, but also operations out of the factory's gates, such as distribution, market, consumption and also food losses and waste build food systems (Tuomisto et al., 2017).

There are several sustainability-related expectations for public catering systems, which are captured in the definition of sustainable public catering systems below.

Sustainable public food systems encompass the full range of activities, components and actors involved in the production, processing, distribution, preparation, serving, consumption, and waste management of food, as well as the spaces and environments in which these processes take place (SchoolFood4Change project - EU Horizon 2020). Public catering systems also include associated educational practices.

Sustainable public food systems aim to promote the health of children and young adults in a way that is profitable for all actors in the food value chain, respects the social and cultural environment, and considers natural resources and ecological processes, while respecting the limits of the planet. Sustainable school catering systems are governed in a democratic and participatory way by all stakeholders, including farmers, purchasers, cooks, teachers, students, parents, municipal and school administrators, researchers, other professionals, and policy makers (SchoolFood4Change project - EU Horizon 2020).

2.2 Methods to Map the Links Between Food Industry Actors

The methodologies used to map the relationships between food industry actors are presented in Table 2.

Table 2. Methods to map the links between food operators

	Value chain mapping	Supply chain mapping	Stakeholder mapping
Focus of relationship	main activities (input-transformation-output)	transaction, documented information flow	groups of stakeholders
Has a prominent role	value added	focal company	the relationship between stakeholders, their expectations
Visualisation method	flowchart	flowchart	stakeholder map (may contain additional information)

Source: own ed., 2022, based on (Berkes, Colding, & Folke, 2003; FAO website, 2018; Smith, 2012)

Value chain mapping is a process that identifies the key activities related to a company's service or product line and is often used in corporate strategy to identify opportunities for performance improvement. Gathering information on a company's key inputs and outputs and examining its role in the overall value chain provides an opportunity to develop sustainability programmes. To this end, sustainability-oriented value chain maps can be drawn up and the impact of the company on a particular process in the value chain (e.g., procurement, supply, and development) can be systematically assessed. The results of the analysis can be used to optimise the value chain (Taylor, 2005).

Supply chain mapping is the process of documenting the relationships between the companies, suppliers, and customers in a company's supply chain, and can even result in a global map of the supply chain from the source of raw materials to the companies that perform the logistics processes and the final consumer. This type of supply chain analysis is best used to identify business opportunities and risks (Anastasiadis et al., 2020; Donaldson et al., 2020).

A *stakeholder map* is the process of visually representing the people and groups associated with an organisation or project. This visual tool should give a clear picture of who the different stakeholder groups are, what their expectations, motivations, interests, and responsibilities are. Stakeholder maps assess each group based on the degree of influence and the level of interest, which contributes to the analysis of the external and internal environment of the organisation by highlighting the forces and interests at play in the life of the organisation (Styk & Bogacz, 2022).

3. RESEARCH METHODOLOGY

Our research is exploratory and started with an analysis of the relevant literature. As a result of the literature review, we compiled a methodology for mapping a public food system from farmers, intermediate actors (processors, traders) and food producers to consumers. Then we tested the proposed methodology and made the necessary modifications as well. The mapping was done with the combination of desk research and in-depth interviews applying the combination of the above-mentioned methods of supply chain mapping (Table 2.). The steps in the data collection process consisted of pre-in-depth-interviews to collect a general view about the specific supply chain being explored. Based on the gained data we contributed to the joint platform of the consortium, in which we participate (SchoolFood4Change project - EU Horizon 2020). Semi-structured questionnaire for each stakeholder group was compiled by the consortium members and we used this structure during the further in-depth interviews with representatives of each stakeholder. Three interviews were taken with the leaders of the catering company and 2 interviews with the representatives of the city involved in the research. The aim of the in-depth interviews was to gain insight into the food system and its processes, and to test the relevance and structure of the interview questions. After revising and correcting the interview questions, we worked on the possibilities of visualising the food system. In our methodological proposal step 1-2-3 represent the basic structure of the questionnaire, they were used only in the questionnaire form in the other participant countries of the

consortium. The visual representation of the interviews provides a possibility for overviewing the public food system and supports further analyses. One public food system in Hungary was selected randomly and based on our possibilities. The information collected was used to produce a case study, which is briefly presented below with the focus on the visualization of mapping a public food system.

3.1 Methodological Proposal for The Analysis of a Public Food System

Our methodology aims to provide guidance for a structured description of a public food system's processes, material flows, stakeholders, legal frameworks, business relationships, "power relations", information flows and funding sources.

We focus on these because they influence the environmental, social, and economic sustainability of a public food system.

The methodology combines methods from supply chain analysis in other industries, as public catering is a very specific field. Our methodology can be characterised as a hybrid of the value chain, supply chain map and stakeholder maps mentioned above.

Our aim is that the proposed methodology can be used to present any other public food system in a standardised way, allowing to analyse the system and identify problems for continuous improvement.

The steps of our methodological solution are listed below, followed by an explanation of each step.

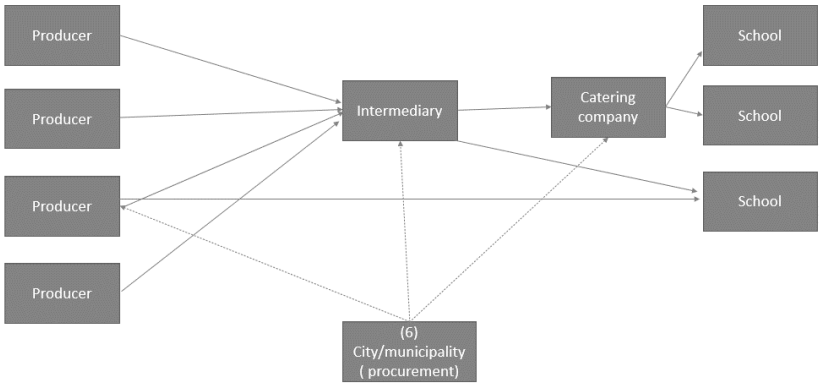
3.1.1. Steps

1. Identification of stakeholders
2. Process mapping (identification of material flows)
3. Analyses of legal and economic environment
4. Selection of the focal company, identification of business relationships (power relations, financing, information flows)
5. Visualisation of the food system map
6. Analysis, identification of problem areas

3.1.1.1 Identification of stakeholders

In terms of food supply chains, we can typically talk about producers, processors, actors with a commercial function, who act as intermediaries in the process. Distribution activities are typically carried out by wholesalers and retailers, for processed or unprocessed food. The distributor is typically followed by a catering company, where ready meals are prepared for schools. This can be either a catering service or a restaurant. At the end of the supply chain, the customer is represented in many different ways. The buyer may be the school itself, the catering company, or even the municipality or the local authority as buyer in the context of public procurement. Beyond the school, the final users are the children and their parents who pay for the meals.

Figure 1: Schematic diagram of the public catering network



Source: own editing, 2022

3.1.1.2 Process mapping

The first thing we expect from the interviewee is a description of the operational activities. Depending on whether the person is a producer or even the actor conducting the interview, we will ask him/her to describe the processes involved in his/her operation. In this section, after the general description of the process, we will describe the relationship with the upstream and downstream actors in the supply chain. Thus, the questions include supplier evaluation, customer relations and partner management, as well as the routes of material and information flows.

3.1.1.3 Legal and economic environment

It is advised to prepare desk research before the interviews about the legal and economic environment in which the food system exists.
Interviewees will be asked to describe the specific food safety and other requirements they are subject to. In addition, a description of the public procurement process is also included in this section if the interviewee is involved in the public procurement process. Questions also relate to how the country/region supports the economic activities of the interviewee in terms of economic policy (tenders, availability of national/international support). We aim to be able to answer the question, what are the regulations and standards for the financing of public catering.

3.1.1.4 Selection of the focal company, identification of business relationships (power relations, financing, information flows)

The primary objective is to identify the focal company against which to assess the buyer/supplier relationships, based on the interviews. In the case of public catering, the focal company is most likely to be the actor with the greatest influence

on the process. These may be the public education institution (as a purchaser in its own right), the municipality (as a contracting authority for public procurement procedures) or even the catering company (as a contractor for public catering in line with legal/customer requirements) in the role of the focal company.

3.1.1.5 Visualisation

After conducting interviews tailored to each actor, visualisation is the next step. The following information is proposed to complement the classic supply chain map:
- Contractual relations
- Stakeholders in the catering system, other stakeholders
- Material flows
- Information flow
- Legislative framework
- Organisational boundaries
- Other relevant information

3.1.1.6 Analysis, identification of problems

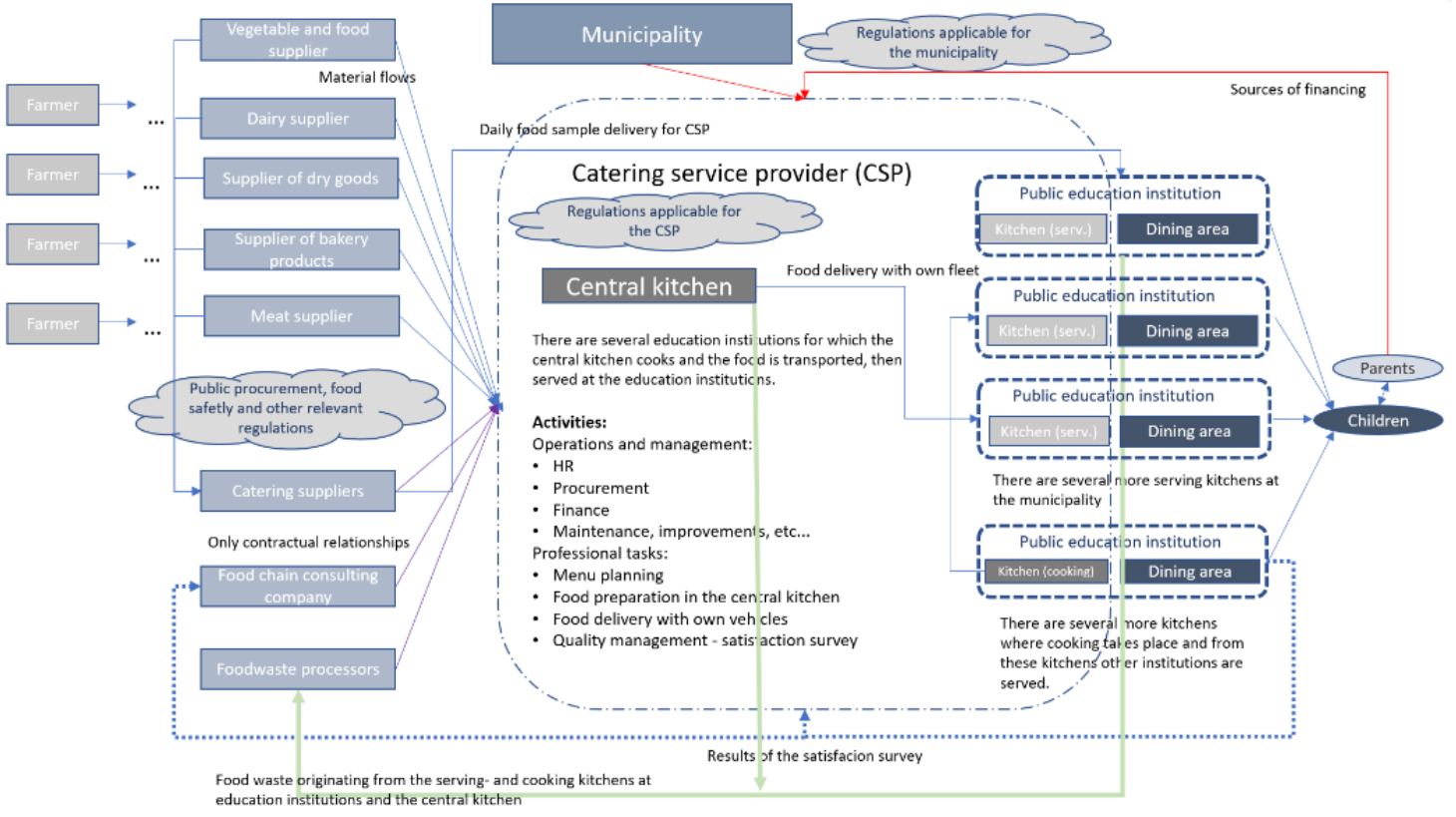
A case study based on the interview transcripts can be prepared and a map of the food system can be used to identify areas of concern. These problems may be caused by customer dissatisfaction, negative environmental impacts, unnecessary costs, or overly strong legal constraints. Once problems have been identified, improvement processes can be initiated with the involvement of stakeholders and with professional support.

4. CASE STUDY

The first results of our research using the methodology described above are presented in the case study below. To test our methodology, we chose a public food system in one of the largest towns in Hungary. The first 5 steps have been carried out, but a more in-depth analysis of the public catering system presented in this study, the formulation of proposals for improvement and the evaluation of their implementation and impact are still tasks for the coming period. Our research is still in its initial phase, and the testing of the methodology on other public food systems is also to be carried out.

The heart of the case study (and the future analyses) is the visualized food system. Figure 2. contains the most relevant information about the public food system and provides a complex overview for better understanding. The farmers, suppliers, catering service provider (CSP), municipality, public education institutions (e.g., day-care, kindergarten, elementary school, high school), children and parents are the most important stakeholders in the system. In the followings the symbols used in Figure 2. are explained, then the relationships between the stakeholders in the food system are described.

Figure 2. Results of the application of the mapping methodology to the food system under study



Source: own editing, 2022

The *full lines with purple* represent a contractual relationship between the parties (e.g., food waste processors have a contract with the CSP, but the food waste is collected physically from different kitchens and sites). The *full lines with blue* represent material flow and contractual relationship on the upstream side of the supply chain (e.g., the supplier of dairy products delivers their products to the CSP, and they also have a contract). On the downstream side full blue lines only represent material flow, there is no contractual relationship between the central kitchen and the other serving kitchens for example.

The *red lines* show the financing arriving from different parties to the catering company for providing meals.

The formalized flow of information is shown with *blue dotted lines* (this means that the schools provide information about their satisfaction with the service within a quality assurance system run by the consulting company). In each case where a contractual relationship exists, we suppose there is some level of interaction and information flow between the parties (for this reason these „natural" information flows are not shown in the figure). Based on the interviews for example market dialogues, consultations with the suppliers are not formally managed and organized by the catering company, which provides room for further development.

Green lines represent the reverse flow of material (food waste) from the place of origin to the food waste processors.

We chose the catering service provider as the "central" actor (focal company) in the public food system because of its greatest impact on customer satisfaction (children and their parents) and sustainability impacts (e.g., support for domestic producers, use of healthy, seasonal, quality ingredients, minimisation of energy use, etc.). However, we should see that the food service provider is in a limited decision-making position in several aspects: market actors/environment, procurement, food legislation, financing, control over the service area all influence the quality-of-service provision and the provider's possibilities for action (hence these elements are also shown in Figure 2).

The food service provider is maintained by the municipality, which provides (part of) the funding on the basis of a legal obligation. The other part of the funding comes from parents. The catering service is subject to public procurement, including the procurement of goods and services. On this basis, on the supplier side, it is in contact with (1) suppliers of food raw materials (the most frequently purchased food groups are shown in Figure 2), from which it prepares meals in its own cooking kitchens using the raw materials and ready-to-cook products it receives.

In our diagram, three points between farmers and suppliers symbolise the unexplored part of the network. In the context of the EU's Farm2Fork strategy (EU Green deal, 2020) and the efforts to support domestic short supply chains (REL) (Government Decree 676), it is important to understand this area in detail, but it is also the biggest challenge (Njt.hu, 2022b). Not only in public catering, but also in other food supply chains, the traceability of raw materials and the identification of producers should be a priority in order to reduce negative environmental impacts and enhance positive social/economic impacts.

On the supplier side, there are also (2) catering service providers who deliver ready meals directly to the public education institutions. One of the contractual

obligations of the catering service providers is to provide a food sample to the catering service provider every day for quality control purposes. Also linked to quality assurance is the (3) food service consultancy partners on the supplier side, who carry out, for example, satisfaction surveys in the public education establishments. The (4) food waste management companies have a contractual relationship with the catering service provider, but at the same time they perform reverse logistics activities from the public education institutions, from where they transport the food waste for further recovery. Of course, the food service provider also has other suppliers (energy, fuel, maintenance, equipment, etc.), but these are not included in the figure for reasons of transparency.

The catering service has a central cooking kitchen and a few cooking kitchens on the premises of public schools, which also serve the institution and other institutions nearby. Food preparation takes place in these areas, from where the food is delivered to the serving kitchens in their own special containers and vehicles. The food service provider has control over the canteens in the public education establishments (both in terms of infrastructure and staff), but the dining area is now the responsibility of the establishment.

The drivers of the system are on the customer side; beyond the school, the final users are the children and their parents who (partly) pay for the meals.

4.1 Analysis, Identification of Problems

Analysing the case, we find several challenges and problems in the public catering system under study. In the followings we only list a few examples, which provide areas of improvement. On the supply side, there is the challenge of tracing the origin of raw materials, and we can state that the upstream side is not sufficiently transparent, involves many actors. The communication between the CSP and their suppliers also provides room for improvement. Regarding the public procurement, scarce funding and legal frameworks also make it difficult to achieve sustainable solutions in public catering.

The catering service provider's internal processes also involve public procurement, which leaves little room for the organisation to engage with small-scale producers, and legislation on public catering also limits the ability to prepare more sustainable food (e.g., it is mandatory to serve animal protein every day (EMMI Regulation 37/2014) (Njt.hu, 2022a), while it is known that 1-2 meat-free days per week (plant-based diet) can significantly reduce environmental impact). The efficiency of the catering service provider's own operations (energy efficiency, waste reduction, chemical use etc.), fleet of vehicles and logistical processes can also be improved to reduce environmental impacts. There is a great possibility in optimizing the forward and reverse flows within the food system in terms of city logistics, GHG emission reduction and also cost optimization.

On the "downstream" side of the food system, i.e., the customer side, the problems are caused by the fact that the canteen is operated, and its staff are employed by the catering service provider, while the dining room is part of the school. This often causes problems in delivering a quality student catering service. The dining rooms are multi-purpose spaces and in many cases the conditions are not ideal for providing a

decent meal (furniture, lighting, etc.). A further problem is the short time available for meals in educational establishments, which does not support a cultural and healthy meal and contributes to an increase in food waste, as children have to rush because they do not have enough time to eat.

5. CONCLUSIONS

In our study, we proposed a methodology for the analysis of public food systems and presented the first results of the testing of the methodology in the form of a case study on the example of a Hungarian public catering system. Public food systems are very complex with a number of constraints (e.g., public procurement, food safety, mandatory service provision) that are not present in supply chains in other industries. They are therefore very interesting systems from a research point of view, but there are also many practical benefits to be gained from understanding them.

We are at the beginning of our research, in the following months the focus of the analysis will be on the upstream side of the supply network (e.g suppliers of the catering service provider, producers, farmers) and parallel to this the improvement action plan for the municipality will be developed. We are also expecting results of similar mapping actions from different EU countries, which migh serve as benchmarks, and provides further analysis and comparison. We are very confident that by the end of our project we will be able to develop a useful and valuable tool for mapping and analysing public food systems and thus contributing to the development of environmentally, economically, and socially sustainable public catering systems.

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CHALLENGES OF CATEGORY MANAGEMENT IN ONLINE SALES MANAGEMENT

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Abstract

Today's modern conditions of megatransition from industrial to information economy, from economies of scale to knowledge economy, from rigid hierarchical structural organizations to organizations of fluid alliances and alliances, from human management to human relations management, from information to expert systems, from one retail location management of multiple channel formats, is characterized by increasing complexity, dynamism and increasingly difficult predictability of business results in which changes take on turbulent meaning. Online sales applies a multi-channel strategy and continuously introduces new formats in order to achieve market and financial sales results. The application of the category management concept affects the importance and significance of operational logistics activities Online sales, improves optimization processes and confirms the importance of logistics performance on the profitability of Online store. The aim of the research is to show how category management plays a central role in the success and efficiency of the company. In accordance with the main objective of the research, a survey will be conducted among online buyers to define variables such as total quality management practices, customer trust, purchase risk management, and their impact on the financial result of sales.

Keywords: Online store, category management, logistics, distribution, sales

1. INTRODUCTION

The historical roots of category management as a concept have been known for more than 20 years when it comes to retail sales. The category management of online stores has been attracting the attention of business economics theorists for a few years now. On the one hand, it is a marketing practice that defines competition in sales channels in the online world of sales, whereby online stores are defined as categories of products and sales space in the online world. On the other hand, category management actually incorporates tasks that improve the efficiency of the supply chain, taking into account the level of optimization of the portfolio of web stores' business tools. In fact, in this way, simplicity and simultaneous comprehensiveness of the market presence is achieved, along with elements of marketing-logistics balance and potential sustainability of the competitive advantage of the web store. Web store category management as a philosophy of strategic management in the background of product category management on the web store simultaneously respects the specificity of searching for competition, whereby the analysis of the effectiveness of the web store is observed through the applied reality of the moment when the customer makes a decision about what to buy and where to buy it in the online world. The difference between category management in retail and online shopping is in relation to innovation and the application of technology, but at the same time it is contained in the focus of the business strategy itself.

At the moment of strategy innovation, the consumer who buys on the web store is at the center of attention of marketing efforts, including the continuous need to structure his needs and requirements, as well as understanding consumer behavior in the online world, but also understanding consumer behavior at a certain level of the web store offer and product category separately. Category management based on the primary interests of suppliers, focuses on consuming those products and/or product brands that respect the consumer and understand their behavior when shopping on the web store. With the development of the web store and its increasingly important role, preconditions are created for the affirmation of the original interests of online retail, both in the area of demand and in the area of supply. Internet online stores is aimed at achieving a satisfied customer, which is gaining more and more importance, which creates the prerequisites for redefining the approach to category management. The goal of the research is to delineate the practice of category management focused on consumers in retail in relation to category management of web stores and their customers, i.e. consumers. At the same time, it is necessary to clarify the key sales strategies of the online store. According to the presented work, research questions were asked: "The inclusion of sales marketing in the category management leads to the redefinition of the web store, with clear elements of the concept of differentiation and positioning through the application of online sales strategies." The research used a qualitative methodology, and the collection of data from secondary sources was adequate in defining the questions that need to be answered in order to fully understand the experiences of category management. The paper will use the method of synthesis of relevant theoretical and practical knowledge about the management of the web store category, which implies defining the phenomenon in the context of the whole. Qualitative research methods as the chosen method are appropriate given that

the online consumer is at the center of demand. In parallel, the work will study the texts of selected theoreticians.

2. THE CONCEPT OF CATEGORY MANAGEMENT ON THE WEB STORE

Category management or the management of product categories according to O'Brien (2019) can be seen as a strategic approach based on the organization of goods and services with other members participating in the process in order to satisfy customer needs and achieve profit. Product category management has a focus on the entire process and on the customers who are the main creators of the categories. Given the differences between physical and online stores, there are also differences in the approach to category management in electronic stores. A focus on overall category performance also has gained prominence in business practice as demonstrated by the significant resource commitments made by both manufacturers and retailers to develop effective category management processes (Dhar, Hoch, Kumar, 2001). According to Biloš et al. (2014), Customer Relationship Management (CRM) facilitates the creation of long-term relationships with consumers who can become regular customers and return to the same electronic store. According to Dujak and Segetlija (2013), a product category represents "one group of products that, from the consumer's point of view, can be seen as a set of related products to satisfy needs". Some authors see shopper marketing as a further development of trade marketing and category management (Harris, 2012; Singh, Glaherty, Sohi, Deeter-Schmelz, Habel, Le Meunier-FitzHug, 2019; Kalyanam, Tsay, 2013; Wade, 2013; Ridge, Johnston , Donovan, 2015; Silveira and Marreiros, 2014). Others argue that customer marketing is distinct from store marketing and category management (Veoder, 2004; Raskin, 2013; Poloian, 2013). In marketing and sales, and in order to manage customer categories, some authors start from the necessity of knowing customer categories and profiles (Inman, Winter, Ferraro, 2009; Kent, 2004; McAfee and Brynjolfsoon, 2012). The category consists of several brands and types of individual products, which represents the breadth of the assortment. The person who is in charge of managing a certain product category in the store is called a category manager. The goal of category management is to offer those products that will satisfy the wishes and needs of customers in order to adapt to customers and their demand in the best possible way.
In order to achieve its own efficiency, an online store must focus on the consumer and monitor:

- who is the consumer of the online store (his habits, lifestyle, ethical influences, etc.)
- what the consumer of the online store buys (which brand he chooses, the size of the packaging, whether and to what extent he buys products on promotional campaigns, etc.)
- why he buys (influence of price, quality, practicality, promotional actions, past experiences, etc.)
- when he buys (when was he last at an online store, how often does he shop, time/day of the week, seasonal purchases, cyclical purchases)

- how much he buys during each visit to the online store (transaction size).

Due to frequent changes in consumer preferences, increased growth of online stores, online stores must follow changes in consumer behavior. In this way, they can attract a larger number of visitors and at the same time stand out from the offer of their competitors. In order to create categories, it is necessary to research several items, and Muller and Singh (2006) state four main items on which category management is based, namely: costs, consumers, competition and drivers of categories. Costs play a big role in the creation of category management, because if the costs are too high in relation to the income, a certain category should be removed or replaced with a more efficient category. Various methods can be used or combined to track costs, depending on the business entity's way of doing business. It is essential to identify all performance indicators in order to get the most accurate insight into the costs, on the basis of which a plan of further activities could be drawn up. Consumers are the ones who create categories and are an important factor in planning activities in the category management process. Product categories in a certain store bring value to consumers, and based on these values, it is necessary to design the right strategy so that consumers can recognize it and decide to buy in that store. Also, in order to be able to define the right product categories, it is necessary to monitor consumer behavior and understand their decisions.

A large selection of categories is necessary for better variety and giving more choice to consumers, but if it is not well planned, it can lead to consumer confusion. This is why category drivers are crucial in category management because they are what make consumers visit a particular store. There are a large number of competitors on the Internet, and because of this, it is an increasing challenge to attract and retain potential customers. Customers have increasing access to information, the ability to compare products and stores with just a few clicks, and can very easily choose the best offer that suits them. Also, generations change over time, and thus consumer habits and product selection criteria. Because of all of the above, it is necessary to follow the trends that will allow the electronic store to get as close as possible to potential customers, offer them a unique shopping experience and create a long-term partnership. Trends in online category management impose new focuses of electronic commerce:

- collecting data on customers and observing the purchase path in order to better personalize the content and create a recommendation of an offer that will suit their individual needs,
- creating a new and improved user experience by connecting physical and electronic stores using technology,
- cooperation with other brands to better approach the target audience,
- improvements based on user experience and feedback.

In order to see the strategic advantages of category management, it is necessary to make a series of category plans. The category plan is a basis that is jointly developed and is based on category goals, the competitive environment and consumer

behavior. Category management theory starts from the fact that sales on the web store and profits are maximized thanks to the optimization of the mix: the type of brands that are sold, the storage of products and the price policy, which are determined by the customer profile and existing sales statistics.

The aforementioned mix is impossible without a systematic category review and results in a category that is differentiated from other competitive categories and recognized as such by the customer. Category management in practice makes it possible to differentiate one's own offer in relation to the competition. Different web stores have different destination categories based on target customers, strategy and form, so two competing web stores will not focus on the same categories in order to ensure a sustainable competitive advantage of the web store.

Content Management System which, according to Biloš and others (2014), "enables publishing, editing and changing content and maintenance via a central interface." Lauren (2018) states that a Content Management System offers a wide range of features that help manage and edit a website to make it as visible to search engines as possible. It can be used to edit the store description, select keywords for SEO (Search engine optimization) construction, adapt the site to foreign users by adding various languages, and the like. The modification of the technological, social, and business landscape of the last decade induced profound changes in shoppers' behavior, such as the emergence of new shopping tools that enable potential buyers - e.g., ability to search for product and price information at any time, outside or inside the store (Wyner, 2011). The design of the website has a great impact on visitors because it represents the entire electronic store and guides visitors through the assortment that is sold. Also, product descriptions, photos and suggested products can have a major impact when it comes to purchasing decisions because in the online world, customers cannot smell or try the product they are interested in. CMS helps the electronic store to become more visible on the Internet, to retain visitors and to further encourage them to research the product and make the purchase itself. In addition to using a CMS, it is also necessary to know the basic elements of building a website and certain design principles for the most efficient results. Based on all the solution systems that can be used to monitor business, we can conclude that they also have an impact on the management of product categories. By conducting an analysis of the collected data, it is possible to see the user's journey through the electronic store, which categories are the best sellers, and which should perhaps be removed due to lack of interest. Also, it is possible to determine what the driver of the category is and, based on that, create a marketing promotion that will attract customers to their electronic store.

3. SALES STRATEGIES OF ONLINE STORES

E-commerce that can be done on computers, tablets or smartphones can be considered a digital version of mail order catalog. Almost every imaginable product and service is available through e-commerce, including books, music, airline tickets, and financial services like stock investing, cryptocurrencies, and online banking. A value proposition can help not only better communicate with potential customers, but

also bring clarity and focus to products and services before they even come to market. Many companies invest a huge amount of resources in product development without really examining the problem it solves, whether the solution is unique and compelling, and how easy it is for users to use. Creating a strong value proposition helps to better understand customers, which is always the first step to success. The e-commerce space has never been so elastic and wide before. Keeping in mind the recent rise in global business, technological advancements and people using online shopping, the digital space has opened up flexible ways to set up e-commerce revenue models online and reach audiences much more easily.

Simply put, e-commerce or electronic commerce business refers to selling, buying or transacting online in a digital marketplace. Products or services are displayed through a website or mobile application that facilitates the purchase of products and financial transactions.

The e-commerce revenue model is usually taken into account when classifying an e-commerce business because revenue refers to the total amount of money a business receives after trading its products or service with its customers. There are a number of options that can be used to generate revenue, including advertising, affiliate marketing, subscriptions, and more. Generally, advertisers are always charged a commission to place their ads on a well-known internet marketing platform. It is a classic principle followed for a business categorized for an advertising revenue model. They take advantage of the huge traffic of people who regularly visit the chosen platform to make a purchase, view an ad and be redirected to the point of purchase. This can be related to how to increase the number of potential customers in the business. Payments are made on the hosting platform based on a fixed commission or the traffic density is decided.

Phygital is the latest buzzword for the strategies and tactics marketers use to engage with their customers. Phygital is a combination of two words or concepts of physical and digital, and represents the merging of physical and digital. Simply put, "Phygital" is the next and latest evolution of that same mindset as marketers think about how best and most effectively to engage with their consumers. Customers today live their lives online. Most aspects of their daily lives have a digital equivalent. As consumers, our lives today are a blend of the digital and the physical. We may not realize it, but the two worlds are so intertwined that the differences are often blurred. It is logical for marketers to meet customers in that same world and with the same approach. Phygital retail is blurring the lines between physical retail and digital retail. What this boils down to is taking the best elements of each and using them to improve the performance of both, while providing a better user experience.

It's no secret that e-commerce has captured an increasing percentage of total retail sales. In the last few years, theories and predictions have been developing about how digital retail (e-commerce) is surpassing physical retail. So city streets are dying and people don't want to go to shops anymore. While it's true that e-commerce has advantages over brick-and-mortar retail, it's just not right to see it as a head-to-head competition. E-commerce allows customers to browse products at their leisure (from their home), look for good deals and have them delivered straight to their door. Physical retail simply can't compete with that and shouldn't try. Physical retail shines with experience, brand loyalty and awareness. The Phygital retail strategy is a concept

that has been around for some time and is thriving with users (consumers). By combining physical and digital retail, the potential of both is maximized, that is, the strengths of each are used. The term Phygital was coined to describe multi-channel marketing, an approach where all marketing channels work together to provide a completely seamless customer experience. The intention of combining physical and digital experiences is to bring out the best of both worlds, and the ultimate goal is to provide customers with unique, highly personalized experiences that leave a lasting impression.

Not only does phygital benefit the consumer experience, but it's also a way for brands to seamlessly integrate their physical and digital marketing efforts and get more opportunities to sell their products.

The Long Tail is a business strategy that allows companies to make significant profits by selling a large number of unique but less popular items that are sold in relatively small quantities. The term was first coined by Chris Anderson, who argued that low-demand or low-volume products can collectively account for a market share equal to or greater than a high-demand product, but only if the store or distribution channel is large enough. The Long Tail concept considers less popular goods that are in lower demand. Anderson argues that these commodities could really boost profitability as consumers move away from mainstream markets. This theory is supported by the growing number of online marketplaces that alleviate competition for shelf space and enable the sale of an immeasurable number of products, especially via the Internet. Although mainstream and high-demand products achieve a higher number of purchases through leading distribution channels and shelf space, their initial costs are high, which raises the question of their profitability. In comparison, "long tail" goods have remained on the market for a longer period and are still sold outside the market channels. These goods have low distribution and production costs and are readily available for sale. Cross selling consists of offering different complementary products to your clients. The key to this system is adding value to the user by showing them that their needs and wants are truly recognized. Like any other marketing campaign, there must be planning and strategy behind cross selling.

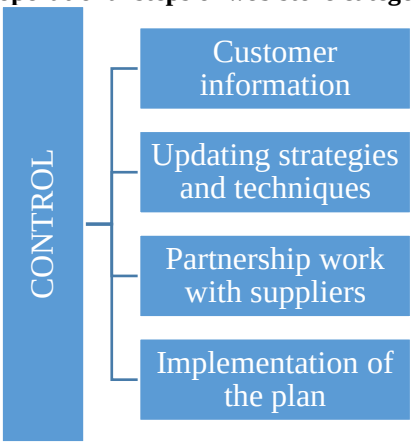
The differences between cross selling and classic selling are big, although these two terms are usually mixed up. However, it is important to clearly distinguish between them. Cross selling, as mentioned above, encourages customers to buy other related products that complement their purchase. However, an upgrade tries to force the customer to buy another, more expensive version of the same product. These are different strategies with the same goal - to increase the average amount of the shopping cart and at the end of the purchase. With the Cross selling strategy, this goal is achieved by adding other products. This method sells a more expensive and thus more profitable product. Another strategy often used in electronic stores is up-selling, which suggests visitors to buy a more expensive product or to buy a larger quantity of products. This is achieved by proposing similar products that meet the same need but are of higher quality and more expensive, and by creating a package of several related products, the purchase of which results in greater savings than when purchased individually. The basic difference between cross-selling and up-selling is that up-selling suggests products only after analyzing the customer's shopping cart and thus suggests related products that could better meet his needs. The main goal of the

mentioned methods is to achieve higher profits and encourage visitors to buy a larger quantity of the products sold.

4. THE EFFICIENCY OF THE REDEFINED CATEGORY MANAGEMENT ON THE WEB STORE

Respect for the variability of the business environment, i.e. quick use of new business opportunities, becomes a condition for the survival of modern retail online organizations that apply category management, especially if it is a web store where products from different manufacturers can be purchased. Web stores have implemented the category management in their established business processes, which they continuously adjust and develop, with priorities set, i.e. speeding up the business process, which is achieved by reorienting customers and applying an appropriate sales strategy while monitoring the competition, treating web stores as a marketing medium , new technologies and loyalty programs. Web store category management must be focused on the customer with local and global application. The focus of the online store category management strategy is the customer, and it starts with defining the category, that is, what determines the category itself, including segments and sub-segments. After defining the categories, priority is given to the continuous collection and selection of information about customers. The key moment of such a redefined category management is the active use of insight into customer profiles obtained through loyalty programs and the CRM approach. Based on the information about the customers of the online store, it is necessary to define and recognize the purchase modalities, the online store develops a strategic and operational plan of the category management that is focused on customers. After the planning part of the business process, which should be 80% dedicated to the basic plan or basic planning, and 20% to adjustments, there follows the implementation of the defined program of the category management, with elements of continuous supervision and development of new solutions. It is especially necessary to pay attention to the supervision of the implementation of the business plan of the category management, which is actually an important source of the new business cycle in the function of improving sales and creating customer loyalty. A key innovation in terms of monitoring the effectiveness of the redefinition of the category management, which is contained in the "new" model of the category management and the separation of the first two described steps of the business process from the subsequent stages of business practice. Namely, the very fact of relatively rare re-examination of the existing definitions and role of the category management relieves the overall process of the category management, creating space to focus on the operational activities that the online store deals with. This speeds up the reaction to business opportunities that arise at the level of the online store, i.e. the product category in question.

Figure 1. Continuous operational steps of web store category management



Source: author's work according to Fowler and Goh (2012), p. 104.

According to Nath and Bharadwaj (2020), the focus of the innovative category management is on finding the best opportunities and avoiding wasting potential customers' time on extensive searches. The emphasis is also on understanding consumer behavior and solving business challenges. The objectified collection and processing of data about customers of online stores is a continuous activity of the business process of the category management, whereby the variables of consumer behavior of customers are registered and clarified, including the potential influence on the efficiency and effectiveness of shopping marketing. The essence is to speed up the processing of a large amount of collected data, primarily through automation and sometimes decentralization, which enables daily updating of detailed insights about customers in a large amount of collected data. Daily updating of customer data and their management processing is essential for the success of the application of category management practices and the overall business in online retail. According to the above, product category management by concept, the effectiveness of which on the web store depends on the following:

1. Sales management begins with the collection of transaction data.
2. Sales support management means managing sales efficiency by collecting requests for interventions and other types of data used for changes in operational business and improvements to the web store;
3. Campaign management provides the possibility of creating and activating campaigns in certain time intervals, statistics of user responses included in campaigns, predictions of future user reactions;
4. Managing call centers means recording input values - user interaction with the company, recording user satisfaction with the service and the ability to measure employee efficiency;
5. Data management: collection of user data as fundamental knowledge for business success.

6. Service quality management: uses already collected interactions and general transactional data for the purpose of analyzing and identifying user needs.

Severović (2013:137) also mentions the queue management component as another integral element of CRM, stating how clients If the same applies to web stores, then when logging in to the web store, clients receive their number and wait for the system to call them when their number is in line. However, if we look at this same component in the context of an information system, it is not common business practice that a queue management system is part of a CRM information system. The CRM information system can, through integration, receive information from the queue management system in order to link exactly that interaction and transaction with each individual client. In addition to standard financial indicators of business performance, web stores also monitor performance using customer-related indicators. Financial indicators that are monitored indicate the consequence of business strategy, while key performance indicators related to customers are indicators that can explain the cause of business results.

Web stores today often categorize their customers precisely according to their different values - for example, high-value users, those who bring less value, users with potential, etc. According to Peppers and Rogers (2004), in the context of the aforementioned attribute of the online customer's lifetime, there are four categories of customers:

- "Most Valuable Customers (MVCs) - clients who bring the most value to the business - those who have the most transactions, bring the highest profit, are extremely willing to cooperate and tend to be very loyal. […] The goal of the business is to keep these clients.
- Clients with the greatest growth potential (MGCs) – clients with the greatest potential that can be realized through cross-selling, keeping clients for a longer period of time or by trying to change the behavior of these clients in using products and the company's service in a way that is cheaper for the company and whose price will be lower. […] MCGs are actually the most desirable customers for competing companies, and that is why the goal of business is the growth and development of relations with this category of clients.
- Below-Zeros clients (BZs) – clients who, regardless of the company's efforts, will record less income than maintenance costs. This means that not only is their actual value below zero, but their potential value is also below zero. […] The goal of the business is either to convert these clients into profitable ones (eg by charging a fee for the use of services they previously had free of charge) or to encourage them to become someone else's unprofitable clients.
- Clients who move (Migrators) – clients who stay on the edge of what is unprofitable and the potential for profitability. [...] The goal of the business is to migrate these clients to the MCG group or to get them to show their "true face" in the context of potential profit for the company in the future."

One of the more important advantages of categorizing or ranking customers by value is that web stores can, thanks to this categorization, allocate resources and

marketing efforts more rationally, focusing more on high-value customers and less on those who bring low value. The goal of the entire process of categorization and ranking of users is also to enable the business to develop different value propositions and strategies for managing the relationship with clients that the company can use.

Automated product processes are part of the web store's product category management system and represent, in fact, application support for business processes within the web store. They enable the reduction of storage costs, the shortening of the time required for the preparation of orders and the shipment of goods, as well as more efficient supervision in the warehouse according to the location and shelf life of the products. In order to eliminate errors when ordering and positioning products, a number of software solutions have been developed that enable automatic ordering and automatic positioning of goods. The automated positioning of goods on the website of the web store can be observed through the positioning of goods on shelves in the warehouse area and the positioning of goods in the retail area. Automated ordering of goods as well as automatic positioning of goods directly affects the reduction of costs through optimization of stocks, and the elimination of human work in repetitive and standardized activities.

5. CONCLUDING CONSIDERATIONS

Web stores offer a whole spectrum of advantages, one of the biggest of which is the availability and greater selection of products. Visitors can shop from the comfort of their own home, and just comparing products and information is much more accessible. But, in addition, they can more easily find similar electronic stores, i.e. competitors, and visit them and make a purchase in just a few clicks. For this reason, attracting and retaining potential customers is a real challenge, and it is important to create a unique electronic store that offers a unique user experience, a wide selection of not only delivery, content personalization and payment methods, but also products and categories. Tracking customers has become much easier compared to physical stores, which leads to better knowledge of customers and their buying habits. This enables an individual approach through the design and management of product categories, cross-selling or up-selling, newsletters and personalized discounts. Content on the electronic store should encourage visitors to buy, which is not available to such an extent in physical stores.

Digitization of the sales process of web stores is the driving force that has brought a series of structured and unstructured data, for the first time ready for analysis and use in the application of appropriate strategies. The feverish race involving manufacturers of hardware, applications, web stores, manufacturers, consulting firms, marketing experts and other participants is aimed at clearer, more accurate and more complete prediction of customer decisions and more effective management of timely information (signals) that facilitate the purchase. by product category, it is also transformed from a concept that contributed to a better understanding of suppliers and web stores into a concept that enables suppliers and web stores to better understand customers.

This ongoing business transformation is accompanied by numerous changes in the business philosophy and organization of both the supplier and the design of the web store, with an emphasis on business analytics, a customer-oriented web store with an IT system that can provide immediate analytics of its customers. It is evident that a new concept of strategic differentiation and positioning is on the horizon. Product category management is a concept that will be intensively studied and researched in the future and in the further development of web stores - category management research in a multi-channel environment will gain importance. Given that in the future the largest number of customers will be oriented towards purchasing, i.e. interaction on the web store, it will be interesting from several aspects to investigate how the behavior of said customers will affect category management and vice versa, whether category management can influence and with which strategies to apply customer behavior. The question of the effectiveness of the category management in electronic commerce has not been sufficiently investigated, which should be the subject of future research and collaboration between the authors. One of the future directions of research can be the application of modern technology and its interaction with category management, that is, the relationship between the benefits that the application of modern technology brings to category management and the resulting costs.

The latest official data of the State Institute for statistics are in favor of increasing sales through web stores, so qualitative research is a limitation and can only be taken as a basis for the implementation of a quantitative sample on those consumers who shop online. Furthermore, category management on the web store was approached in this paper in general, and it is necessary in future research to take into account the fact that it is necessary to conduct two studies. One, on a web store that sells several manufacturers, and the other, that is, a web store whose sales are based exclusively on one manufacturer.

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IV. EFFICIENCY AND COORDINATION IN SUPPLY CHAIN

STARTUPS – BUSINESS MODELS FOR ENHANCING SUPPLY CHAIN 4.0

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Abstract

Digitization within global supply chains has been on the firm forward pace since its early beginning in 2011. Supply chain members are now in position not only to learn about digitization, but to proactively plan and implement technological innovations in their business models. Value chains are being much more circular and more structured than ever so has been the urge for digital upgrade of the companies who are creating the value. Observing the drivers for digital acceleration, there is a need to understand the role of startups in everyday business conduct of supply chain members. Multinational companies (MNCs) are investing significant amounts of financial resources in order to achieve viable results from their R&D departments, but many of them are trying to add value through a more holistic approach: cooperation and/or acquisition of startups into the business. Logistics industry especially has become the "fertile" area for external drivers, such as logistics focused startups, to act and improve some of the key functions and processes within the companies. This paper aims to explore and confirm the positive connection between MNCs' drive for digital upgrade of their supply chains and cooperation with logistics focused startups in observed functional areas. Authors are focused to determine theoretical and practical business enhancement of supply chain 4.0 which has been based on cooperation with startups, by conducting literature review and by researching several related mini case studies.

Key words: supply chain, digitization, startups, industry 4.0

1. INTRODUCTION

Supply chains are considered as one of the most innovation related value chains around the globe in terms of industry development. Production, logistics, warehousing, transportation and retail have been among pioneers of adopting

innovative technological solutions. Industry 4.0 is "producing" a variety of technological innovations and many of them have been implemented in everyday business models of companies.

Digitization based on innovations 4.0 has been on "full steam" ahead since few years ago. Many multinational companies (MNCs) around the global supply chains, dedicated enlarged budgets to their R&D departments in order to generate additional value to their business models through digitization. Technological innovations such as Internet of things (IoT), blockchain, big data management, robots, augmented reality (AR), virtual reality (VR), autonomous vehicles are reshaping interconnection between business models of companies and added value through innovation.

Regarding the logistics and supply chain industry, there has been a variety of drivers for digitization of companies. One of the most common categories regarding drivers could be focused on two types of drivers: internal and external. Internal drivers, as the name states for itself, are drivers coming from within the company, such as: need for function and/or process improvement, adjusting business models, governance style, need for reshaping or improving organization culture etc. External drivers are drivers coming from business environment, such as: competition and market pressure, customer expectations, consumer behavior, governmental policies, etc.

Lately, with expansion of startup community and rise of entrepreneurial mindset of society (especially amongst millennials), innovators are transforming their inventions into small business endeavors. The result of these endeavors is possibility to sell their products or even whole businesses to MNCs.

The connection between startups which have been absorbed, merged or acquired by MNC, is exactly the main focus of this research. During the research, this two-side cooperation has been observed as a trend in business community, especially among supply chain members. The possibility to invest asset in acquiring startup within MNC in order to digitize and evolve the business has been considered as a driver for fast and qualitative supply chain digitization.

At the start, this paper is giving the insight on the Industry 4.0 technological impact on supply chain; afterwards, authors are giving the perspective on supply chain digitization drivers; at the end, cooperation between startups and MNCs has been focus of the analysis. The analysis ends with comparison of several mini case studies regarding the mentioned topic of the research and conclusion.

2. LITERATURE REVIEW

The research has been based on descriptive methods. Literature review of the most relevant and trending scientific articles, proceedings, analysis, databases and journals has been used to understand the treated topic relevance and contribution of other authors. At the end, several mini case studies are representing real business examples that confirm the theoretical findings.

Descriptive and explanatory methods are dominant in the paper. Literature review of scientific papers and conferences proceedings set the foundation for theoretical research on cooperation. Business, institutional publications and case

studies provide the insights of practical cooperation between startups and MNCs. Further, in person interviews and cross analysis of selected case studies focusses on selecting the results and conclusions on the topic of the research. The literature review has been based on exploring and selecting the most viable articles on online open access database of scientific publications, such as "Science Direct", "Emerald Publishing", "Wiley online library" and "Springer/Kluwer" and review of the conference proceedings, business databases, public business journals, publications, analyses and studies from institutions of importance to the topic of the research. Keywords for searching the appropriate sources included the following keywords: "supply chain digitization", "supply chain startups", "startup and logistics", "logistics 4.0", "startups and industry 4.0", "supply chain digitization drivers" and "startups innovation".

During the mentioned research, authors have managed to process 42 relevant literature sources. Out of 42 literature sources, the authors consider 28 sources to be of narrow relevance to the topic. The most significant findings related to the topic of the paper can be found in the following sources: 1. "Research on the impact of supply chain integration of startups: service supply chain perspective" (Lin & Lin, 2018), 2. "The digital supply chain of the future: from drivers to technologies and applications" (Pflaum et al., 2018), 3. "Engaging with startups: MNC perspectives" (Prashantham & Kumar, 2019), 4. "Startups in the supply chain ecosystem: an organizing framework and research opportunities" (Wagner, 2021), 5. "Engaging with startups to enhance corporate innovation" (Wieblen & Chesbrough, 2015), 6. "Startup funding in logistics: focused investment in a growth industry" (McKinsey and Company, 2022).

Other than science paper research and review, authors have conducted secondary research on startup integration by examining available business information regarding the topic. The main issue with literature review on the topic of startup - MNC integration is limited amount of available online studies within mentioned scientific database. Authors have had to understand what is the difference between the startup acquisition process in MNC compared to the traditional processes of integrating one company into another.

Mini case studies analysis based on online research of available startup – logistics/supply chain 4.0 cases. The research was conducted by typing the following keywords into "Google.com" search bar: "logistics startups", "supply chain startups", "Amazon and startups", "MNC and startups", "startups 4.0 case study" and "startups and MNCs cooperation". The range of selected case studies for paper research estimated from 5-10, but only 3 of them were selected for analysis. Authors have picked: Maersk – Huub integration, Bosch – Five integration, Shopify – Deliverr integration regarding the topic relevance, paper context and theoretical findings.

3. THE IMPACT OF INDUSTRY 4.0 TECHNOLOGIES ON SUPPLY CHAIN DIGITIZATION

Since 2011. when the term - Industry 4.0 – was introduced at Germany's National Academy of Science and Engineering (Kurt, 2019), digitization of business became one of the most important aspect of maintaining critical competitive

advantage on the market. The predictions made regarding rapidly transforming business models in supply chain are proving to be correct (Schrauf & Berttram, 2016). Invented technologies managed to set themselves as a necessity for improving business performances in observed period of time.

The course of rapid transformation motivated researchers to even define the concept of digitized supply chain. One of the most appropriate definition of digital supply chain (DSC) describes the supply chain as a value-motivated and efficient process for generation of new forms of production value for organizations, as well as for finding new approaches to technology and analytical methods applicable to the supply chain (Büyüközkan & Fethullah, 2018). The definition refers to transformation model which ought to replace traditional functions and processes in order to gain maximum results by using modern technologies.

Advances in digital technologies are extensive especially in managing of supply chains (Sang & Trimi, 2021). The connection between invented technologies 4.0 and possibilities for technology implementation within companies has always been tight. Leading technologies with significant impact on transforming supply chain business such as Internet of things (IoT), blockchain, big data management, robots, drones (UAV), augmented reality (AR), virtual reality (VR), autonomous vehicles have already been in continuous everyday flow of work. Many authors through their papers are presenting that most important impact from technology 4.0 lies in rise of the level of transparency, speed, communication, collaboration, flexibility and responsiveness, which was systematically analyzed in the paper "Digital supply chain - leading technologies and their impact on industry 4.0" (Aćimović & Stajić, 2019).

After more than a decade of innovation 4.0-based growth, MNCs are no longer bringing in question opportunities coming from possible use of technologies 4.0. However, there are several more questions for decision makers, such as: 1. determination and necessity regarding the transformation of sector, function, process, product or service, 2. internal or external innovation process, 3. technology adaptability. First and second question are actually referring to driving forces for digital transformation. Decision makers need to understand company's necessity for digitization and to point out transformation motive. They have to determine whether they have inner drive for change or outer pressure for adapting new market/consumer expectations. The following step is to evaluate options for bearer of conducting the transformation (decision on possibility for internal innovation process or implementation of external innovative technology). Drivers for change often define whether the company need to change its business model.

4. SUPPLY CHAIN DIGITIZATION DRIVERS

Regarding the analysis and determination of supply chain digitization drivers, the first and foremost task is to discover the relatable source of necessity for digitization. It has been broadly accepted that drivers are derived from necessities. The foundation for determination of drivers could be found in operational business problems (Accorsi et al., 2018; Gunasekaran et al., 2018), a change in business strategy models (Hainen et al, 2018) and business environment factors. These

enumerated elements are foundation for generating and structuring drivers (internal – external drivers) for supply chain digitization which is shown in Table 1.

Table 1. Certain supply chain digitization drivers (internal and external) derived from the base change necessities

Necessity for change	Examples	Driver (Internal/External)
Operational problems	• Warehouse pallets manipulating • Last mile delivery options • Big data management • Transportation and utilities cost • Raw materials origin tracking …	Internal
Change in strategic business models	• Cost reduction • New product/service • Adaption of current product/service portfolio • Investment cycle • Supply chain reconfiguration …	Internal - External
Business environment factors	• Competition "innovation pressure" • Consumer expectations • Market adjustments to new technological trends • Public and governmental policies • Advanced business models (i.e. startups) ...	External

Source: Authors

Table 1. represents structured example of certain digitization drivers which are derived from determined necessities for change. The drivers are structured as internal and external as most common comparison model. They are also structured as internal and external to cover the topic of paper being addressed. Operational problems, strategic business models and business environment factors are set as fundamental detected areas for improvement of company. Further, several examples are given to specify the unique activities within the detected area for improvement. All together are resulted as the internal or external driver for supply chain digitization.

Business environment factors have been strong external driver for company digitization. Discovering new possibilities regarding digital technologies resulted with several different market behaviors such as: 1. competition pressure regarding business model innovation; 2. change in consumer expectations especially in terms of product/service customization and delivery time; 3. adjusting policies and regulations of business conduct on local, regional or national level; 4. raising of entrepreneurial behavior in order to turn technological advantages in profits; etc.

If startups have shown a successful business indicator, they are fertile area for MNCs to integrate them in everyday business.

5. INTEGRATION OF STARTUPS IN ORDER TO ENHANCE DIGITIZATION

Startups and MNCs are tightening their cooperation in order to deliver innovative product or service on the market. Certain MNCs are finding more interest in investing or even acquiring in startups in comparison to cost of internal innovation development. Logistics and supply chain startups are tackling many supply chain areas such as: last mile delivery, road freight and marketplace solutions, visibility and transparency, inventory and warehousing, etc., so many MNCs are always "on the market" searching for best option for external business development. In several further second level titles, authors are focusing on structural topics regarding integration of startups into MNC.

5.1. MNC's motivation for cooperation with startups

Startups are associated with innovation, emerging technologies, high reward – failure risk, fast business scaling and global impact (Wagner, 2021). Startups are based on innovative business models which are mostly or fully digitized. They are strictly oriented on solving business problems which are highly challenging and based on different value proposition. The main characteristics of startup is to resolve business problem through technological implication. Owners are often oriented on fast (up to couple of years) developing of the startup and selling it afterwards in order to obtain high level of buyouts. Logistics industry, sometimes wrongfully considered as a not so innovative and dynamic in terms of developing innovations, has been on a prime impact from new technological advancements. Entrepreneurs realized that logistics 4.0 could be fertile area for raising logistics startups. They have discovered that almost every new 4.0 technology advancement could be implemented in some form of profitable startup entity. That entity could be later sold to MNC or venture capital investor. Some authors are considering that MNCs have realized that startup's open innovation to commercially exploit profitable inventions, will successfully manage external knowledge into their business models (Del Sarto et al., 2022).

The inside report issued by World Economic Forum states that „due to the variety of digital technologies and their embedded complexities, it is difficult – if not impossible – for companies to possess knowledge about all opportunities enabled by digital technologies" (World Economic Forum, 2018). MNCs are facing several key desicions regarding particular digitization alternatives. Among others, they need to evaluate risks regarding internal innovation development and external drivers such as possibility for startup integration as well (Prashantham & Kumar, 2019).

MNCs are conducting financial cost-benefit analysis in order to determain whether or not the internal innovation development is most viable option. Key assessment factors are: strategic orientation towards innovation, level of expenses regarding internal digitization, know-how, knowledge regarding technology

implementation, available support services, potential additional educated and skilled workforce, duration of investment cycle, internal infrastructure botlenecks, patent policies etc. MNCs are weighing the amount of time and financial resources in comparison with overal cost of possible external integration. In many cases, digitization based on external integration has been more viable, because after the integration, company`s task is to acquire knowledge, assimilate it, then transform the new technologies within the current functions and processes and exploit the technologies to improve their performances (Trantopoulos et. al., 2017) which has been resonated as less expensive way.

MNCs are trying to minimize direct and indirect cost of digitization (Bogodistov & Ostern, 2019). Direct costs of digitization, i.e. implementation of pallet robot in warehouse, and indirect costs of digitization, i.e. ttraining costs for warehouse workers, could be a threat for cost management and successful digitization. As mentioned above, cost – benefit analysis more often shows that internal innovation could be both time and cost consuming.

Intellectual property (IP) rights for product/service invented in supply chain startup, but also designs and trademarks can become a point of interest for a MNC to explore possibilities for cooperation. Eventhough, startup founders are trying to save the rights on patent, in order to make an integration, large corporations are requiring that all IP patents, documents and similar are being transfered to MNC (Weiblen & Chesbrough, 2015). In order to freely and properly manage digitization within company, many corporations are very persuasive in terms of the IP transfer.

Corporations identify startups as organizations with business models based on „lean methodology“. Those models are ensuring MNCs that startup pay full attention to: creating unique value for customer, produce only what is important for customer, identify value stream, create flow, pursue perfection (Ghezzi & Cavalo, 2020). Once MNC finds matching startup, it is ensured that mentioned methodology has been completely followed.

As a stand perspective of a startup as a customer, MNCs are indifferent toward cooperation. They realise that partial benefit from mentioned cooperation could be conduct through creating new sales channels and customized deversification (Bjorgum et.al, 2021). In another words, the MNCs would gain several new rather small customer channels.

As from a stand perspective of a startup as a supplier, MNCs are little bit more interested in supply chain startups. Potentials for customized product/services, additional small-size supplier network, flexibility, organizational agility etc are something which will birng attention to possible cooperation (Wouters et al., 2018). But, according to Ketchen and Craighead (2021) and their recently introduced concept of „supply chain entrepreneurial embeddedness“ (SCEE), the more detailed integrated cooperation through joint cooperation in business ventures affects the growth of business capacities of both entities.

Integration is the topic especially interesting to MNCs when neccessity for digitization meets appropriate external candidate. Mature startups are representing optimal candidates for integration and digitization development. There are several phases of maturity of startup company, but overall phase which describes startup integration readiness is „born global startup” (Lotti Oliva, et al., 2022). Born global

startups are typically young - led, entrepreneurial, small entities characterized by limited resources. Despite this restriction, they undertake international business from the initial stage of their development and gaining profits from several different countries. They are „big players" market oriented and competing with some of the biggest companies in the industry.

Rapid expansion in terms of market share and employees rate is also key indicator that startup can be considered for integration.

When supply chain startup is aligned with these indicators, MNCs are usually open for negotiation and integration.

5.2. The options for integration of startup by incumbent MNC

Fourth industrial revolution implicates necessity for MNCs to review their traditional business models. Academia still doesnt have a completely sure answer regarding the scope of digitization change for future business conduct of MNC. There is still an argument that digitization should present overal change in corporate culture. On the other side, certain authors are representing the idea that only new functions and/or departments, such as Innovation department, should be basic carrier of development, rather than transforming entire organization. The vision of decision makers and business capacities are defining the level and scope of digitization.

After thorough cost-benefit analysis, the MNCs are making the decision regarding the options for integration. According to study conducted by EY in 2021, one of the largest audit-consulting company in the world, depending on scope and business capacities, MNCs are open for:

1. preservation model (similar goals, targets, business conduct, etc with minor integration level), 2. symbiosis model (similar goals, similar targets, aligned strategy, brand acquisition, partial functional digitization, major integration) and 3. absorption model (full scope acquisition).

More regarding options for integration in Table 2.

Table 2. Characteristics, benefits and digitization outcomes from diferent option of startup integration by multinational company

	Preservation	Symbiosis	Absorption
Integration level	Run acquired startup almost as separate business.	Selective integration of certain elements of business model.	Full integration of startup into MNC.
Characteristics	Statutory alignment, small wins (such as cross-sales); existing functions with minimal digitization changes.	Overhead and back office functions integration; functions synergy (e.g. sales, R&D); partnership model for some activities.	Corporate and administrative functions consolidation; integration of strategy and operations and tools, core

			functions integrations.
Benefits	Retains existing culture, transaction speed, minimum business disruption	Common value drivers derived from partial integration; cost – efficient synergetic effects.	Full synergy effects; full scope of digitization.
Digitization outcomes	Low level of digitization, certain transformation of processes.	Middle to high digitization transformation of functions and processes.	Full level of business model or function and/or processes.

Source: adapted from https://www.ey.com/en_ch/strategy-transactions/how-do-you-integrate-startups, [access June 10, 2022]

Table 2 represents an overview of the possible level of integration and the outcome of digitization in terms of the vision and business capacity of the existing company. The level of integration is correlated with the expected level of transformation and achieved benefits from digitization. It is believed that with each higher level of integration, starting from the level of "preservation" and ending with the level of "absorption", there is a higher realization of synergistic effects and thus an increase in the level of transformation of the process. A harmonized vision of the company's digitization, business capacities and the level of desired integration directly determines the quality and scope of the MNC's business transformation.

Digital transformation through the integration of an external driver (startup) affects the entire industry, especially the areas of logistics and/or retail. In these sectors, existing traditional business models are largely being challenged by organizations coming from the startup community. Large supermarket chains, megastores and ecommerce often receive signals from the market that a digital change of certain functions and/or processes is needed, both through competitive activities and through their own research.

New organizations using technologies such as virtual reality, large database management, etc. to create the possibility of reacting and repositioning members in the supply chain in an increasingly digitized business environment (Pflaum et. al., 2019).

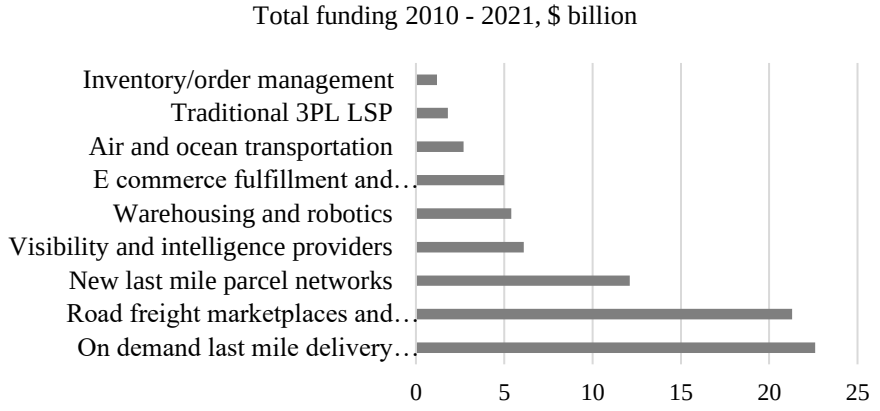
5.3. Supply chain startups – most common areas for innovations

As early mentioned, logistics startups are mostly tackling several key challenges within supply chains, such as: last mile delivery, road freight and marketplace solutions, visibility and transparency, inventory and warehousing, etc.

In order to understand most common segments of supply chain which have been tackled by startups, McKinsey and Company conducted survey and a secondary type of research, within over 500 companies in 18 countries in 2022. Data showed that more than several tens of billions of dollars has been invested in span of 11 years.

The survey is based on total funding into supply chain startups from 2010 – 2021. in 9 business segments of supply chain which has been shown on Figure 1.

Figure 1. Startup business models (9) challenging the traditional supply chain industry



Source: adapted from https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/startup-funding-in-logistics-focused-investment-in-a-growing-industry, [access June 15, 2022]

Figure 1 is a representative view of the current state of financial investment in startups dealing with the specified supply chain segments and a realistic indicator of the amount of funds invested in the industry. McKinsey and Company, during its research, determined that the data from Figure 1 shows that only in these 9 categories, in the observed period, more than 80 billion dollars were invested in the development of innovative business models in the supply chain. The table indicates that over 40 billion dollars have been invested in startups with the aim of solving problems in last mile delivery and road transport. The rest of the nearly $40 billion is split into a number of other categories (warehousing, robotics, e-commerce, air freight, inventory, etc.). Such a structural distribution also indicates in which segments there are the greatest challenges and needs for digitalization, as well as the need to invest multi-million capital in terms of digital development of the segment. Figure 1 provides an overview of how large the startup market is for the organizations within supply chain improvement area.

Considering the mentioned segments and the amount of funds invested in the development of such startups, Table 3 shows an example of several global startups that deal with business development in the field of supply chain management, and whose estimated value is over 1 billion dollars.

Table 3. Certain supply chain management startups valued at more than $1 billion

Startup name	Website	Business model	Estimated value
Flexport	flexport.com	A platform for ordering products and monitoring procurement. Organization of the entire supply chain.	$3.2B
Exotec	exotec.com	They create robotic systems that manage inventory and storage through integrated hardware and software solutions.	$2B
Deliverr	deliverr.com	An online platform based on machine learning for 3PL providers that connect to deliver products to the consumer within 1-2 days.	$2B
Lalamove	lalamove.com	A mobile application that allows ordering, loading, transportation, delivery and similar functions in real time.	$10B
Relex Solutions	relexsolutions.com	They use machine learning to understand the impact of hundreds of demand drivers for highly accurate demand forecasting, improving planning processes in merchandising and operations that impact better visibility into future demand.	$5.7B
Convoy	convoy.com	A platform that uses artificial intelligence to improve road transport that emits almost 0% CO2.	$2.7B
Loadsmart	loadsmart.com	A platform that represents an engine that uses big data for automated assignment of loading, transportation, etc.	$1.3B
Stord	stord.com	They provide efficient storage and distribution. They use 4.0 technology (AI, machine learning and cloud platforms) to connect a network of independent warehouse 3PL providers that manage the ordered products of consumers.	$1.13B

Source: Authors

The selected examples of startups in Table 3 are showing the actual impact of the startup industry on the supply chain. Their business models, are solving everyday challenges in almost all segments within the chain, represent realistic options for the digitization needs of MNCs. Such, but also similar somewhat less developed startup models represent mature startup models that are ready for some of the MNC integration models.

5.4. Integration of startups to digitize MNC supply chain

Innovative organizational forms, such as startups, manage to position themselves as a relevant factor in Industry 4.0, which through their action can influence the faster and more efficient digitization of the process, function or business model of a traditional MNC (Silva & Sehnem, 2022). The external form of driver of digitalization of a company, as stated in the previous chapters, due to the possibility of low transaction costs and the speed of assimilation in MNC, manages to win over a larger part of decision makers in MNC compared to the possibility of internal research and development. Especially in the supply chain domain, technological innovations incorporated into the startup's core business show significant results. Therefore, startups as initiators of digitalization of the supply chain definitely have their role in the traditionally innovative-rigid members of the chain.

As the integration procedure itself has not been sufficiently covered in academic circles, the authors conducted a series of data and information analysis based on available business documents. Given the above, the conclusion is that cooperation between MNCs and startups starts from the first phase, which can include: a. identification of the need for digital transformation or b. a signal from the market environment that indicates an external solution that is applicable in the MNC (Valsalidis, 2020). It is the signal that comes from the market and indicates to decision makers the possibility of digitizing a part or area of business through a certain type of integration of an external entity, which is perceived as an external driver for digitization. As explained in part 4, external initiators, among others, can be startups that, by their actions on the market, represent a signal for MNCs that there is a possibility of digital transformation of business through a specific integration model. The second phase refers to the identification of the necessary processes or functions for digitization with the targeted startup model on the market. In the third phase (which is often called the matching phase), negotiations with the targeted startup are beign set and initial tests are carried out in order to align the positive connection between the need for transformation and the offered options for cooperation (through the use of the product/service, through the beta testing period, etc.). If the conditions for technical cooperation are finally enabled, next is due diligence phase, i.e. with an assessment of the startup's business capacity. After the assessment phase is completed, the initial offer phase begins, as well as the finalization of negotiations. The final phase includes the buying and selling process itself, as well as the implementation of integration into regular business flows (e.g. the application of robotics solutions in the warehouse, application of a platform for managing big data in road transport, connection to the cloud platform of existing ERP systems, the use of blockchain technology in monitoring the originality of the procurement of raw materials, etc.).

Further, depending on the integration option specified in section 5.2. the "domestication" and implementation in the MNC is carried out, both of the technology, as well as of the possible workforce and other resources that the startup "brings in" with the integration.

During discussions research, it was learned that the levels of integration "preservation" and "symbiosis" are more common forms of partial integration (purchases of products/services from startups, transfer of IP, transfer of know-how of the startup sector, purchase of technology and integration of engineers, integration of the business model through the formation of a separate unit of the company, etc.). Companies want to improve performance in warehouse inventory manipulation, data processing in the procurement process, matching supply and demand in the chain, or they want to improve existing work systems. The level of integration "absorption", which includes the complete acquisition of startups by MNCs, is most often perceived as „eliminating competition", but there are certainly cases where the motives of the entire integration are open, true and oriented towards a real need.

In the continuation of the paper, mini case studies are presented that practically demonstrate closer cooperation between multinational companies and startups. Those cases point to cooperation and achieved levels of integration, whose essential purpose is - digital transformation.

6. PRACTICAL RESULTS OF MNC - STARTUP COOPERATION IN THE FIELD OF SUPPLY CHAIN - MINI CASE STUDIES

The way of cooperation and the results achieved through integration are best described through real case studies that are related to the topic of the paper. 3 mini-studies are given below and their goal is to show how startups influenced MNCs to actively accepting technological solutions from the startup community that will influence the increase in the level of digitization of MNCs. The case studies are: 1. MAERSK - HUUB integration, BOSCH - FIVE integration, SHOPIFY - DELIVERR integration. Finally, Table 4 will show a cross-overview of the characteristics of these 3 mini-cases.

6.1. MAERSK – HUUB integration

Maersk is a Danish multinational integrated shipping company, active in ocean and inland cargo transport and related services, such as supply chain management and port operations. Maersk Growth is the company's corporate venture that invests in startup companies and partners to digitize and decarbonize logistics with them.

HUUB is a Portuguese startup company, specialized in B2C storage technology solutions for the fashion industry.

Maersk had the intention to digitize its omnichannel sales through internal or external development forces. Technological logistics startup HUUB offered a cloud-based solution on the market that would make it much easier for Maersk's customers

to focus on their core business of producing and selling goods and to quickly bring them to end consumers.

By researching the market back in 2018, the company made a decision to invest certain resources in the startup, so in 2019 it invested 1.9 million dollars in exchange for part of the equity capital. Through further assessment of business capacities, and after the negotiation phase, Maersk made a decision that the best solution for the current demand for digitization of sales channel management is the acquisition of the aforementioned startup in which they already have confidence and insight into the business model. The acquisition and integration were carried out in 2021, the details of the transaction were not disclosed, but both organizations gave a joint notice that the value of the acquisition was several hundreds of millions of dollars. The company has acquired an operations team that works together with engineers at Maersk, while the rest of the teams are partially or completely untransferred to the domicile company.

The specific digitization of part of the business model of this MNC related to the entire management system of key service operations, and this cloud solution covers all the basics of logistics operations, such as inventory, fulfillment and delivery, while the system is simultaneously connected to other business parties such as warehouses , carriers, online stores and enterprise resource planning (ERP) systems.

6.2. BOSCH – FIVE integration

Bosch is a German multinational company. It is one of the leading companies in the world in the production of electronics, home appliances and car parts. It also deals with engineering and development of safe systems in thermotechnology.

Five is a British startup company that primarily focuses on a platform for developing and testing software used in self-driving cars - autonomous vehicles (AV). Five has built a team of experts in cloud software, security, robotics and machine learning, and has positioned itself at the forefront of the development of software and AI-based solutions for autonomous driving in Europe.

The Bosch company intended with further refine of its software model in the field of the automotive industry in the segment of autonomous vehicle management. Working on the development of this model, the company saw the possibility to transform the existing solutions obtained from their R&D department in a faster and more optimal way through the integration of an external partner. With that, Bosch and Five integrated in 2022 and offered one of the most secure software solutions in this field on the market. Bosch retained the entire team that worked at the startup and fully completed the acquisition, and the startup became part of the Cross-Domain Computing Solutions Division.

The concrete digitization of the business model was reflected in the acceptance of a completely new 4.0 technological solution. The platform is able to analyze real data from a fleet of test vehicles, create advanced test scenarios and build a simulation environment that enables the evaluation and validation of system behavior at hyper-scale. In this way, the company used the digitization process

through a new technological solution to present a new product on the market and thus remain at the forefront of the competitive race.

6.3. SHOPIFY – DELIVERR integration

Shopify is a Canadian multinational e-commerce company headquartered in Ottawa, Canada. It is also the name of their e-commerce platform for online sales and retail outlet system.

Deliverr is a startup company based in California. By using predictive analytics and machine learning, Deliverr, which rents warehouse space and uses warehouse fulfillment departments to pick and pack e-commerce orders, predicts demand for products based on geography and other variables.

Shopify wanted to establish a complete express delivery system that was integrated with the existing solution, but also to completely transform the system in terms of the technology it uses. Their final goal was the complete automation of the end-to-end logistics service, and they found that kind of service externally, in the startup market - precisely in Deliverr. The acquisition and integration took place in 2022, and Shopify paid about 80% of the purchase in cash (almost $1.68 billion), while about 20% of the company, or $420 million, is in stock, totaling $2.1 billion. Deliverr, along with some previous acquisitions, currently represents a single organizational logistics unit that reports directly to the company's CEO.

The concrete transformation that took place after this acquisition has been reflected in the „rounded logistics unit“, which, with machine learning, completely rounds off the end-to-end logistics service for the consumer. By integrating this startup, the company completely changed the previous system of operational and auxiliary work in the logistics sector.

6.4. Mini case studies comparison

Table 4. Comparison of the mentioned case studies - integration of startups in MNCs

MNC	Startup	Problem	Transformation areas	Dominant technology 4.0	Integration options	Transformation outcomes
Maersk	HUUB	Key service logistics operations.	Logistics operations.	Cloud platform, big data management.	Symbiosis	High medium level of transformation.
Bosch	Five	A software product for the advancement of an autonomous vehicle.	Sales services.	Cloud platform, robotics, machine learning.	Symbiosis	Medium level of transformation

Shopify	Deliverr	Complete logistics service.	Logistics operations.	Machine learning, predictive analytics.	Absorption	Complete transformation.

Source: Authors

Table 4 represents comparison model of startup integration into MNC and its dominant characteristics derived from integration: key transformation, integration options and transformation outcomes. It shows that there are several levels of transformation outcomes considering the key problem in traditional sector and leading technology 4.0. Also, previous mentioned models of integration options are defined by level of digitization neccessity within MNC. MNCs are looking for leading technologies 4.0 in order to achieve partial or full scope of transformation.

7. CONCLUSION

With the development of innovative technologies, with a special focus on the current Industry 4.0, a trend of intensive digitization of processes, functions and partial or complete business models has been observed. Multinational companies represent traditional business models, but at the same time pioneers in the adoption of innovations and the transfer of adopted know-how on a global level. In order to maintain and improve their competitive positions on global markets, MNCs are continuously researching and implementing all technological innovations that reduce costs and improve business segments.

In today's global business, the impact of technological innovations is visible in almost every business segment. New technological solutions, such as blockchain technology, AI, VR, AR, big data analysis, autonomous vehicles (AV), robotics, machine learning, and the like manage to change both functional units of business and entire business models. Looking at the supply chain, which has proven to be a business segment that is among the leading segments in terms of innovation absorption, these changes are extremely visible. In the relatively short observed period (from 2011 until now), the supply chain has taken on and defined a new dimension of chain management - the digital supply chain, which is a kind of proof of the aforementioned pioneering role in the implementation and use of new technologies.

The drivers of digitalization of MNCs, among others, are most often perceived and linked to the company's needs. Therefore, this paper presents the drivers that come "inside" the company and the drivers that act "outside". External - external drivers play an important role in the digitalization of the company and related activities in the supply chain. Among the aforementioned drivers, innovative business models stand out, i.e. startups that, through their actions on the market, are positioned as a relevant model that MNCs can "use" in order to achieve a quality business transformation. MNCs have positive preferences regarding cooperation with startups because by integrating them, they avoid high transactional, direct and indirect costs of internal business transformation, but also introduce new technologies, new knowledge and new innovative business models into their traditional management

model. Depending on the level of integration, some MNCs change their business models from the level of "preserving" their own business culture to the level of completely changing segments or the entire business ("absorption" of startups). Companies are finding significant interest in integrating startups that digitize their supply chains, especially in areas such as last mile delivery, integrated logistics operations management, road transport solutions, supply and demand matching platforms, warehouse operations management, inventory management, advanced analytics management, etc. Mature startups can be worth hundreds or even billions of dollars and their business models are developed to an optimal extent that serves MNCs to more easily integrate these organizational models and thus accelerate digitization. The acquisition and integration of startups in MNCs is not too different from the acquisition of traditional companies in MNCs, but it is fundamentally different in terms of changing the way of conducting operations and accepting or rejecting a new business culture. Depending on the level of integration also depends on the level of transformation of the company, i.e. transformation of the supply chain in the observed case. The mentioned mini case studies show and prove real business examples that took place in the last two years, and were implemented by leading companies in their business fields: Maersk - global shipping, Bosch - global manufacturer, Shopify - global e-commerce provider. These companies showed that rapid transformation could lead to increase performances in: last mile delivery, data management, cost reduction, human error redundance etc.

Startups influence the initiation of digitization of a process, function, part or the entire business of an MNC and have the potential to significantly influence the transformation of the MNC's business.

Limitations to the paper are reffered to narrow range of available literature with the focus on deep startup – MNC integration. There is an opportunity for deeper primary research in order to completely understand integration process. Another limitation is refferd to integration effects. The both sides, startups and MNCs, are providing minimal data regarding financial effects of the integration. After-integration data is cruical for understanding critical financial aspects of digitization.

Related to limitations, further research could be more focused on deeper analysis on financial aspects of after-integration proces.

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THE USAGE OF INDICATORS FOR CITY SERVICES AND QUALITY OF LIFE DEFINED BY ISO 37120 IN SUPPLY CHAINS

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Abstract

A smart city is a complex system emerging from a million individual actions of citizens and producers, which city planning attempts to coordinate and give coherence. It is a cyber-physical engine for improving logistics resources of the supply chains, integrating digital and non-digital components. Standard ISO 37120, Sustainable cities and communities – Indicators for city services and quality of life, defines indicators to measure smart city performance and on the level of management supports standard ISO 37101, Sustainable development in communities – Management system for sustainable development – Requirements with guidance for use on the level of leadership. With the help of the first mentioned standard, the situation when existing indicators at the local level are often not standardized, consistent, or comparable over time or across cities is exceeded. These indicators can monitor city performance progress to achieve sustainable supply chain development. Some indicators are directly related to individual logistics resources and supply chains, and some are indirect. This paper will describe a model using the indicators and their application in logistics and supply chains.

Key words: ISO 37101, ISO 37120, Smart City, Supply Chain, Logistics

1. INTRODUCTION

Cities must plan to deliver the resources and services, required to ensure their future populations survival and their thriving. Public transport and facilities, water supply, sanitation, energy, food, and security are some pressure points that will be affected by rising urbanization. ISO international standards represent international consensus on best practices from variety of fields (Midor & Płaza, 2020), providing tools, foundations, and platforms for cities to enable productivity in the future, protection of environment and ensuring prosperity of all (Midor & Płaza, 2020). The challenges that cities face (and will continue to face) are complex and multi-sectorial, such as establishment of sustainable development (Melo et al., 2020). These challenges are also particular, as no two cities are the same.

Informal and formal standards have been shaping the cities for long (White, 2020). Benefits of international standards enable cities to achieve appropriate technical, environmental, and social indicators that have a significant impact on the infrastructure, safety, and life of residents. ISO standards represent the international consensus on best practices in many areas that contribute to making a smart city better and fulfilling the United Nations Sustainable Development Goals to end poverty, ensure prosperity for all, and protect our environment. These include overarching frameworks that city leaders and planners can use to define objectives and priorities for making their cities more sustainable, as well as specific guidelines for things like energy management systems, road safety, intelligent transport, responsible water consumption, health and well-being, cybersecurity, connectivity, and more.

Groups of experts develop ISO standards within technical committees (TCs). TCs comprises representatives from industry, non-governmental organizations, governments, and other stakeholders who ISO's members put forward. Each TC deals with a different subject, such as energy management, water quality, or intelligent transport systems.

ISO/TC 268, Sustainable cities and communities, comprises city and standardization experts from more than fifty countries worldwide. It is responsible for the ISO 37100 series of standards to help cities define their sustainability objectives and implement strategies to achieve them. Sustainable cities and community's politics, guidelines, and, consequently, standards consider the following facts (Habitat III, 2016):

- By 2050 the world population is expected to reach nearly 10 billion people (UNDP, 2017).
- 80% amount of people living in cities in 2050 (World Food Research and Innovation Forum, 2022).
- 2% surface occupied by today's cities on the earth's surface.
- 60% amount of energy consumed by actual cities.
- 70% amount of waste and greenhouse gas emissions produced by cities.

The ISO standards for smart cities aim to provide cities with measurement of their sustainability and to seek answers for the following question: "how can cities adapt and establish to provide adequate resources and a sustainable future?" (Midor

& Płaza, 2020). Cities need indicators to measure their performance to improve sustainability and quality of life. Existing indicators at the local level are often not standardized, consistent, or comparable over time or across cities. Because of this challenge, ISO 37120 focuses on city services and quality of life as a contribution to the sustainability of a city (ISO, 2018) and establishes a set of standardized indicators, which provide a wholesome approach to what and how it is measured. (ISO, n. d.) These indicators can be used to track and monitor progress on city performance. To achieve sustainable development, the whole city system must be considered. Planning for future needs should consider the current use and efficiency of resources to better plan for tomorrow. (ISO, 2018) Alongside, ISO 37101 establishes a coherent framework to enable the community to develop its purposes and vision. It sets out requirements and guidance to help communities achieve a framework that will allow them to become more sustainable. It does not set benchmarks or expected levels of performance. (ISO, 2016a)

While the challenge of sustainable development is global, the strategies for achieving it at the community level are local to a large extent. They can therefore differ in context and content from country to country and region to region. Community strategies must reflect the context, preconditions, priorities, and needs, particularly in the social environment, e.g., social equity, cultural identity and traditions, heritage, human health, safety and comfort, and social infrastructure. (ISO, 2018)

This paper reviews the core and supporting indicators for city services and quality of life described by ISO 37120. In addition, the following has been found: a) direct and indirect connections to the issues from ISO 37101 connected to logistics and supply chains and b) the connections to the contributions to the purposes of the city defined by ISO 37101.

2. THEORETICAL BACKGROUND

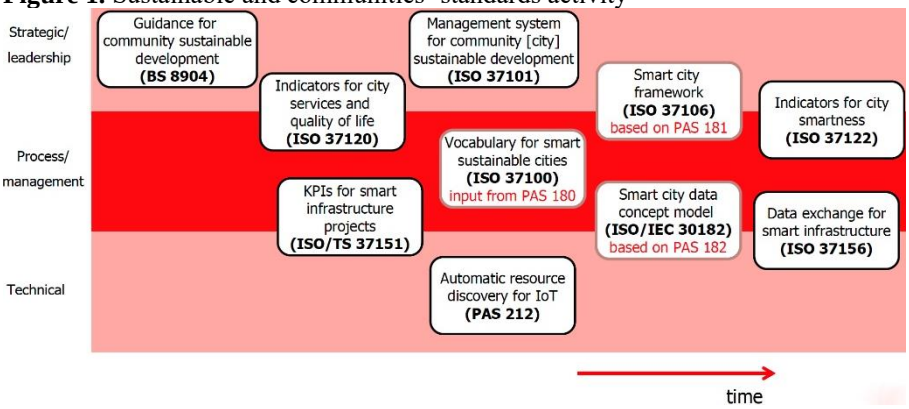
Standards present our everyday life. They regulate human and non-human behaviours, the physical forms of buildings, land, and roads (White, 2020). They also have an essential role in business through cooperation, improved productivity, reduction of information asymmetry, and increase of trust (Castka, 2020). Standards have the power to impact entire supply chains, innovation eco-systems (Teece, 2018), and national economies with their established reference points and platforms (Blind et al., 2018). The concept of smart city is regulated by standards in a way that regulates the functioning of the city (Lai et al., 2020). To ensure effective provision of better services and increased quality of life, smart cities have to function based on correlated and integrated systems (Midor & Płaza, 2020).

A management system is a set of policies, processes, and procedures that help an organization meet the requirements expected by its stakeholders. It is based on the continual improvement principle represented by the Plan-Do-Check-Act cycle, a four-step management method used by organizations to control and continually improve processes, products, and services (like: ISO 9001, ISO 14001, and ISO 37001).

Figure 1 represents sustainable cities and communities' standards activity. In this paper, the focus will be on ISO 37120 in connection with ISO 37101. The latter is a

standard about the strategic level used by community or city leadership, while standard ISO 37120 is partly about the strategic and the process level to manage the communities or cities.

Figure 1. Sustainable and communities' standards activity

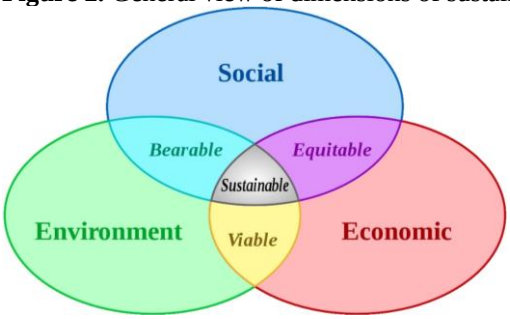


Source: ISO, 2016b

ISO standards for sustainable cities represent a family of four basic standards, which are: ISO 37101, ISO 37120, ISO 37122, and ISO 37123. Implementation of ISO 37101 standard helps cities to establish consensus on sustainable development, and to increase efficiency and attractiveness of cities, among other (da Silva de Santana et al., 2018; Fitsilis, 2018). While ISO 37120 establishes methodologies for number of indicators to measure and monitor the performance of city services and quality of life. These two standards can be applied om conjunction (Midor & Płaza, 2020) since ISO 37120 supports ISO 37101 with specific guidance for developing and implementing strategies.

Sustainable development can be defined as development that meets the environmental, social, and economic needs of the present, without compromising the ability of future generations to meet their own needs (Ayodele & Ogunlola, 2016). The intersection of sustainable development is represented in Figure 2.

Figure 2. General view of dimensions of sustainable development



Source: Ayodele & Ogunlola, 2016

ISO 37101 sets out the basic requirements for sustainable development in communities, helps cities determine their sustainable development objectives, and puts in place a strategy to achieve them (ISO, 2016a). Directly aimed at city leaders, this management system standard covers everything a city must address to become more competent, such as responsible resource use, environmental management, citizens' health and well-being, governance, mobility, and more.

2.1. ISO 37101 – Sustainable development in communities – Management system for sustainable development – Requirements with guidance for use

ISO 37101 adopts a holistic approach to the establishment of the requirements of a management system for sustainable development in communities, including cities, and provides guidance aimed at (ISO, 2016a):

1. improving the contribution of communities to sustainable development;
2. fostering smartness and resilience in communities, while taking into account the territorial boundaries to which it applies;
3. assessing the performance of communities in progressing towards sustainable development.

The organization shall identify, review and document all the purposes and issues contributing to sustainability, as outlined in Table 1 (ISO, 2016a).

Table 1. Purposes and issues that contribute to sustainability

Attractiveness	Appeal to citizens and other interested parties, e.g., investors; belonging; culture; place; sense of identity.
Preservation and improvement of environment	Improved environmental performance, including reducing greenhouse gas emissions; protection, restoration and enhancement of biological diversity and ecosystem services, including protection of ecosystems, plant and animal diversity and migration as well as genetic diversity; reduced health hazard.
Resilience	Anticipation; climate change mitigation and/or adaptation; economic shocks and stresses preparedness, social evolution.
Responsible resource use	Consumption; distribution; improved land management; reducing, reusing, and recycling of materials; respect for scarcity of all types of resources (natural, human, financial); sustainable production, storage, and transport.
Social cohesion	Accessibility; culture; dialogue with external parties not limited by boundaries, diversity; equity; heritage; inclusiveness; inequalities reduction; rootedness; sense of belonging and social mobility.
Well-being	Access to opportunities; creativity, education; happiness; healthy environment; human capital improvement; live-able city; prosperity; quality of life; security; self-confidence; welfare.

Source: Adapted based on ISO, 2016a

To evaluate the contribution to achieving the six purposes of sustainability (Represented in Table 1), it is necessary to consider the twelve sustainability issues described (ISO, 2016a):

1. Governance, empowerment, and engagement;
2. Education and capacity building;
3. Innovation, creativity, and research;
4. Health and care in the community;
5. Culture and community identity;
6. Living together, interdependence and mutuality;
7. Economy and sustainable production and consumption;
8. Living and working environment;
9. Safety and security;
10. Community infrastructures;
11. Mobility;
12. Biodiversity and ecosystem services.

When reviewing all strategies, programs, projects, plans, and services for inclusion in the organization's strategic plan, the organization shall evaluate their contribution to achieving the six purposes of sustainability and how they take the sustainability issues into account. To do so, the organization shall undertake an iterative cross-analysis of objectives and topics.

By twelve issues and six purposes of sustainability, the organization shall evaluate their contribution to achieving the six purposes of sustainability and how they take the sustainability issues into account by together 72 evaluations.

ISO 37101 has been designed to help communities: define their sustainable development objectives and put in place a strategy to achieve them. The aim of ISO 37101 is to set out the broad principles (referred to in the standard as “purposes of sustainability”) of what a community may wish to achieve with a sustainable development strategy, such as responsible resource use, preserving the environment, and improving the well-being of citizens. It requires communities to consider sustainability issues such as governance, empowerment, education, health, and mobility, which will help to define their sustainable development objectives. (ISO, 2016a)

ISO 37101 sets out the steps a community needs to take to achieve its sustainable development goals, such as creating an action plan, allocating responsibilities, and measuring performance. It is based on the continual improvement principle, meaning users must regularly adjust their objectives and strategy to ensure they are constantly moving forward. (ISO, 2016a)

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This standard has been designed to be used at the community level by a multi-actor structure. One of the first steps when using the standard is to create the group or system that will implement it on behalf of the community. ISO 37101 defines a

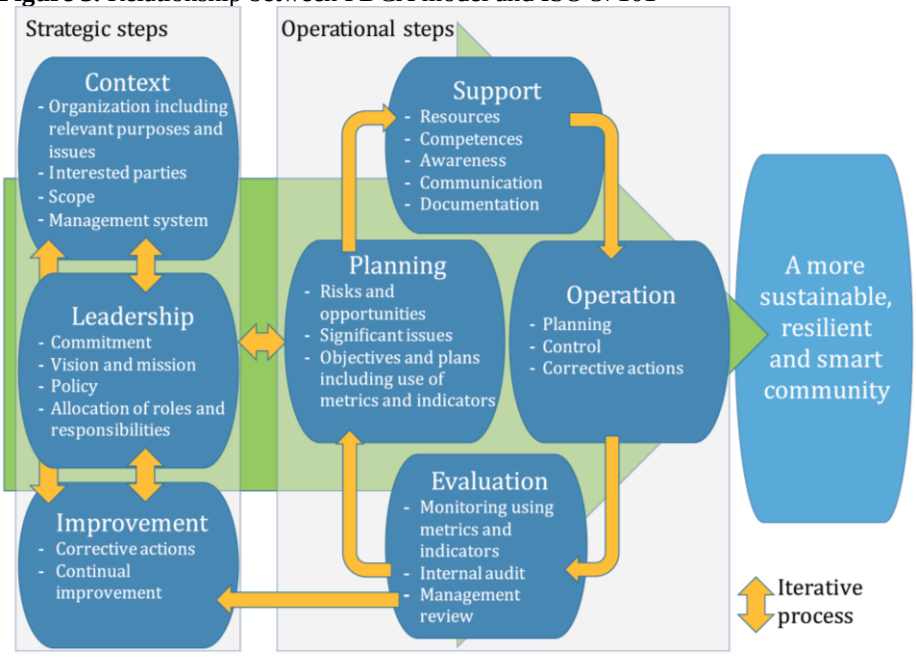
community as a "group of people with an arrangement of responsibilities, activities, and relationships." (ISO, 2016a)

Figure 3 represents the structure of ISO 37101. The content of the standard establishes requirements for a management system for sustainable development in communities, including cities, using a holistic approach to ensure consistency with the sustainable development policy of communities in the following areas (ISO, 2016a):

1. context of the organization;
2. leadership
3. planning;
4. support;
5. operation;
6. performance evaluation;
7. improvement.

The first step is understanding the organization and its context. In this step, we need to understand the needs and expectations of interested parties, then determine the scope of the management system for sustainable development in communities and establish a management system for sustainable development in communities. We also define six sustainability purposes and 12 sustainability issues in this step.

Figure 3. Relationship between PDCA model and ISO 37101



Source: ISO, 2016a

2.2. ISO 37120 – Sustainable development of communities – Indicators for city services and quality of life

The standard establishes and defines the methodologies for a set of indicators to measure and steer the performance of city services and quality of life. (ISO, 2018)

The core, supporting, and profile indicators are classified into themes according to the different sectors and services provided by a city. The classification structure denotes each indicator type's services and application area when a municipality reports. This classification of themes has no hierarchical significance and is organized alphabetically. The indicators are structured around the following themes (ISO, 2018):

- economy;
- education;
- energy;
- environment and climate change;
- finance;
- governance;
- health;
- housing;
- population and social conditions;
- recreation;
- safety;
- solid waste;
- sport and culture;
- telecommunication;
- transportation;
- urban/local agriculture and food security;
- urban planning;
- wastewater;
- water.

Recognizing the differences in resources and capabilities of cities worldwide, the comprehensive set of indicators for city performance has been divided into (ISO, 2018):

1. Core indicators: indicators that are required to demonstrate performance in the delivery of city services and quality of life.
2. Supporting indicators: indicators that are recommended to demonstrate performance in the delivery of city services and quality of life. These indicators can be selected according to city objectives.
3. Profile indicators: indicators that are recommended to provide basic statistics and background information to help cities determine which cities are of interest for peer comparisons. Profile indicators are used as an informative reference.

Users may also consider the following aspects, which shall be clearly stated in the paper and justified (ISO, 2018):

1. indicators can be aggregated to larger administrative areas (e.g., region, metropolitan area);
2. since some indicators are indirectly linked to sustainability, there is a need to consider the resource efficiency of a city;
3. indicators can be grouped together for analysis when taking into consideration holistic characteristics of a city; and
4. this set of indicators may be complemented by other indicator sets in order to have a more comprehensive, holistic approach to analysis on sustainability.

Furthermore, it is also essential to acknowledge the potential antagonistic effects of the outcome of particularly positive or negative indicators when analyzing results. For example, the number of automobiles per capita will potentially increase greenhouse gas emissions.

For each indicator, the correspondence with the issues of ISO 37101 is noted in the next chapter.

3. METHODS

This paper starts with the ISO 37101 sustainable issues "Community infrastructure" and "Mobility" as the main issues connected to logistics and supply chains. For this paper, they have been named "Direct issues" associated with some other issues from the list of twelve. The "Indirect issues" are defined as issues that are mentioned in the table "Mapping of indicators to ISO 37101 issues and purposes" with the origin in "Direct issues". There also exists "Other issues", which are not mentioned in the table "Mapping of indicators to ISO 37101 issues and purposes", and they haven't the origin in "Direct issues".

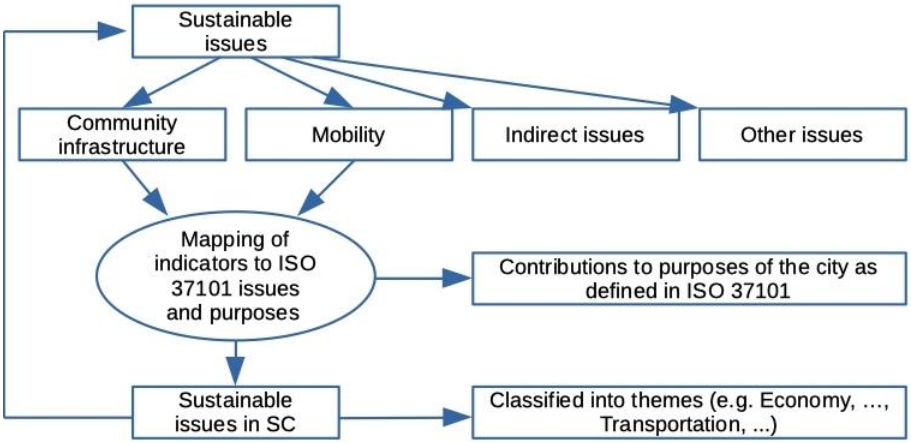
Figure 4 represents how core, supporting indicators and contributions to the purposes of a smart city based on sustainable **issues** in supply chains were defined. The following essential steps were followed (see Figure 4):

1. From the twelve sustainability issues described in ISO 37101, "Community infrastructure" and "Mobility" were chosen as "Direct issues" regards to the supply chain.
2. By the "Mapping of indicators to ISO 37101 issues and purposes" (described in Annex B of ISO 37120), the set of ISO 37120 core and supplying **indicators** derived from both above defined "Direct issues" were obtained.
3. The set of indicators, as mentioned earlier, defines all the issues back as "Direct" and "Indirect issues". The remaining issues are "Other issues", which are not the subject of interest in this paper.
4. From the set of indicators, defined in step 2, the "Contribution to **purposes** of the city as defined in ISO 37101" was obtained.
5. Set of indicators defined in step 2 are classified into themes (e.g., Transportation, Economy, Urban plan, etc.).

Following this procedure, the indicators and purposes in the smart city supply chains were obtained, based on the sustainable issues connected with the logistics and supply chains with their interdependencies or interrelationships. The issues (named

"Indirect issues") were also acquired, which are related to the origin sustainable issues ("Direct issues" which are "Community infrastructure" and "Mobility").

Figure 4. The algorithm to define Sustainable issues and Contributions to purposes of smart city in a supply chain from "Community infrastructure" and "Mobility" issue.



Source: Own source

4. RESULTS: APPLYING BOTH STANDARDS TO LOGISTICS AND SUPPLY CHAINS

4.1. Interconnections between indicators, themes, and direct issues

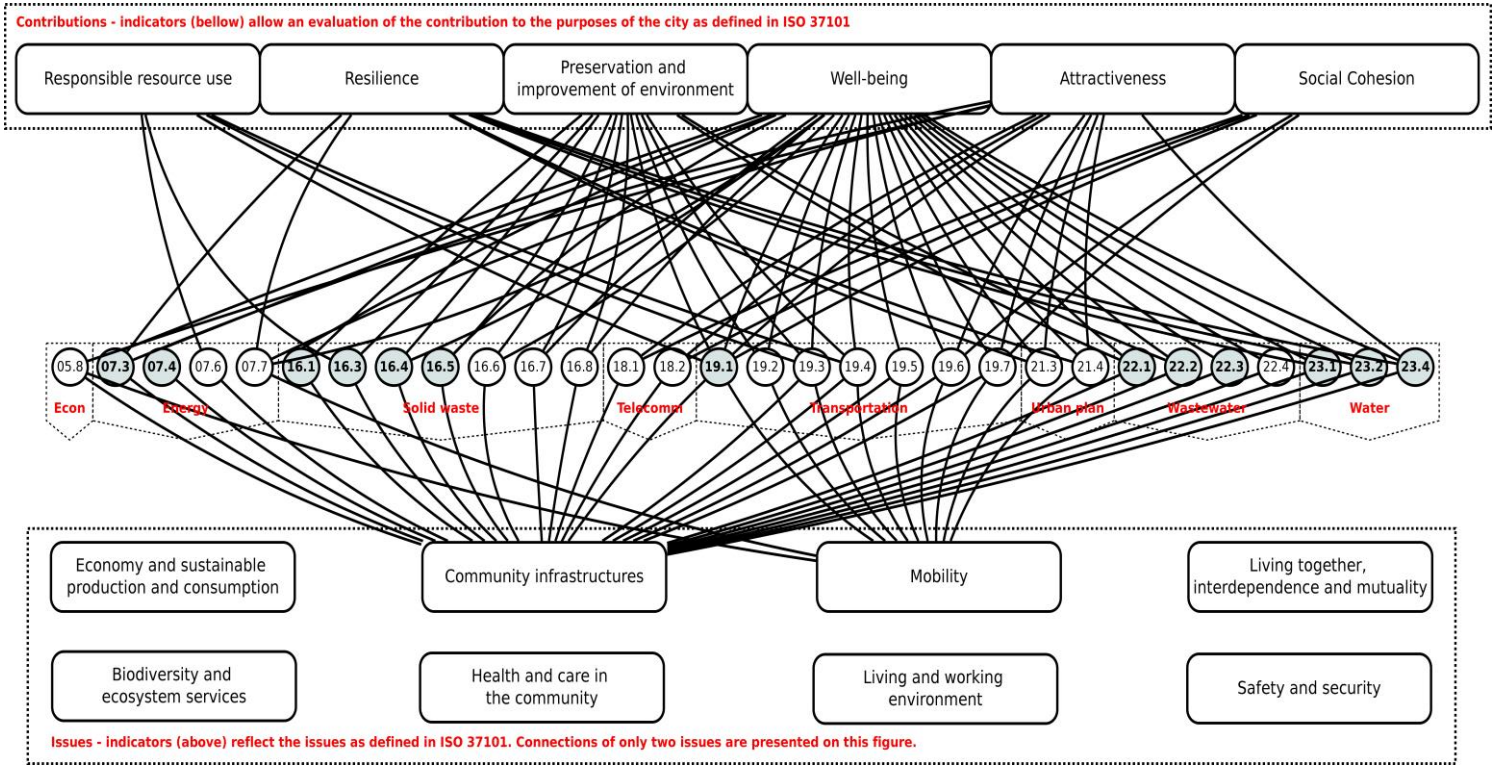
The research began with the ISO 371012 "direct issues" which are during the procedure "Mapping ISO 37120 indicators to ISO 37101 issues and purposes" connected with the following indirect issues: "Health and care in the community", "Living together, interdependence and mutuality", "Economy and sustainable production and consumption", "Living and working environment", "Safety and security" and "Biodiversity and ecosystem services".

On the other hand, it was found that all six purposes are connected to the two direct issues presented.

Figure 5 represents:

1. indicators belong to themes that are connected with both direct issues;
2. purposes, connected with the indicators which are connected to both direct issues;
3. issues, directly connected with the logistics and supply chain and indirectly connected with the direct issues;

Figure 5. Interconnections between indicators, themes, and direct issues



Source: Authors

Examples of purposes related to the issue of "Community infrastructure" are represented in Table 2, and purposes related to the point of "Mobility" are defined in Table 3.

Table 2. Examples of purposes related to the issue "Community infrastructure"

Attractiveness	How does the capacity and quality of infrastructures available in communities contribute to their attractiveness?
Preservation and improvement of environment	How do communities reduce the environmental impact of their infrastructures and of their use?
Resilience	How is the resilience of infrastructures evaluated? How is the impact of the environment on the infrastructure assessed?
Responsible resource use	How do communities ensure efficient use of natural resources and energy in the operation of their infrastructures, e.g., by implementing smarter solutions?
Social cohesion	How do communities ensure that infrastructures provide the same level of service for everyone?
Well-being	To what extent do the services provided by community infrastructures satisfy everyone? How can they be improved, particularly by making them smarter?

Source: Adapted based on ISO, 2016a

Table 3. Examples of purposes related to the issue "Mobility"

Attractiveness	How does investment in improved mobility show a return in terms of greater economic interaction, opening new contacts, diversifying local trade and contribute to the attractiveness of communities?
Preservation and improvement of environment	What steps are taken to reduce pollution (noise, air quality, greenhouse gas emissions throughout the associated life cycle) resulting from improved or increased mobility in communities?
Resilience	How is the resilience of mobility services evaluated? What plans and capabilities are in place to restore services in the event of a disaster or disruption?
Responsible resource use	How do communities develop and encourage sustainable mobility, e.g., by adopting a sustainable mobility policy?
Social cohesion	How does improved mobility bind communities together and increase shared experience?
Well-being	How do mobility conditions in communities enhance quality of life?

Source: Adapted based on ISO, 2016a

4.2. Indicators, connected with issues "Community infrastructures" and "Mobility"

Both two direct issues ("Community infrastructure" and "Mobility") define the core and supporting ISO 37120 indicators which belong to the following themes: "Economy", "Energy", "Solid waste", "Telecommunication", "Transportation", "Urban planning", "Wastewater" and "Water". Each theme has many indicators. In Table 4, some indicators are connected with the direct issue of "Community infrastructures", while in Table 5 are indicators associated with the immediate problem of "Mobility". In both tables, core indicators are boldfaced, while the supporting indicators are written in standard text.

Table 4. Indicators, connected with the direct issue "Community infrastructures"

ID	Theme	Indicator
05.8	Economy	Commercial air connectivity (number of non-stop commercial air destinations)
07.3	Energy	**Percentage of city population with authorized electrical service**
07.4	Energy	**Number of gas distribution service connections per 100 000 population (residential)**
07.6	Energy	Electricity consumption of public street lighting per kilometre of lighted street (kWh/year)
07.7	Energy	Average annual hours of electrical service interruptions per household
16.1	Solid waste	**Percentage of city population with regular solid waste collection (residential)**
16.3	Solid waste	**Percentage of the city's solid waste that is recycled**
16.4	Solid waste	**Percentage of the city's solid waste that is disposed of in a sanitary landfill**
16.5	Solid waste	**Percentage of the city's solid waste that is treated in energy- from-waste plants**
16.6	Solid waste	Percentage of the city's solid waste that is biologically treated and used as compost or biogas
16.7	Solid waste	Percentage of the city's solid waste that is disposed of in an open dump
16.8	Solid waste	Percentage of the city's solid waste that is disposed of by other means
18.1	Telecommunication	Number of internet connections per 100 000 population

ID	Theme	Indicator
18.2	Telecommunication	Number of mobile phone connections per 100 000 population
19.1	Transportation	**Kilometres of public transport system per 100 000 population**
19.3	Transportation	Percentage of commuters using a travel mode to work other than a personal vehicle
19.4	Transportation	Kilometres of bicycle paths and lanes per 100 000 population
19.5	Transportation	Transportation deaths per 100 000 population
19.6	Transportation	Percentage of population living within 0,5 km of public transit running at least every 20 min during peak periods
19.7	Transportation	Average commute time
22.1	Wastewater	**Percentage of city population served by wastewater collection**
22.2	Wastewater	**Percentage of city's wastewater receiving centralized treatment**
22.3	Wastewater	**Percentage of population with access to improved sanitation**
22.4	Wastewater	Compliance rate of wastewater treatment
23.1	Water	**Percentage of city population with potable water supply service**
23.2	Water	**Percentage of city population with sustainable access to an improved water source**
23.4	Water	**Compliance rate of drinking water quality**

Source: Own source

Table 5. Indicators, connected with the direct issue "Mobility"

ID	Theme	Indicator
05.8	Economy	Commercial air connectivity (number of non-stop commercial air destinations)
19.1	Transportation	**Kilometres of public transport system per 100 000 population**
19.2	Transportation	**Annual number of public transport trips per capita**
19.3	Transportation	Percentage of commuters using a travel mode to work other than a personal vehicle

ID	Theme	Indicator
19.4	Transportation	Kilometres of bicycle paths and lanes per 100 000 population
19.5	Transportation	Transportation deaths per 100 000 population
19.6	Transportation	Percentage of population living within 0,5 km of public transit running at least every 20 min during peak periods
19.7	Transportation	Average commute time
21.3	Urban planning	Jobs–housing ratio
21.4	Urban planning	Basic service proximity

Source: Own source

5. CONCLUSION

The popularity of technology innovations is causing a lot of noise in many industries. Amongst them, supply chains could be the ones that are impacted the most due to, as described in theory, intertwined networks of different stakeholders.

In a competitive and ever-challenging environment, we must plan today to be prepared for tomorrow. This mantra should be the core "business" idea of every city initiative and management operation. The planning, execution of ideas, and management of cities can be done based on theoretical knowledge presented to us in the form of ISO standards. As it had been explained in an example, standards are meant to be used in different environments for various purposes.

This paper has presented the example of standard ISO 37120 usage in connection with standard ISO 37101. Based on the covered indicators, themes, and issues, the direct issues were emphasized, "Community infrastructures" and "Mobility", extract their relationships with different indicators (which are directly corresponding to these two direct issues), and indicate their intertwinement with six contributions.

For future research, the same method can be used to emphasize other ten (out of twelve) existing issues, which are resented with the ISO standard, and indicate their connections with different indicators, contributions, and themes.

ISO standards present the international consensus on best practices in a wide range of areas, which contribute to the better functioning of a city and should be acknowledged as fundamental components of city management.

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DUPONT INDICATOR SYSTEM AS A SUPPORT IN THE MANAGEMENT OF LOGISTICS COMPANIES

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Abstract

Timely, quality, reliable and accurate information is key for making business decisions. For managers to have access to the information necessary for management, they seek support in accounting. The accounting system is the starting point and bloodstream of every company for quality management and business decision-making. Several techniques and analyses arise from accounting to support company management. One of the methods and analyses, i.e. the management tool for providing information on the profitability of the business is Dupont analysis. This paper aims to examine the profitability of selected logistics companies using the DuPont indicator system and to determine the efficient and effective use of its assets. The DuPont analysis indicates to managers which form of assets to pay attention to when managing, which is a great challenge, especially for logistics companies today, so they can operate undisturbed in conditions of the rapid growth of globalization and degree of competitiveness.

Key words: DuPont system indicators, DuPont analysis, financial indicators, logistics business, logistics

1. INTRODUCTION

Given the increase in globalization and internationalization of business, along with constant growth and development of new technologies, new business conditions are created. Managers are faced with the task, but also the challenge, to monitor and control their business by applying various methods so that ultimately the management of the company is successful, competitive, and sustainable. This is provided by

accounting which enables and facilitates managers to make business decisions. A series of analyzes and techniques as part of the accounting system provides key information and financial data that is impossible to manage.

One of the methods and analyses, that is a management tool for ensuring information about business rentability and profitability is the Dupont analysis. The paper aims to represent the application of the mentioned tool to selected logistics companies. The DuPont system of indicators indicates to managers, which forms of the asset they should pay attention to. The Dupont system of indicators includes two basic financial reports, the profit and loss account, and the balance sheet. It represents one of the financial analyzes that provide insight into current business results as well as business development over a certain period. Based on the previously defined problem and research aim, two research hypotheses were defined; H1: By applying the DuPont analysis to selected logistics companies, it is possible to determine the business profitability, and H2: By applying the DuPont analysis to selected logistics companies, it is possible to determine the efficient and effective use of assets and capital in the selected period.

2. BUSINESS LOGISTIC

As a science, business logistics represents an economic discipline that includes part of management science, based on the study of flows and transformations of economic content within the company. The meaning of logistics in business is characterized by a constant trend of growing importance, which makes it one of the most important business activities. Marketing determines what should be sold and produced, production determines investments, and logistics ensures the availability of production goods and information in the right quantities, the required quality, and at the right time and in the right place (Segetlija, Lamza-Maronić, 1995). The goal of business logistics is to connect the place of goods source as efficiently as possible with the point of their delivery to consumers. Those tasks imply that the receipt point is supplied from the point of delivery, with the right product in the right condition, at the right time, in the right place, and all this has to be organized with minimal costs. The purpose of logistics is to constantly improve the flow of goods and information through the company. The following goals can be set such as reducing stocks, shortening the time of these flows, shortening the reaction time (eg to customer orders, etc.), etc., (Segetlija & Lamza-Maronić, 1995).

3. DUPONT ANALYSIS

The DuPont system of indicators is the most famous deductive system of indicators. It was named after the American chemical company DuPont de Nemours & Co and was developed in the nineties of the last century. The model was developed to give company managers the ability to evaluate performance in terms of return on investment (ROI). This model has remained until today and represents an important

management tool that indicates to managers which form of assets should be paid attention to during management (Vidučić, 2002).

The system has the shape of a pyramid consisting of a left and a right side. The left side is calculated based on the data and information found in the profit and loss account (P&L), and the right side is based on the data and information found in the assets of the balance sheet. The top indicator is the return on assets (ROA), that is, the profitability of the total assets, which reflects the basic goal of the business. From ROA requirements are derived, that need to be met at lower levels of business operations. In addition to ROA, the return on equity (ROE) is also often included in this analysis, which provides information on the return of invested capital per unit (Sesar, et al. 2015).

ROA or return on assets is an indicator of the company's success in using assets to make a profit. It refers to the profit that the company generates from one unit of invested assets and puts the total capital and realized profit into a relationship. At the same time, it talks about the intensity of the asset. The lower the profit per unit of invested assets is, then the higher the degree of asset intensity is reached. Higher asset intensity requires more money to be invested in the business to continue to make a profit. A lower indicator shows sales stagnation and lowers earning power. The value of ROA varies depending on the industry where the company operates (Renko, 2005). ROE or return on equity shows us how many monetary units of profit the company achieves based on the one unit of equity invested by comparing equity and profit after taxation (Vidučić et al., 2015).

Those companies that have high-profit margins and lower total asset turnover ratios apply a differentiation strategy, while companies that achieve low-profit margins with high asset turnovers apply a low-cost strategy (Turić, 2018). The low-cost strategy is used by companies that maintain competitiveness by lowering the prices of their products or services lower than competing companies. The products offered by these companies are simple and standard. In this case, the company will have a large volume of production and sales, which will result in a high turnover ratio of total assets (Renko, 2005). The differentiation strategy is used by companies whose business is focused on the production of more creative and innovative products or services. Differentiation can be related to service quality, product specificity, company image, and the like. This strategy is based on higher product quality, and therefore on a higher market price, and by applying it, the company can achieve a higher profit margin than the competition (Renko, 2005).

4. DUPONT ANALYSIS OF THE SELECTED COMPANIES IN LOGISTICS

Through this chapter, a DuPont analysis was applied to three selected logistics companies from the area of Koprivnica - Križevačka County: company "A", company "B" and company "C". The analysis was conducted for the period 2018-2020. Companies were selected based on the business activity that is the NKD classification (road transport) and company size (selected companies are registrated as small companies). The data used in the calculation were collected from the database Poslovna Hrvatska (Poslovna. hr).

4.1. Analysis of business operations by the use of DuPont system of indicators – company „A“

Company "A" is a registered trade company for road transport in Koprivnica-Križevac County, which has been operating since 2005. According to data from Poslovna. hr, the business has a credit rating of A2 and employs 14 people of which 12 are drivers. The calculation of DuPont implies the calculation of return on assets (ROA) and return on equity (ROE).

Table 1 provides basic data from the balance sheet and profit and loss (P&L) statement that are important for calculating the profit margin and equity multiplier for company „A“ (Sertić, 2021).

Table 1. Abbreviated Balance Sheet and Profit and Loss (P&L) Statement for the company "A“ (in Croatian kuna - HRK)

BALANCE SHEET			
YEAR	**2018.**	**2019.**	**2020.**
ASSETS			
B) LONG-TERM ASSETS	1.341.000.00	1.706.000.00	580.600.00
C) SHORT-TERM ASSETS	3.565.500.00	5.809.600.00	6.643.200.00
LIABILITIES			
A) EQUITY and RESERVE	785.100.00	1.657.300.00	2.587.700.00
C) LONG-TERM LIABILITIES	1.427.000.00	2.918.800.00	2.917.400.00
D) SHORT-TERM LIABILITIES	2.694.300.00	2.939.500.00	1.718.700.00
TOTAL ASSETS	4.906.500.00	7.515.600.00	7.223.800.00
TOTAL LIABILITIES	4.121.300.00	5.858.300.00	4.636.100.00
PROFIT AND LOSS (P&L) STATEMENT			
YEAR	**2018.**	**2019.**	**2020.**
I. OPERATING REVENUES	5.612.300.00	8.526.700.00	7.352.700.00
II. OPERATING EXPENSES	4.805.900.00	7.309.900.00	6.184.700.00
III. NON-OPERATING REVENUES	46.100.00	105.400.00	133.600.00
IV. NON-OPERATING EXPENSES	155.700.00	223.100.00	222.900.00
IX. TOTAL INCOME	5.658.400.00	8.632.100.00	7.486.300.00
X. TOTAL EXPENSES	4.961.600.00	7.533.000.00	6.407.600.00
XI. GROSS PROFIT OR LOSS BEFORE TAX	696.600.00	1.099.100.00	1.078.600.00
XII. PROFIT TAX	147.400.00	226.900.00	148.200.00
XIII. NET PROFIT OR NET LOSS	549.500.00	872.200.00	930.500.00

Source: Processed by the author according to Sertić 2021.

In table 2, the profit margin for company „A“ is calculated using net profit and operating revenue, which, along with the equity multiplier, is required for calculating the return on assets. The company's profit margin increases gradually until 2020 compared to previous years by 2.87 percentage points. The increase in profit margin is the increase in net profit. In 2019. the profit margin increased by 0.44 percentage points.

Table 2. Profit margin (in Croatian kuna) for company „A“

	2018.	**2019.**	**2020.**
NET PROFIT	549.500.00	872.200.00	930.500.00
OPERATING REVENUE	5.612.300.00	8.526.700.00	7.352.700.00
PROFIT MARGIN	**9.79%**	**10.23%**	**12.66%**

Source: Processed by the author according to Sertić 2021

Table 3 shows the calculation of the indicator of the assets turnover ratio for company „A“ which compares operating revenue and total assets. The total assets turnover ratio shows how successfully the company uses total assets to generate revenue, i.e. how many times total assets are turned over during one year. It is positive that this indicator is greater than 1, and it is desirable to be as high as possible. In 2019, the value of the indicator is slightly lower compared to the previous year and amounts to 1.13. this means that 1 Croatian kuna of invested assets generates 1.13 Croatian kuna of revenue. This means that during 2019 the property turned over 1.13 times. In 2020, the total asset turnover ratio drops to 1.02, which means that the company is still using its assets efficiently but less than the year before. The decrease in the coefficient is due to a decrease in financial revenue and revenue from sales. The calculation shows that company „A“ uses its assets most efficiently in 2018 (Sertić, 2021).

Table 3. Assets turnover ratio (in Croatian kuna) for company „A“

	2018.	**2019.**	**2020.**
OPERATING REVENUE	5.612.300.00	8.526.700.00	7.352.700.00
TOTAL ASSETS	4.906.500.00	7.515.600.00	7.223.800.00
ASSETS TURNOVER RATIO	**1.14**	**1.13**	**1.02**

Source: Processed by the authors according to Sertić 2021.

The following table 4 shows the return on assets (ROA) for company „A“ which is calculated by multiplying the profit margin and the turnover ratio of total assets. It can be seen that throughout the years the company uses the return on assets consistently it controls costs well and has higher revenues. In 2020 company “A” recorded the highest return on assets compared to previous years and recorded a growth of 1.75 percentage points (Sertić, 2021)

Table 4. Calculation of return on assets (ROA) for company „A“

	2018.	2019.	2020.
PROFIT MARGIN	9.79%	10.23%	12.66%
TURNOVER RATIO OF TOTAL ASSETS	1.14	1.13	1.02
ROA	**11.16%**	**11.56%**	**12.91%**

Source: Processed by the authors according to Sertić 2021.

Table 5 shows the calculation of the equity multiplier, which is obtained by putting the total assets and capital into a relationship, as well as a brief analysis of the obtained indicators. In 2020., the equity multiplier is the lowest, which shows that company used financial leverage the least. A value of 2.79 indicates that a company with 100 Croatian kunas of assets finances 36 Croatian kunas from its sources. The highest value of the equity multiplier, in the observed period, was in 2018. In 2018. the company uses financial leverage the most, and the value of 6.25 indicates that the company borrows more, is financed from debt sources compared to the previous year, and is now equally financed from its own and other sources. Out of 100 Croatian kunas of assets, the company finances 16 Croatian kunas from its sources (Sertić, 2021).

Table 5. Calculation of the multiplier (in Croatian kuna) for company “A”

	2018.	2019.	2020.
TOTAL ASSETS	4.906.500.00	7.515.600.00	7.223.800.00
EQUITY	785.100.00	1.657.300.00	2.587.700.00
EQUITY MULTIPLIER	**6.25**	**4.53**	**2.79**

Source: Processed by the authors according to Sertić 2021.

The following is the calculation of the return on equity, which is calculated as the product of the profit margin, the turnover ratio of total assets, and the equity multiplier, and which indicates the ability to achieve net profit using own capital shown in table 6 (Sertić, 2021). The value of ROE should be as high as possible. Table 6 shows that in the observed period the company achieved the highest ROE in 2018. After 2018, the ROE decreased, and it indicates that the company realizes added value for the owners, but at a smaller value (Sertić, 2021).

Table 6. Return on Equity (ROE) for company „A“

	2018.	2019.	2020.
PROFIT MARGIN	9.79%	10.23%	12.66%
TOTAL ASSETS TURNOVER RATIO	1.14	1.13	1.02
EQUITY MULTIPLIER	6.25	4.53	2.79
ROE	**69.75%**	**52.37%**	**36.03%**

Source: Processed by the authors according to Sertić 2021.

Through the data presented, we can conclude that company "A" is achieving a positive trend and good indicators in the observed period.

4.2. Analysis of business operations by the use of DuPont system of indicators – company "B"

Transport company "B" is a registered trade for road transport in Koprivnica-Križevac County, which has been operating since 1991. According to data from Poslovna. hr, the business has a credit rating of A2 and employs 7 people, all of whom are drivers. Table 7 provides basic data from the balance sheet and profit and loss statement that are important for calculating the profit margin and equity multiplier for company "B" (Sertić, 2021).

Table 7. Abbreviated Balance Sheet and Profit and Loss (P&L) Statement for the company "B" (in Croatian kuna)

BALANCE SHEET			
YEAR	**2018.**	**2019.**	**2020.**
ASSETS			
B) LONG-TERM ASSETS	1.455.200.00	2.288.100.00	2.330.900.00
C) SHORT-TERM ASSETS	1.628.800.00	1.093.500.00	1.557.700.00
LIABILITIES			
A) EQUITY and RESERVE	2.356.300.00	2.587.100.00	3.241.200.00
C) LONG-TERM LIABILITIES	353.900.00	361.700.00	72.600.00
D) SHORT-TERM LIABILITIES	373.800.00	433.400.00	574.800.00
TOTAL ASSETS	3.084.000.00	3.381.600.00	3.888.600.00
TOTAL LIABILITIES	727.700.00	795.100.00	647.400.00
PROFIT AND LOSS (P&L) STATEMENT			
YEAR	**2018.**	**2019.**	**2020.**
I. OPERATING REVENUES	3.957.000.00	4.213.400.00	6.651.600.00
II. OPERATING EXPENSES	3.654.000.00	3.922.800.00	5.622.700.00
III. NON-OPERATING REVENUES	1.700.00	5.200.00	1.000.00
IV. NON-OPERATING EXPENSES	20.500.00	10.800.00	9.500.00
IX. TOTAL INCOME	3.958.700.00	4.218.700.00	6.652.600.00
X. TOTAL EXPENSES	3.674.600.00	3.933.700.00	5.634.400.00
XI. GROSS PROFIT OR LOSS BEFORE TAX	284.200.00	285.000.00	1.018.200.00
XII. PROFIT TAX	55.200.00	54.300.00	124.000.00
XIII. NET PROFIT OR NET LOSS	229.000.00	230.700.00	894.100.00

Source: Processed by the authors according to Sertić 2021.

In table 8. the profit margin for company "B" is calculated using net profit and operating revenue, which, along with the equity multiplier, is required for calculating the return on assets. The company's profit margin increases gradually until 2020 compared to previous years. The increase in profit margin is the increase in net profit.

In 2019 the profit margin decreased by 0.31 percentage points, but then it increased significantly by 7.96 percentage points (Sertić, 2021).

Table 8. The profit margin for company „B“ (in Croatian kuna)

	2018.	2019.	2020.
NET PROFIT	229.000.00	230.700.00	894.100.00
OPERATING REVENUE	3.957.000.00	4.213.400.00	6.651.600.00
PROFIT MARGIN	**5.79%**	**5.48%**	**13.44%**

Source: Processed by the authors according to Sertić 2021.

Table 9 shows the calculation of the indicator of the assets turnover ratio for company “B”, which compares operating revenue and total assets. In 2018 the value of the indicator is 1.28, that is, for 1 Croatian kuna (HRK) of invested assets, 1.28 (Croatian kuna) of revenue is realized. In 2019 the value of the indicator drops slightly compared to the previous year and amounts to 1.25 (Croatian kuna) (for 1 Croatian kuna of invested assets, it realizes 1.25 HRK of revenue). This means that during 2019 the assets turned over 1.25 times. In 2020 the total assets turnover ratio increases to 1.71 which means that the company continues to use its assets efficiently. The calculation shows that the company uses its assets most efficiently in 2020. (Sertić, 2021).

Table 9. Assets turnover ratio for company “B” (in Croatian kuna)

	2018.	2019.	2020.
OPERATING REVENUE	3.957.000.00	4.213.400.00	6.651.600.00
TOTAL ASSESTS	3.084.000.00	3.381.600.00	3.888.600.00
ASSETS TURNOVER RATIO	**1.28**	**1.25**	**1.71**

Source: Processed by the authors according to Sertić 2021.

Table 10. presents the return on total assets (ROA) for company „B“ which is calculated by multiplying the profit margin and the turnover ratio of total assets. It can be seen that throughout the years the company uses the return on assets evenly, controls cost well, and has higher revenues. In 2020. company „B“ recorded the highest return on assets compared to previous years and recorded a growth of 16.13 percentage points. From what is shown, it can be seen that the ROA indicator is in a slight decline in the first two years, and 2020. experiences a jump. This means that the company's income has increased and that costs are well managed (Sertić, 2021).

Table 10. Calculation of return on assets for company „B“ (ROA)

	2018.	2019.	2020.
PROFIT MARGIN	5.79%	5.48%	13.44%
TURNOVER RATIO OF TOTAL ASSETS	1.28	1.25	1.71
ROA	**7.41%**	**6.85%**	**22.98%**

Source: Processed by the authors according to Sertić 2021.

Table 11 shows the calculation of the equity multiplier, which is obtained as a relationship between total assets and equity, as well as a brief analysis of the obtained indicators (Sertić, 2021). In 2020., the equity multiplier is the lowest, which shows that company used financial leverage the least. A value of 1.20 indicates that a company with 100 Croatian kunas of assets finances 83 Croatian kunas from its sources. The highest value of the equity multiplier, in the observed period, was in 2018. and 2019. These are the years in which the company uses financial leverage the most, and the value of 1.31 indicates that the company borrows more and is financed from debt sources compared to the year 2020. and is now equally financed from its own and other sources. From 100 HRK of assets, company "B" finance 76 HRK from its sources (Sertić, 2021).

Table 11. Calculation of the multiplier for company „B" (in Croatian kuna)

	2018.	**2019.**	**2020.**
TOTAL ASSETS	3.084.000.00	3.381.600.00	3.888.600.00
EQUITY	2.356.300.00	2.587.100.00	3.241.20.00
EQUITY MULTIPLIER	**1.31**	**1.31**	**1.20**

Source: Processed by the authors according to Sertić 2021.

Table 12 presents the calculation of the return on equity for company "B", which is calculated as the product of the profit margin, the turnover ratio of total assets, and the equity multiplier, and which indicates the ability to achieve net profit using own equity (Sertić, 2021). Table 12 shows that in the observed period the company achieved the highest ROE in 2020. In 2018 ROE is 9.71% and has a slight decline in 2019. which means that the company successfully disposes of equity, which is proven by the increase in ROE in 2020 (Sertć, 2021).

Table 12. Return on Equity (ROE)

	2018.	**2019.**	**2020.**
PROFIT MARGIN	5.79%	5.48%	13.44%
TOTAL ASSETS TURNOVER RATIO	1.28	1.25	1.71
EQUITY MULTIPLIER	1.31	1.31	1.20
ROE	**9.71%**	**9.0%**	**27.58%**

Source: Processed by the authors according to Sertić 2021.

Through the data presented, we can conclude that company "B" is achieving a positive trend and good indicators in the observed period, but lower than company "A".

4.3. Analysis of business operations by the use of DuPont system of indicators – company "C"

Transport company "C" is a registered road transport company in Koprivnica-Križevac County, which has been operating since 1995. According to data from Poslovna. hr, the business has a credit rating of C2 and employs 13 people, 12 of whom are drivers. Table 13 shows the data for calculating the profit margin, which,

along with the equity multiplier, is needed to calculate the return on assets using the abbreviated balance sheet and profit and loss statement for company "C".

Table 13. Abbreviated Balance Sheet and Profit and Loss (P&L) Statement for the company "C" (in Croatian kuna)

BALANCE SHEET			
YEAR	**2018.**	**2019.**	**2020.**
ASSETS			
B) LONG-TERM ASSETS	1.968.200.00	1.947.400.00	1.351.100.00
C) SHORT-TERM ASSETS	2.838.000.00	3.114.200.00	3.441.300.00
LIABILITIES			
A) EQUITY and RESERVE	1.933.300.00	2.148.500.00	2.435.600.00
C) LONG-TERM LIABILITIES	1.833.200.00	1.916.300.00	1.421.000.00
D) SHORT-TERM LIABILITIES	1.053.900.00	1.011.000.00	950.100.00
TOTAL ASSETS	4.820.500.00	5.075.800.00	4.806.700.00
TOTAL LIABILITIES	2.887.100.00	2.927.300.00	2.371.100.00
PROFIT AND LOSS (P&L) STATEMENT			
YEAR	**2018.**	**2019.**	**2020.**
I. OPERATING REVENUES	4.345.600.00	5.196.700.00	5.554.900.00
II. OPERATING EXPENSES	4.097.000.00	4.985.200.00	5.249.700.00
III. NON-OPERATING REVENUES	46.700.00	201.200.00	122.900.00
IV. NON-OPERATING EXPENSES	35.500.00	76.600.00	47.200.00
IX. TOTAL INCOME	4.392.300.00	5.397.800.00	5.677.800.00
X. TOTAL EXPENSES	4.132.500.00	5.061.800.00	5.297.000.00
XI. GROSS PROFIT OR LOSS BEFORE TAX	259.800.00	336.000.00	380.900.00
XII. PROFIT TAX	61.800.00	77.100.00	51.800.00
XIII. NET PROFIT OR NET LOSS	198.000.00	258.900.00	329.100.00

Source: Processed by the authors according to Sertić 2021.

The following table 14 shows the calculation of the profit margin for company „C" which along with the equity multiplier, is required for calculating the return on assets. The company's profit margin increases gradually until 2020 compared to previous years by 1.36 percentage points. The reason for the increase in profit margin is the increase in net profit. In 2019 the profit margin increased by 0.43 percentage points (Sertić, 2021).

Table 14. The profit margin for company „C“ (in Croatian kuna)

	2018.	2019.	2020.
NET PROFIT	198.000.00	258.900.00	329.100.00
OPERATING REVENUE	4.345.600.00	5.196.700.00	5.554.900.00
PROFIT MARGIN	**4.56%**	**4.99%**	**5.92%**

Source: Processed by the authors according to Sertić 2021.

Table 15. shows the calculation of the indicator of the assets turnover ratio for company „C“ which compares operating revenue and total assets. (Sertić, 2021). In 2019, the value of the indicator is higher compared to the previous year and amounts to 1.02, i.e. that 1 HRK of invested assets generates 1.02 HRK of revenue. This means that during 2019., the assets turned over 1.02 times. In 2020, the turnover ratio of total assets increases to 1.16, which means that the company continues to use its assets efficiently. In 2018., the coefficient is less than 1 and is 0.9, which means that the company does not use its total assets well to generate revenue, and the decrease in the coefficient in 2018 is due to a decrease in financial revenue and revenue from sales. The calculation shows that the company uses its assets most efficiently in 2020 (Sertić, 2021).

Table 15. Assets turnover ratio for company „C“ (in Croatian kuna)

	2018.	2019.	2020.
OPERATING REVENUE	4.345.600.00	5.196.700.00	5.554.900.00
TOTAL ASSESTS	4.820.500.00	5.075.800.00	4.806.700.00
ASSETS TURNOVER RATIO	**0.9**	**1.02**	**1.16**

Source: Processed by the authors according to Sertić 2021.

Table 16 shows the return on total assets (ROA) for company „C“ which is obtained as a product of the profit margin and the turnover ratio of total assets. It can be seen that throughout the years the company uses the return on assets consistently that it controls costs well and has higher incomes. In 2020, it recorded the highest return on assets compared to previous years and recorded a growth of 2.8 percentage points. From what is shown, it can be seen that the ROA indicator is growing slightly, which means that the company's income is gradually growing and that costs are well managed (Sertić, 2021).

Table 16. Calculation of return of assets for company „C“ (ROA)

	2018.	2019.	2020.
PROFIT MARGIN	4.56%	4.99%	5.92%
TURNOVER RATIO OF TOTAL ASSETS	0.9	1.02	1.16
ROA	**4.1%**	**5.1%**	**6.9%**

Source: Processed by the authors according to Sertić 2021.

Table 17 shows the calculation of the equity multiplier, which is obtained by putting the total assets and equity in relation, and brief analysis of the obtained indicators. In 2020, the equity multiplier is the lowest, which shows that in 2020 the

company uses financial leverage the least. A value of 1.97 indicates that a company with 100 kunas of assets finances 51 kunas from its sources. The highest value of the equity multiplier in the observed period is in 2018. In 2018., the company uses financial leverage the most, and the value of 2.49 indicates that the company borrows more and is financed from debt sources compared to 2020 and is now equally financed from its own and other sources. Out of 100 HRK of assets, the company finances 40 HRK from its sources (Sertić, 2021).

Table 17. Calculation of the multiplier for company „C“ (in Croatian kuna)

	2018.	**2019.**	**2020.**
TOTAL ASSETS	4.820.500.00	5.075.800.00	4.806.700.00
EQUITY	1.933.300.00	2.148.500.00	2.435.600.00
EQUITY MULTIPLIER	**2.49**	**2.36**	**1.97**

Source: Processed by the authors according to Sertić 2021.

Table 18 shows the calculation of the return on equity (ROE) for company „C“ which is calculated as the product of the profit margin, the turnover ratio of total assets, and the equity multiplier, and which indicates the ability to achieve net profit using own capital (Seretić, 2021). It is evident from the table that in the observed period the company achieves the highest return on equity in 2020. In 2018 the amount of ROE is 10.21% and has a slight increase in 2019. which means that the company successfully disposes of equity, which is proven by the increase in ROE in 2020. (Sertić, 2021).

Table 18. Return on Equity for company „C“ (ROE)

	2018	2019	2020
PROFIT MARGIN	4.56%	4.99%	5.92%
TOTAL ASSETS TURNOVER RATIO	0.9	1.02	1.16
EQUITY MULTIPLIER	2.49	2.36	1.97
ROE	10.21%	12.01%	13.52%

Source: Processed by the authors according to Sertić 2021.

Through the data presented, we can conclude that company "C" is achieving a positive trend and good indicators in the observed period, but also lower than company "A".

5. COMPARISON OF DATA OF SELECTED LOGISTICS COMPANIES USING DUPONT ANALYSIS

For managers to be able to reliably and successfully manage companies, in this case, logistics companies, DuPont analysis is one of the most important analyzes in providing key information for quality management of the company, but it also provides and insures information on how to achieve higher return with lower risk. The DuPont system of indicators on selected logistics companies shows whether the

selected companies operate and profitably and whether they use their assets efficiently and effectively. Without key and timely information, the company cannot be managed well. For this reason, companies need to choose tools and analyzes that will help them in their management and at the same time provide them with key information necessary for survival in the market. The data provided by DuPont analysis are the basis for management in managing a company and making business decisions. It is necessary to use the analysis, including the DuPont analysis, continuously so that its purpose, which is to provide management with key data for managing a company fulfills its function. Only continuous and timely use of tools, in this case, DuPont analysis can have effects and benefit for company management.

After the conducted analysis, it is necessary to present the trend of the selected companies in the period from 2018 to 2020. Table 19 shows DuPont indicators for the observed period of 2018, 2019, and 2020 for selected companies.

Table 19. Comparation of DuPont analysis data of selected logistics companies for 2018/2019/2020.

COMPANY /YEAR	**A 2018**	**B 2018**	**C 2018**	**A 2019**	**B 2019**	**C 2019**	**A 2020**	**B 2020**	**C 2020**
PROFIT MARGIN (%)	9,79	5,79	4,56	10,23	5,48	4,99	12,66	13,44	5,92
TURNOVER OF TOTAL ASSETS	1,14	1,28	0,9	1,13	1,25	1,02	1,02	1,71	1,16
ROA (%)	11,16	7,41	4,10	11,56	6,85	5,09	12,91	22,98	6,87
EQUITY MULTIPLIER	6,25	1,31	2,49	4,53	1,31	2,36	2,79	1,20	1,97
ROE (%)	69,7	9,7	10,21	52,37	9,0	12,01	36,03	27,58	13,52

Source: Processed by the authors according to Sertić 2021.

The analysis shows that in all three observed years, company "A" has the highest ROA, which shows that the company makes a revenue with its assets, but also has a higher intensity of assets, while in 2020, company "B" records a significant increase in ROA. Also, company "A" recorded the highest profit margin during the observed period (best controls its costs), while company "B" recorded a significant increase in profit margin in 2020. Company "A" has the highest equity multiplier, which means that it uses financial leverage the most, that is, it borrows and finances from debt sources, and to a lesser extent from its funds, and because of this, there is a higher return on equity in other companies. The highest return on equity (ROE) is again achieved by company "A", while the best turnover of total assets is achieved by company "B".

Based on all the data presented, it can be concluded that all companies operate successfully, that they have to further improve the utilization of their assets and that further net profit can be expected through the use of their capital in future operations as well.

6. DISCUSSION AND RECOMMENDATIONS

The DuPont system of indicators is a very useful and powerful tool and is applicable in many industries in the process of managing and making business decisions. In combination with other financial and accounting methods and tools, but also independently, the DuPont system of indicators has many benefits for the organization. It enables better planning as well as management of operations and development of the organization. Given that it combines information from two basic reports, the balance sheet and the profit and loss statement, it enables consideration of how a change in any element included in the system will affect the change in the profitability of total assets (capital). Using the DuPont system of indicators, it is possible to analyze the success of the company's business and evaluate the profitability of the business. Precisely information about the profitability of assets and the profitability of own capital is important for managers in order to know how efficiently and effectively the company's assets and capital are used in daily operations. Financial and accounting tools make it possible to analyze previous years, compare them and monitor business trends, where it is possible to easily and quickly reach conclusions and determine actions that were successful and that led to negative results.

This paper presents the advantages and benefits that the DuPont indicator system has in its practical application. The impact of this research is visible in raising awareness of both researchers and managers about the Dupont indicator system. Still, there is a lack of research on the DuPont indicator system in its practical application and use in business in the territory of the Republic of Croatia but also broader.

This research, however, is not without limitations. The conducted research includes the small logistic companies from the area of Koprivnica - Križevačka County in the Republic of Croatia. A better overview of the researched topic would be obtained if the sample included the other counties in the Republic of Croatia, especially the counties in the North of Croatia, on the basis of which the data obtained by the Dupont analysis could be compared and certain conclusions could be drawn. Likewise, this research includes a comparison of small logistics companies, where it would be desirable to include micro, medium and, large companies in the research, both companies from the area of Koprivnica-Križevačka county but also from the area of other counties of the Republic of Croatia.

Additionally, there are some suggested guidelines and directions for further research, in the application and usage of DuPont, which are as follows: an evident trend of its application in business decision-making is visible but still insufficient, especially regarding research in its use in logistics companies; DuPont and its practical implications should encourage both scholars and managers for future analysts of DuPont and better understanding of its use and beneffits that it has for the organization.

The findings of our research indicate that the use DuPont indicator system in logistic companies is providing information essential for management and business decision-making. The obtained results can provide valuable inputs for future research to investigate the possibility and identify methods of measurement for the current model, but also to expand the current model with new constructs that can capture the

conceptual differences between the current model and its construct as well as a potential new one. Also, this is the research area that needs more empirical evidence, theoretical and quantitative evidence and presents scope for many studies to be carried out in the future.

7. CONCLUSION

Through this paper, the importance of DuPont analysis and its application in the calculation and prediction of profitability of assets and profitability of equity is highlighted. This paper provides an overview of a specific application of Dupont analysis in the operations of logistics companies showing specific areas that should be taken into account when managing a company and which provide key information necessary for making business decisions.

By applying the DuPont system of indicators, the company receives timely and quality information that is necessary for good company management. The profitability of assets and the profitability of own capital are significant to managers, as well as information about how efficiently and effectively the company's assets and capital are used in daily operations. In this paper, the calculation and analysis of the indicators of the DuPont system for three logistics companies in the area of Koprivnica - Križevačka County, in the period 2018 – 2020 was carried out. The presented data show how well companies achieve a return on their total assets and a return on their equity, that is, how profitable their business is. Business analysis through the DuPont system of indicators shows a positive trend in all indicators for all observed companies, but also provides guidelines for further better management of assets and equity. Although all companies operate profitable and with income, there is still a need for some improvements.

The set hypotheses through this research were proven which confirms that the DuPont analysis nowadays is an imperative in doing business when using financial analysis in managing a company.

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VISUALISATION OF THE BULLWHIP EFFECT PHENOMENON APPLYING QUALITY MANAGEMENT TOOLS

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Abstract

Bullwhip effect analysis and FMEA (Failure Mode and Effect Analysis) tools are not connected with each other based on the literature. FMEA tools are aiming to support the quality management and the process improvement purposes. This does not mean that they are not able to cover other areas. Tangibility of bullwhip effect analysis is low. Adaptability of the best practices is also limited due to the number of factors that needs to be considered. In addition, limited resources are available, this further complicate the analysis. To ensure better visibility of the phenomenon application of existing resources and processes can be the solution. The lack of understanding causes significant problem in the resolution of the bullwhip effect. Visualization of the situation can support to increase the level of understanding. It can also help associates with less visibility on the topic to get an overview. FMEA frequently use the fault tree analysis and the Ishikawa chart. Both can support to visualize the problem and it also highlights the most crucial points to make the first steps. The two mentioned tools can successfully support the visualization of the practical occurrence of the bullwhip effect.

Key words: bullwhip effect, FMEA, fault tree analysis, Ishikawa

1. INTRODUCTION

Bullwhip effect (BWE) analysis has often been a focal point of scientific and practical studies in the past 30 years. Quantification of the oscillation and the impact of the phenomenon is difficult. There are case studies of the successful analysis (such

as Cao et al., 2014 or Pastore et al., 2019) but due to the number of factors that need to be considered adaptability is very limited. FMEA is a quality management tool. The focus is on proactive improvement of processes to maximize the customer satisfaction. As part of this improvement, product and process related changes can happen at the same time.

Common research of FMEA and the bullwhip effect is not typical. In ScienceDirect there are twelve articles as result of "bullwhip effect" AND "FMEA" research. Out of these, seven articles includes both of them. The focus of these articles is mainly risk assessment and quality management. FMEA is spotlighted in multiple articles as risk assessment method (Wan et al., 2019; Venkatesh et at., 2015; Rostamzadeh, 2018; Giannakis & Papadopoulos, 2016) or as a supportive tool in analysing phase (Giannakis &Luis, 2011; Hosseini & Ivanov, 2020; Lyu et al., 2009). Bullwhip effect is present in these articles as a supply chain risk (Wan et al., 2019; Venkatesh et at., 2015; Rostamzadeh, 2018; Giannakis & Papadopoulos, 2016; Hosseini & Ivanov, 2020) or as potential improvement area that is developed due to the FMEA approach's results (Giannakis &Luis, 2011; Lyu et al., 2009) Bullwhip effect is mainly connected to FMEA approach in literature as potential risk. Beside the role of forecasting risk, bullwhip effect is also considered as so called 'chaos risk' that is impacting quality processes. It covers over- and unnecessary reactions and consequences of them (Faisal, 2006). Even if their combined research so far was not typical, we can still find improvement potentials in connecting the two areas. The goals are not far from each other. The process improvement approach is also part of the aims of bullwhip effect analysis. The phenomenon can be handled better through targeted improvement of processes.

Due to the limited tangibility the overall understanding of bullwhip effect is low. Adequate summarisation and visual interpretation can support to increase the knowledge regarding the phenomenon. It can enable stakeholders to find the tasks they can influence and open new lines of cooperation. FMEA has multiple tools to support the visualisation and increase the transparency regarding the examined question. Applying these tools can support to make the first step of better understanding of the bullwhip effect with low level of human and financial resource investment.

The goal of this article is applying this clear structure to bullwhip effect analysis. This would broaden the circle of members understanding the phenomenon. Even if their work is not connected directly to forecasting or supply chain, they can see the impacts generated by their contribution. It can bring closer departments with conflict of interest on the topics related to bullwhip effect (such as sales department can see the impact of ad-hoc planning, or price changes).

This article consists of two parts. The literature review is the first part. It focusses on the bullwhip effect, especially the reasons of the phenomenon. The other focus is the FMEA approach, and the visualisation tools applied in it. The second part is the application of these tools. Usage of them is not typical in bullwhip effect context. This part of the article shows the possibility of using fault tree analysis and Ishikawa chart for bullwhip effect visualization purpose.

2. LITERATURE REVIEW

2.1. Bullwhip effect

The research of bullwhip effect has long history behind. First analysis of the topic was by J.W. Forrester (MIT Sloan School of Management), it is also known as the Forrester effect (Forrester, 1961). The "*bullwhip effect"* term was assigned to the phenomenon by Lee, Padmanabhan and Wang (1997). The basis of their investigation was the analysis of customer demand fluctuation. Procter and Gamble diapers showed unexplainable level of variability in sales.

The definition used in books focuses on increasing fluctuation of orders (Chopra and Meindl, 2016; Ivanov et al., 2019; Hugos, 2018). Below definition is from Hugos (2018, pp213): "*What happens is that small changes in product demand by the customer at the front of the supply chain translate into wider and wider swings in demand experienced by companies further back in the supply chain*". Keeping the same perspective Ivanov et al. (2019) focuses on the supply chain impact, as the smooth operation is damaged. Chopra and Meindl (2016) emphasise the impact on the coordination of the supply chain. As the phenomenon leads to increase of costs in multiple areas and decrease in profitability and product availability. Hugos (2018) focuses on the differences on supply chain role and industry level. As the different market view and served markets highly influence the phenomenon.

2.1.1.Reasons of the bullwhip effect

The main causes behind the phenomenon have been listed by Lee et al., 1997 as below:

- Demand signal processing: this focuses on the impulses generated by the retailer. The tracking of these signals, real demand pattern is not reaching the supplier.
- Rationing game: the focus this case is on the manufacturer, but relevant at all levels of the chain. It collects cases related to limited supply availability and gambling due to the changes on the market.
- Order batching: Rules, strategies and policies may differ in the supply chain. Limitations and regulations on time and quantity related operation can lead to bullwhip effect.
- Price variation: planning of promotions, changing of prices may not be in accordance with the supply and production capabilities. Free return policy can make it even harder.

Even though the above categories were defined some time ago, their validity is not disputed in the scientific community. However we shall note that digital technology impacted supply chain operations a lot. The change is mainly visible at information, financial and material flow (Wiedenmann & Größler, 2019). Based on the original concepts these tools recently available should support avoiding the bullwhip effect, but the practical experience does not seems to confirm it.

To the above mentioned areas the lead time parameter was added by Geary et al., (2006), due to the changes in the consumption and the lifestyles of the customers.

Nevertheless, supply chain operations also changed because of the technical and technological development. As bridging distances became easier the number of longer, international chains increased. At the same time the average lead time also grew.

The above described causes did not consider the human factors yet, the focus was on operational reasons. It is only reflected as potential improvement of the bullwhip effect (Sterman, 2006). Recently, the number of studies considering the human side of the causes increased. The focus is on information sharing, training and communication, trust in collaboration, human influence in forecasting and reactions on the impacts of the bullwhip effect (Yang et al., 2021).

The reason groups can be broken down to sub-reasons:

- Demand signal processing: Forecast is in the focus in this category. The quality of it (forecast accuracy), the applied strategy and the understanding of the market. Besides the stock out management and the way of learning out of mistakes.
- Rationing game: This group is containing factors related to the supply chain characteristics. The size of the chain (number of echelons, geographical distance); applied synchronisation and control policies are contained in this group. The level of transparent operation is also examined here. The application of chain level approaches on local level can also have impact on the bullwhip effect. Connected to this, the echelon level appearance of the fear of shortage can influence the performance of the full chain. This is also impactful from the bullwhip effect perspective.
- Order batching: Technical background is mainly in the focus regarding this category. The requested order quantities or values, lot sizes and timelines can lead to unrealistic demand signals. If the chain is missing or having low level of harmonisation this can be further aggravated. Limited availability of the needed capacity also has negative impact (Potter & Disney, 2006).
- Price variation: The bullwhip effect can also be caused by promotional activities or sales deals. If the planning is not according to the global chain level requirements it can lead to the occurrence of the phenomenon. Price changes both on finished goods or material level can also trigger oscillation.
- Lead time: Forecasting strategy need to contain an additional factor to be considered, the lead time. It has impact on the forecasting and replenishment strategy at all levels of the chain. The other related factor is the delay in information flow. Lead time is mainly due to the physical distance, but this also means distance in the communication (Geary et al., 2006).
- Human factor: The main sub-reasons here are: trust, information sharing and human influence. It can only be eliminated if the process is fully automated without human intervention. Trust and information sharing relates to the level of information shared and the time it is communicated. This can be regulated but here we may face differences at different levels of the chain. Human influence means the decisions made by the responsible person based on facts and subjective factors. It can contain for example fear of shortage or

misunderstanding of the changes on the market (Bhattacharya & Bandyopadhyay, 2010).

2.1.2. Consequences and reduction

Bullwhip effect can have contradictory results, both overstock and stock out as potential outcome. These results are decreasing the supply chain performance and have direct or indirect financial impacts. For example, cost impact can be realized due to lost sales opportunities or via increased warehousing costs. This impact can increase through the chain due to the multiplication effect. This leads to serious consequences on chain level, mainly striking the manufacturing side. Beside the cost, information is also impacted, it gets distorted due to bullwhip effect (Szegedi, 2012). The impact is not only realized on stock level but also highly influencing the capacity utilisation. The production schedules are also impacted by losing the stability (Disney, Lambrecht, 2008; Wang, Disney, 2016). The phenomenon results in uncertainty in planning, and expenses also appear due to production and transportation capacity utilization (Disney & Farasyn, 2007).

Due to the characteristics of modern supply chains co-operation became more difficult. The distances in supply chains are longer and the coordination of the ever growing number of echelons is more difficult. The ideal operation would include information transparency, a global strategy at all levels of the chain and a very high level of coordination of the processes. These circumstances would decrease the probability of the occurrence of the bullwhip effect. Nonetheless, these characteristics are not likely to happen considering the real-life circumstance in the foreseeable future.

Information sharing would support better forecasting strategies and processes. It would support avoiding the highest peaks on the long run. Lead time also needs to be considered. It means a potential viewpoint to find the bottlenecks and highlight critical processes. This supports to have better control, lower uncertainty, and manageable processes. Level of information sharing, and consideration of the lead time are the first steps. This can be followed by harmonisation of strategies (forecasting, replenishment) and consideration of redesigning batch sizes and processes (Towill et al., 2007).

Information sharing has been investigated from bullwhip perspective in various research. Still, it does not always work (Haines et al, 2017). Even though, increased level of transparency and information sharing is still important. It supports detection of the bullwhip effect and resolution of the problem.

2.2. FMEA

Failure Mode and Effect Analysis (FMEA) is used for quality purposes. Risk analysis is in scope due to several reasons from costs and customer requirements to legal and technical questions. FMEA can be defined as "*a specific methodology to evaluate a system, design, process, or service for possible ways in which failures can occur*" (Hu-Chen, 2016, pp 5.). The approach is proactive. So instead of problem

solving, monitoring waste and quantification of reliability it concentrates on the prevention, elimination, and reduction (Stamatis, 2003).

It was firstly used in aerospace industry. Due to the severe potential impacts of failures on human life prevention is crucial. As the method was described in an understandable way it appeared in other industries and companies and became typical in automotive industry in error and risk reduction (Chiozza & Ponzetti, 2009).

The goal of application is minimizing probability of the effect of the failure. In each case estimation is made based on occurrence, severity, and detection. Application can be both qualitative, and quantitative. According to Stamatis (2014) a good FMEA consists of:

- identifying potential failures,
- identifying causes and effects of it,
- prioritizing the identified failures (based on occurrence, severity, and detection),
- providing follow up and corrective action.

The basis is the customer as prioritization and definition of critical factors are based on customer requirements. Improving processes and quality, avoiding problems are with the aim of maximizing customer satisfaction (Stamatis, 2003).

2.2.1. Types of FMEA

There are four types of FMEA: System, Design, Process, and Service. Stamatis (2003) describes as follows (Stamatis, 2003):

- System FMEA is used to analyse systems in early or design stage by concentrating on potential failures between functions of the system caused by the system. It helps in the selection of the optimal system.
- Design FMEA means analysing products before production has taken place. Focus is on potential failures due to design problems and as a result, critical and significant characteristics can be detailed. List of parameters can be defined which are basis of proper testing and inspection.
- Process FMEA analyse manufacturing and assembly processes. Focus is on failures caused by processes, and it results in a list of critical and/or significant characteristics, recommended actions to address these.
- Service FMEA analyses the service before it reaches the customer. It focuses on system or process deficits related failures and critical tasks; bottlenecks can be defined. It eliminates error and monitors the system.

2.2.2. Research on FMEA and BWE

Analysation has been initiated regarding the research considering both bullwhip effect and FMEA. First ScienceDirect database has been used. The result shows that bullwhip effect is part of FMEA research as risk (Wan et al., 2019; Venkatesh et at., 2015; Rostamzadeh, 2018; Giannakis & Papadopoulos, 2016; Hosseini & Ivanov, 2020). Wan et al. (2019) aims to develop a model to assess risk factors of maritime supply chains. Bullwhip effect is considered as a new risk parameter that is included

in the FMEA risk assessment. Venkatesh et al. (2015) also use FMEA to mitigate supply chain risk and bullwhip effect is present as an example of the demand uncertainty. Rostamzadeh (2018) and Hosseini and Ivanov (2020) both present bullwhip effect as supply chain risk. FMEA is applied in assessment of risks. Giannakis and Papadopoulos (2016)'s focus is on rating of the risks; bullwhip effect is present as a factor leading to supply chain operational risk. On other examples the two topics are present in the same research without connecting them (Giannakis &Luis, 2011; Lyu et al., 2009). Giannakis and Luis (2011) is working with performance and complexity. Bullwhip effect is considered related agent-based technology example. Lyu et al. (2009) examines connection of bullwhip effect and the RFID technology that is considered as a reduction possibility related to the phenomenon. These two examples both presents FMEA and bullwhip effect but not connects the two areas.

Extending the research in Scopus database further articles have been checked containing also bullwhip effect and FMEA expression. The analysis led to similar result. Hsu et al. (2022) concentrates on bullwhip effect which is result of the inaccurate forecasting, FMEA is present as the applied risk assessment tool. Ghadir et al. (2022) use FMEA as the tool to identify the top supply chain risks related to COVID-19, bullwhip effect is present as one of those. Zhu et al. (2021) and Gupta et al. (2021) both present study on risk management using the FMEA approach and bullwhip effect is present among the risk factors.

These articles are considering the phenomenon from quality perspective. Detailed analysation of the bullwhip effect is not in the scope. The phenomenon means risk for quality management. The approach in this study is in opposition. The bullwhip effect is in focus and quality management is used as potential tool of analysation.

The main advantage of introducing FMEA logic and concept to measurement of bullwhip effect in practice is the different viewpoint and the developed technical background. To apply these tools, cross functional cooperation is needed but the steps to take and tools to use are already in hand. To have connection in scientific area is also important, as it gives higher availability of information to potential users.

3. METHODOLOGY

Based on the analysis of the bullwhip effect and FMEA literature the common interest is visible. Using the learnings of the theoretical background a model fault tree and Ishikawa diagram was built up by the authors. It showed that by theory it is possible to connect the approach of FMEA and bullwhip effect.

As the next step, subject matter experts have been interviewed regarding their experiences. These interviews as part of preliminary research aimed to collect examples of experiences on the bullwhip effect. There have been ten interviews conducted on machinery industry. These interviews aimed to test if the designed approach can be applied on real life examples. The respondents are logistics experts working with forecast and or inventory. They have been asked on examples of bottlenecks they faced in the supply chain operation during their daily work. The feedback from these interviews has been formed according to the fault tree analysis.

These examples replaced the theoretical sub-reasons of the bullwhip effect. As these interviews includes feedback for multiple experts, the result cannot be used to highlight exact steps to be taken. Current approach is a simulation aims to test the applicability of the designed approach. Beside the interviews cases studies on bullwhip effect has also been presented in Ishikawa diagram format. Two example from the literature and one from the experience of the authors is visualised.

4. APPLICATION OF FMEA TOOLS

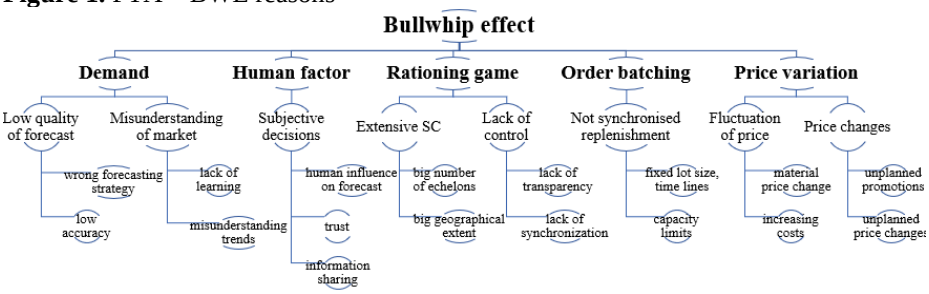
There are several quality management tools that are frequently used during the FMEA process. As example fault tree analysis, Ishikawa diagram, Pareto chart, risk matrix, and paired comparison are among the numerous different methods (Lim, 2020; Luthra et al., 2021). In this article the goal is to implement visualization tools to have better overall understanding. In Chapter 4.1. two widely used tools of FMEA is presented: fault tree analysis and Ishikawa diagram.

4.1. FTA

Fault Tree Analysis is a relatively old method first used by Bell Telephone Laboratories. Since then, it has been improved and adopted, and nowadays it is one of the most widely used tool for reliability and safety studies. In this approach, the undesired event is described, and analysed to find all combination of basic events that has led there. Basic events are the basic causes, which can mean several different things from human error to environmental condition (Xing, Amari, 2008). The logical connections are visualized in a graphical representation. It is a logical framework that show how the system fails. This support us understanding how the operation can be successful (Xing, Amari, 2008).

FTA can be used to visualise reasons and sub reasons of the bullwhip effect. Figure 1 shows the theoretic version of it. It visualizes reasons which are in the literature part of the article also collected in Chapter 2.1.1. Making this visualisation not only helps the understanding of the phenomenon, but also supports finding the most relevant reason groups. Once it is defined it is easier to place the focus on the required field. Visualization can be used to pass the information regarding the problem without going into details.

Figure 1. FTA – BWE reasons



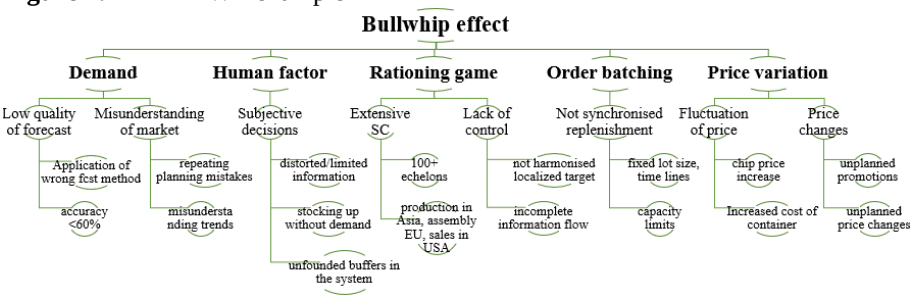
Source: Authors' edition

This structure can be further specified by real life examples, which is visible on Figure 2. The lowest level of the tree is filled up with authentic reasons. These examples have been collected in informal interviews with supply chain professionals about their experience on the bullwhip effect. "Applied forecasting method not working" refers to the tool generating the forecast based on the trends. Maybe some setup of the algorithm is not correct, accuracy under the targeted percentage (value depends on industry, product or even county level). These are driving low-quality forecast which is going through the supply chain. Planning mistakes and misunderstanding of trends lead to the same consequences. These are examples that can drive the bullwhip effect from demand perspective. Personal decision can also appear in system modification without real background data, leading to buffers on products resulting in unnecessary production and increased level of inventory.

Human factor is filled by potential errors of the subjective decisions made by the person. It can be influenced by information. Decision on level of information needs to be shared is not always clear. This can lead to distorted or limited level of shared information. Fear of shortage, low level of trust and subjective decision lead to stocking up on given products.

For rationing game, the example is also split to two categories. Supply chains with 100+ echelons (warehouses, plants, headquarters, sales locations, training centres, testing stations, etc.) are extensive. Smooth and complete information flow is impossible at this level. Complexity can also come from geographical extent. Example on Figure 2. is present in several companies' operation. Missing control can be the result of incomplete information flow. It can be caused by wrong processes or by the mentioned distances. Localized targets without harmonization also decrease the chain level control and transparency.

Figure 2. FTA – BWE example



Source: Authors' edition

Order batching shows difficulties of replenishment. Fixed lot sizes and ordering timelines are against flexibility. Long distances lead to higher lot sizes due to economical quantity perspective. These lot sizes can differ on manufacturing location level and on distributor level. It leads to disharmony in the chain level processes and decreases flexibility.

Price variation reasons are also presented in Figure 2. For example, current situation with the chip price influences the product of finished goods, or the delivery problems from Asia due to increased demand and increased prices. Price related issues can also hinge on companies. Price increase or promotion without planning can impact demand significantly.

Figure 2. shows that corporeal examples can be placed into the chart replacing theoretical reasons. Considering one case this technic can highlight the main drivers or most relevant reasons of BWE. It can be used as a visual executive summary and support cross functional cooperation. The visual interpretation gives broader understanding of the whole area.

4.2. Ishikawa

Ishikawa diagram is tied to Kaoru Ishikawa. Key elements considered by him were the followings: costumer demand need to be defined first, instead of the symptoms causes need to be handled, quality management is a responsibility for all divisions, and it needs to be priority for them, quality begins and ends with learning and most (95%) of the problems in the organization is resolvable by simple tools (Stefanovic et al. 2014). These are showing that aims and purposes of FMEA are all integrated in the Ishikawa approach as well.

Ishikawa diagram is also known as cause-and-effect or fishbone (because of the shape) diagram. It is a diagram-based approach supporting thinking through possible causes of a problem. The main steps are as followed: identification of the problem, identification of the major factors involved, description of possible causes, analysation of the diagram. There are typical categories used for grouping problems: people (man), methods, machines, materials, measurement, environment (milieu) (Liliana, 2016). The listed categories are also known as the 6M of production, aiming to support the waste reduction and process simplification (Yahya, 2021).

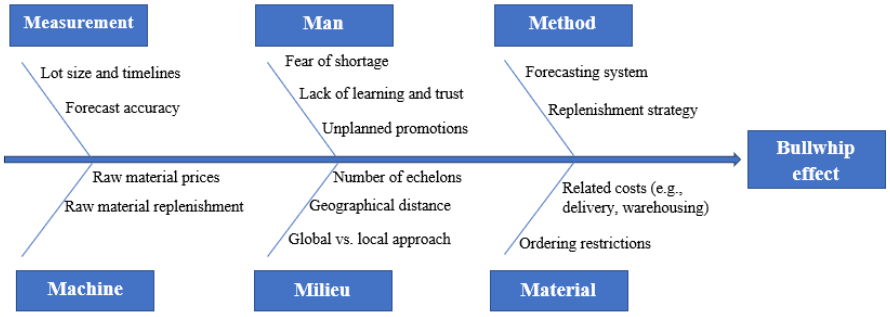
The 6M approach is typically used with Ishikawa, this article is using this approach to categorise issues during visualisation. The Ishikawa diagram beside summarisation and visualisation, also breaking down main issues to manageable elements. This method can also be used for visualising the bullwhip effect. As the diagram has its' own grouping methodology, it leads to a new perspective for categorizing reasons. Figure 3. shows the Ishikawa of the bullwhip effect reasons using 6M categorisation.

Measurement group represents measurable issues, and the points connected to measurement failures. In the example of bullwhip effect these are the strict given timelines, lot sizes and accuracy of the forecast. Category Man shows reasons that are connected to human behaviour and decisions. Fear of shortages, lack of learning and trust, and unplanned promotions (or any unplanned events) can be listed here. Method contains system related problems. Forecasting and replenishment strategy can differ within the chain that complicates cooperation. Forecasting system can also work incorrectly.

Machine stands for mainly the manufacturing background. Raw material prices and replenishment policy applied can impact operation of the chain downstream. Milieu means the environment, characteristics of the chain itself. Increased number of echelons and big geographical distances can have negative impact on transparent operation and control of the chain. The bigger the distance the higher the chance for localized approaches, which misses to connect with global goals. Material category means raw material and connected issues. Limited availability of products, increase of material prices, or any related costs lead to fluctuation of the price which can start demand fluctuation.

The application of the Ishikawa for mentioned purpose has already been presented in a case study. It also presents causes of the bullwhip effect in Lexmark (Disney et al., 2013).

Figure 3. Ishikawa – BWE reasons

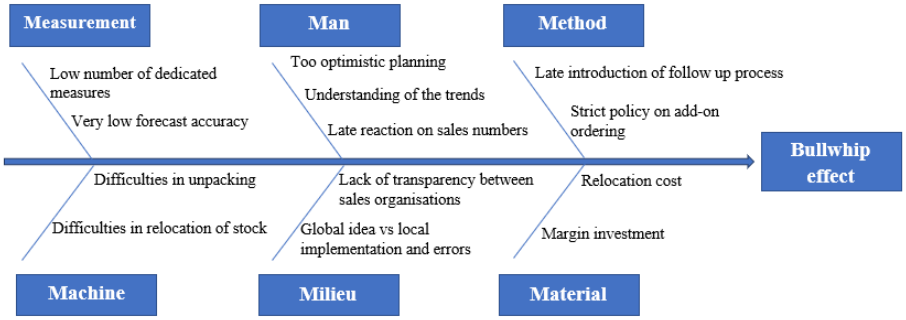


Source: Authors' edition

This visualization and structure of reasons can support analysis of the bullwhip effect. Figure 4. shows the fishbone diagram of a real-life example based on the experience of the authors. The visualized example is a poorly planned promotional activity. A well rotating product sold with a gift (add-on) free of charge. The market was not interested in the added product, it led to significant overstock of the gift after

the promotion. As it is not sold individually cost is realized on multiple angle such as warehousing or margin.

Figure 4. Ishikawa – BWE example



Source: Authors' edition

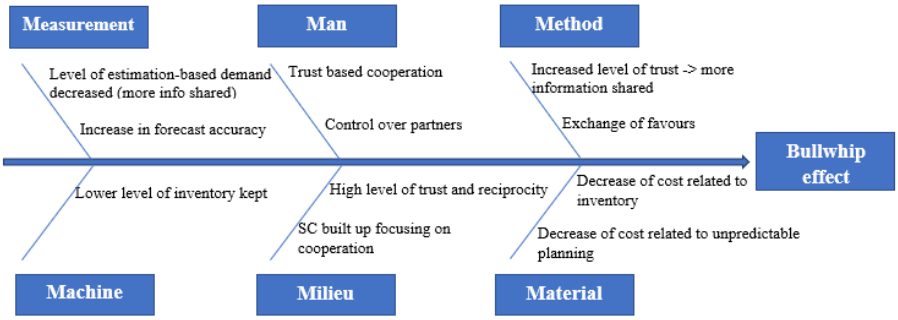
This example resulted in high level of overstock. As the event is not that special, similar promotions are planned on trimester base improvement potential is high. Measurements here are crucial from long term perspective. Issue faced are partially due to low number of dedicated measures that supports the activity from the beginning. Measured low forecast accuracy is also indicating the occurrence of the bullwhip effect. From man perspective the reason is mainly too optimistic expectations which are combined with misunderstanding of the market trends (the gift was not interesting at all for the targeted group). The other problem was the late reaction. Forecast change has not happened even after first sales numbers showed that the interest is very low. Beside the change in number the action to improve the performance of the promotion was also missing. From method perspective missing sales follow up process was deepening the issue. Here also the gift ordering process' difficulty and inflexibility need to be mentioned.

From machine perspective the physical difficulties of relocation appeared. Langue and differences in regulations needed to be bridged. Cost impact was also significant as the product with add-on needed to be repacked (separated). Regarding the milieu the global idea versus the local implementation need to be mentioned. Even if local needs were considered during planning implementation and global aims had significant gap in-between. Furthermore, communication of sales organisation was incomplete, best practices, good approaches or even mistakes had not been shared. Due to the lack of flexibility regarding material background the chart should also consider the impacts of this. It led to additional costs as the generated overstock needed to be sold with margin investment. This is connected to the bullwhip effect due to increasing distance of real market demand and planning.

In a literature example Cao et al. connect the approach of guanxi and the increase of supply chain performance by decreasing the bullwhip effect. Guanxi is a form of social capital focuses on interpersonal and interorganisational relationships. It results in continued exchanges of favours over time. Guanxi has three main components: trust, information sharing and control. These components are also connected to supply

chain performance. Bullwhip effect is taken into consideration due to the impact of information sharing. Trust and reciprocity are basic requirements which must exist to enable it. Connection is here due to core benefits of guanxi that are the mentioned two elements. The study shows that in appropriate circumstances guanxi can reduce probability of the bullwhip effect. Still useability is limited by multiple factors such as competitiveness of business environment (Cao et al., 2014).

Figure 5. Ishikawa - Guanxi approach to decrease bullwhip effect



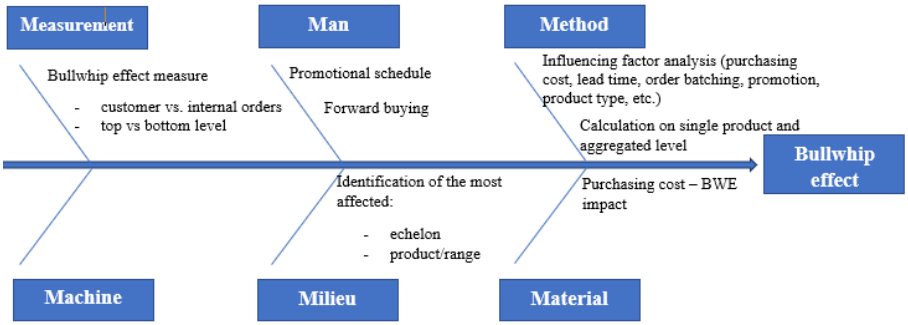
Source: Authour's edition based on Cao et al, 2014

Figure 5. shows the application of Ishikawa diagram at the core ideas of Guanxi to reduce the probability of the occurrence of the bullwhip effect. The focus is on trust and information sharing from multiple perspectives. Once the reciprocity and trust are built on the daily operation exchange of favours can work which leads to a two-way dependency on a positive manner. It also supports decreasing the level of unpredictability of demand estimation.

Pastore at al. examine spare parts industry. Based on the examination of two years data the calculation showed that both on aggregated and on single product level demand variability increases in the chain moving from final customer to external suppliers. The findings also show that rotation of products have impact on probability of the bullwhip effect. Fast-moving items are more impacted by the bullwhip effect then slow movers. This is mainly due to forward buying possibilities when dealers prefer to stock up fast-moving items. It was also presented in the result that promotional periods are influencing forward buying, so indirectly the bullwhip effect (Pastore et al. 2019).

On Figure 6., Ishikawa chart shows that the focus of the analysis is wide. Calculation of the bullwhip effect is happening on two dimensions: customer versus internal orders and top versus bottom level. The investigation is also from multiple angles regarding the product portfolio. It is considering single product and aggregated level. Considering the bullwhip effect influencing factors such as lead time or order batching has been collected from the literature and analysed regarding the impact on the phenomenon. As it is also visible in Ishikawa focus here is rather on the supply chain planning and information flow then on the production side.

Figure 6.: Ishikawa – data analysis approach – spare parts industry



Source: Authour's edition based on Pastore et al, 2014

5. CONCLUSION

Competition is getting fiercer, and circumstances are becoming more difficult. Extraordinary cases such as COVID-19 or crucial availability issues (such as microchip shortage) test the resilience and the operation of supply chains. Due to the competition, it is not enough to get through the difficulties, continuous improvement is needed. As bullwhip effect has key role in the supply chain operational performance it needs a high level of attention and understanding. Visualization of the phenomenon aims to extend the circle of people who understand the issues and work on the solution.

Fault tree analysis and Ishikawa approach can be used as adequate tool to present the reasons of the bullwhip effect. This supports in increasing the understanding of the phenomenon. It gives also high-level overview and summary where focus needs to be placed. As these tools are well-known and likely used by another department introduction is not resource intensive. It can be a first step toward the understanding of the phenomenon and determination of the main reasons of the bullwhip effect in the examined cases.

FMEA is applied in mainly in the most bullwhip relevant supply chains. These are complex networks that have multiple echelons. The cooperation needs to be kept under control. This is also true from a quality perspective. FMEA aims to maximize the customer satisfaction through reaching the highest potential of the product or service. FMEA approach applies multiple tools to visualize problems, processes, or hierarchical connections. These tools can support the bullwhip effect analysis as well. Application of the fault tree analysis and Ishikawa diagram is possible in connection with bullwhip effect. This visual approach has two main advantages:

- *It increases the level of understanding*: People of related departments can understand better the bullwhip effect. They can see the consequences of mistakes or decisions they make (for example sales department can see the potential impact of the unplanned promotions). It can be also used as part of executive summary to highlight areas where process improvement approach would be needed.

- *It highlights the main reasons of bullwhip effect in the analysed chain*: The reasons behind the phenomenon are available in the literature but still it differs chain by chain. Visual interpretation of the actual, experienced reasons can show the weighted overview of the phenomenon, highlighting the most critical factor.

The main limitation of the research is the industrial representation. The examples are only covering one segment. Extension of the analysis is needed for further industries. The number of interviews also limits the potential to generalise the results, but it still supports testing application of quality tools in bullwhip effect extent.

As the potential extension of the scope of this research, a survey can be conducted. It can broaden the examination by checking other industries. The survey can also have additional questions that can show the perception of the bullwhip effect in the supply chains. As a result, industry level and overall consequences can be conducted. It can highlight the most critical reasons of the bullwhip effect, that would help in improving the performance of the supply chain.

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