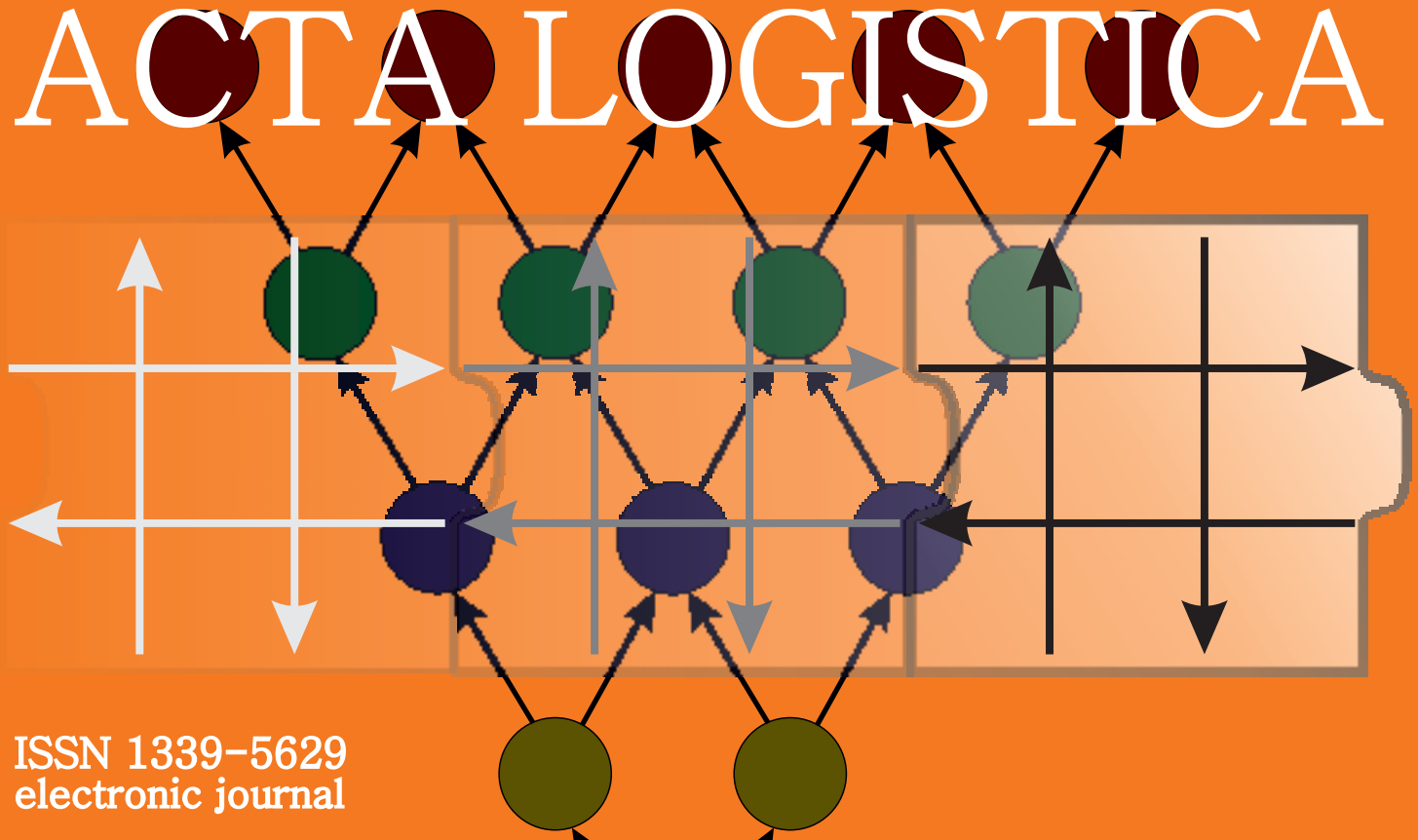
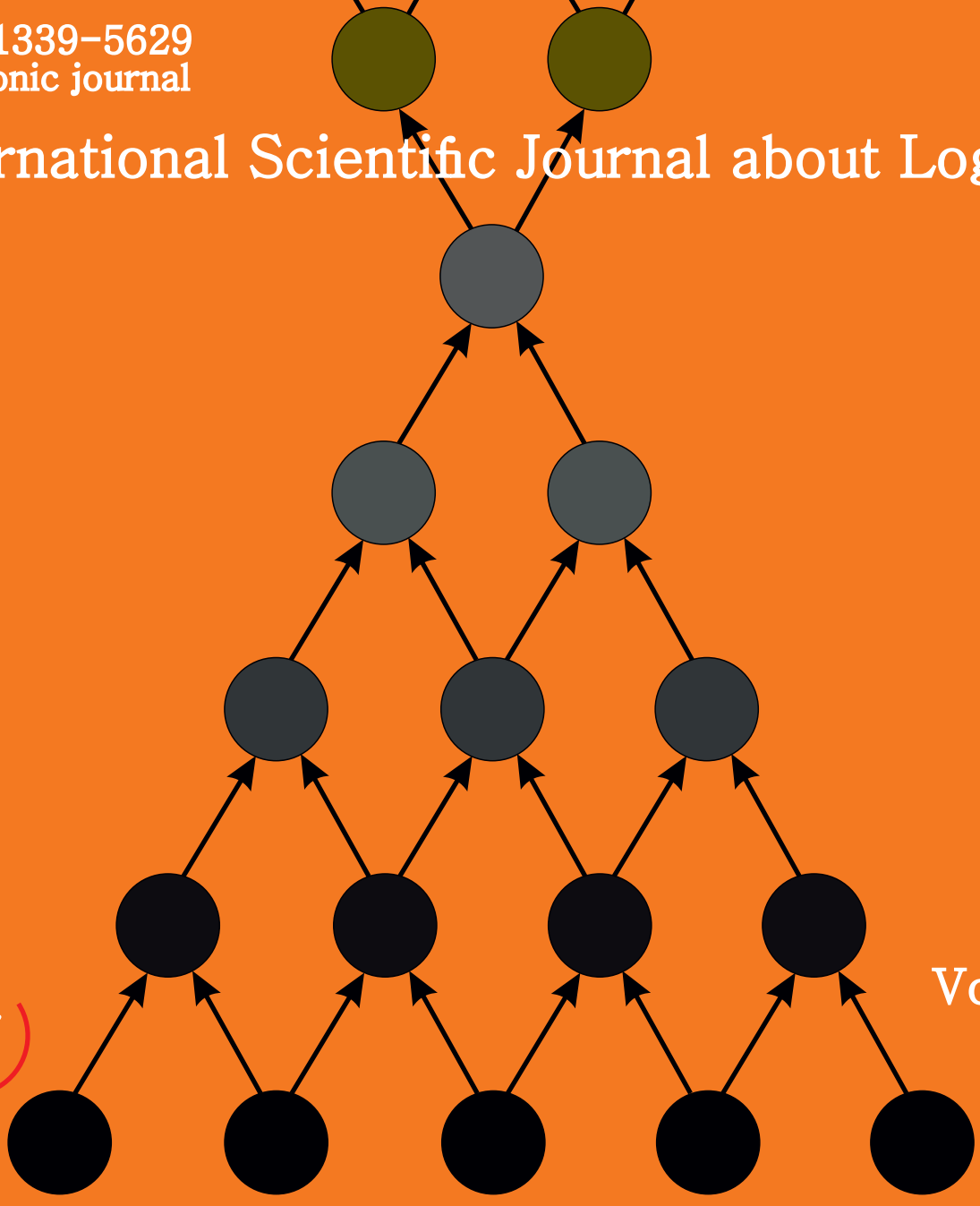
ACTA LOGISTICA



ISSN 1339-5629
electronic journal

International Scientific Journal about Logistics



Volume 7
Issue 3
2020

CONTENTS

(SEPTEMBER 2020)

Acta logistica - International Scientific Journal about Logistics
Volume: 7 2020 Issue: 3 Pages: 145-154 ISSN 1339-5629

METRICS IN THE PREPAREDNESS PROCESS
Vesa-Jukka Vornanen; Josu Takala

doi:10.22306/al.v7i3.163 *Received: 07 Mar. 2020; Revised: 15 June 2020; Accepted: 19 Sep. 2020*

METRICS IN THE PREPAREDNESS PROCESS

Vesa-Jukka Vornanen
University of Vaasa, P.O.Box 205, FI-48101, Finland, City of Kotka,
vesa-jukka.vornanen@kotka.fi (corresponding author)
Josu Takala
University of Vaasa, P.O. Box 700, FI-65101 Vaasa, Finland, josu.takala@uwasa.fi

Keywords: preparedness process, PDSA, content analysis, discourse analysis, BCFI analysis
Abstract: The phenomenon under study relates to the preparedness process. We need metrics to achieve multi-strategic goals. Situational factors and the direction of development of operational priorities are measurable factors. Public officers need measure these, that political decision-makers leads in the right direction. The research problem of a new servant in office is how to interpret the measured results to make a decision proposal. The research method was an action research. The problem solving follows the logical steps of the Deming Cycle: Plan the exercise, Do the notes, Study the content, Act customer-oriented. Multi-method approach promotes value-generating processes in the region's hybrid organization. The evaluation of results is based on stakeholder feedback, a participate-decision by the City of Kotka's Urban Board and a decision on funding by the Kymenlaakso Regional Council. In practice, content analysis of situational factors creates certainty of interpretation about the direction of development of operational priorities. This is important for BCFI analysis especially in turbulent situations. Implemented in the context of the readiness exercise, this was found to be exceptionally meritorious.

1 Introduction

The City of Kotka is a key player in a Kotka-Hamina region as the largest residential centre and the 19th largest city in Finland [1]. The city is home to 61 % of the population in the region. Of the 21 major Finnish cities, Kotka has the fifth largest number of immigrants, 9.6 % of the population [2]. The Kotka-Hamina area, formed by two cities, is located on the southeast coast of Finland [3]. From the supply point of view, the region is nationally significant. Port of HaminaKotka Ltd is Finland's largest port, with regular connections to all major ports in the world. Port of HaminaKotka Ltd is a joint-stock company owned by local authorities, the City of Kotka (60 %) and the City of Hamina (40 %) [4]. The joint-stock company is one of many in Kotka Group businesses [5]. Thus, the public shareholders play an important role in corporate governance to deliver value to society.

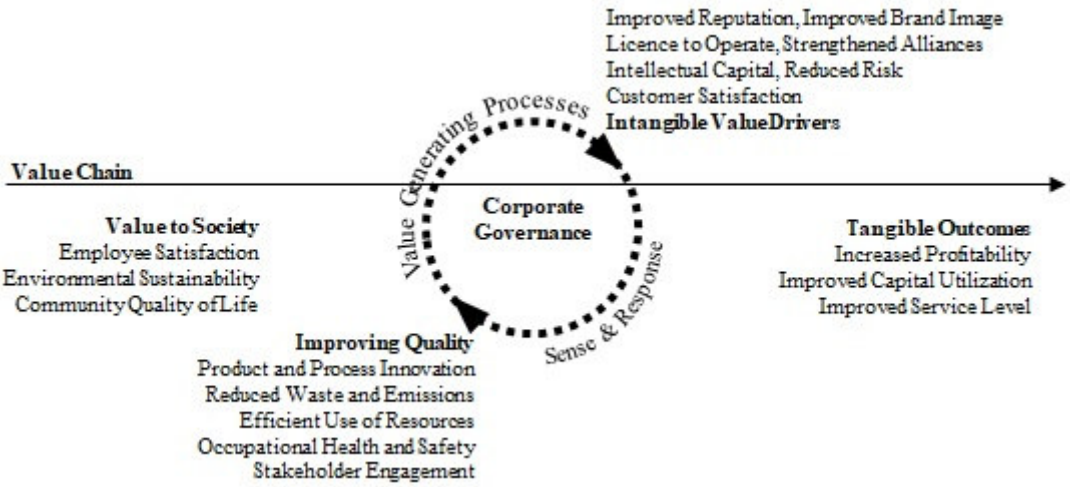


Figure 1 Linking value generating preparedness process to sustainable development by value chain securing

The Finnish concept for comprehensive security means that the vital functions of society are ensured through the co-operation of authorities, citizens, companies and the third sector. The way that works based on the crisis management model in which competent authority supported by all relevant security actors [6]. The key idea of the society's security strategy is that we are all security actors. The role of local government is crucial as the decision-making system directly influences the foundation of the crisis management model, in other words, the above-mentioned stakeholders. Based on the author's years of experience in the research field, a strategy that reinforces a

community-wide operations, enhance resource-based view [7] and strengthen mutual trust [8], thus, promote a joint performance [9]. Figure 1 illustrates stakeholder value generating processes in value chain securing, owner collaboration, and value-generating factors [10,11].

1.1 The need for an action research

Working in the City of Kotka with the Kotka Group has taken a year. The scope of the study 2019-2020 covers a larger entity than in the previous target organization 2009-2018. From a national perspective, and referring to the Kotka Group assets, the logistical importance of the current action research is far more critical. In both cases, the assisting target organization has been, and is, facing change. In responding change, actions have to be a part of continuity management to influence the competitiveness of the city properly.

The need for action research based on a situation: in which the organization performance and operational impact of an organization examined with making the necessary changes. This article addresses the statutory obligation of a public organization to act in all situations. It is challenging to meet all the obligations if there is a structural change in the organization and no common approach has not yet established. Background of the target organization in the City of Kotka is in two separate technical organizations: Facility Management and Municipal Engineering. The integration at 2019 brought together nine independent service units, without the common purpose, why the 400 employee's division exists. Identifying critical operational priorities can be challenging in such a situation, as the interpretation of criticality relative to the goal cannot made. However, the preparedness process includes trainings, in which provides useful insights into the expectations of the larger hybrid organization and people there. By developing dynamic capabilities, a public service organization has purpose; it shares a common identity, and gets enhanced opportunities to achieve joint performance [12].

The second reason for action research is a wicked problem. The preparedness process is continuous, works year after year, and intended to work in all circumstances. A competent authority should be able to react as the situation changes in a turbulent environment. In order to be able to manage processes, it should be possible to measure demand for commodities, expectations for the management and service production system. On the other hand, disaster and emergency preparedness plans are not legally public, but all stakeholders must work together to make the processes work effectively to deliver a sustainable competitive advantage to the community [13].

Finally, the most important reason for action research is the personal interest as a researcher and as a director of technical services. To live up to expectations, management must be effective and results must support the sustainability goals of the city. To achieve above-mentioned goals, it is necessary to measure the direction of development of priorities and to be able to evaluate the results obtained. The need for methodological support in management is particularly evident in a disruption when the manager has begun in a new, security-critical organization, in a new area. Situational factors must identified in order to target decision-making properly – how else a new manager interprets what the measurement result looks like. In such situation, there is a need for a management takeover procedure related to forming situational awareness, to be relevant security actor, and on the other hand, to successfully deal with corporate governance to support region value generating processes.

2 Methodology

The theoretical framework of the study is based integration of two viewpoints of separate dissertations. Tuomi (2012) point out the quality management in public sector [14]. The situation factors need to know to achieve performance. Corresponding author introduced an innovative preparedness process to achieve joint performance - to conduct the Security Strategy of Society and the City Strategy to the critical public service unit's Operations Strategy [7]. Figure 2 illustrates a theoretical framework of this action research.

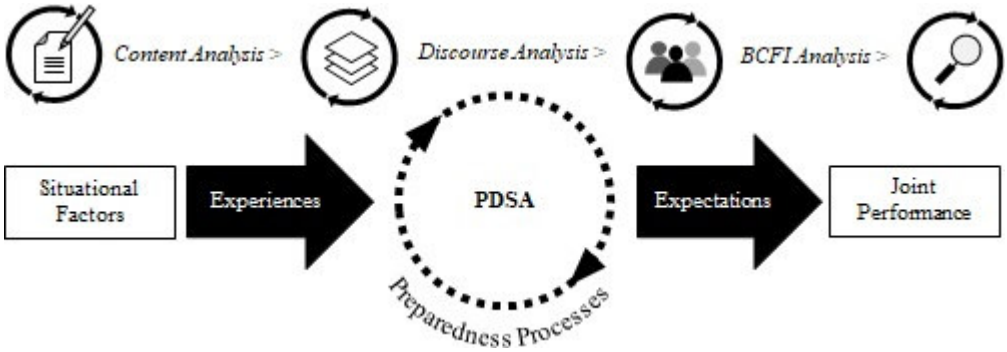


Figure 2 a theoretical framework of the study

The multi-methodology based action research was carried out in the previous organization of the researcher.

The study has published in international peer-reviewed publications. In this publication, objectivity achieved through the same manner. There are two levels at the public sector, an administrative level and an operational level. The feedback of decision-makers tells whether the results and the development measures are successful as intended. The structure of the theoretical framework reflects the narrowing gap between expectations and experiences.

The decision-making and implementation system is shown in figure 3. One-year timeline includes several board's meetings, and different exercises. Because the timeline is a continuum, the graph represents the process metrics.

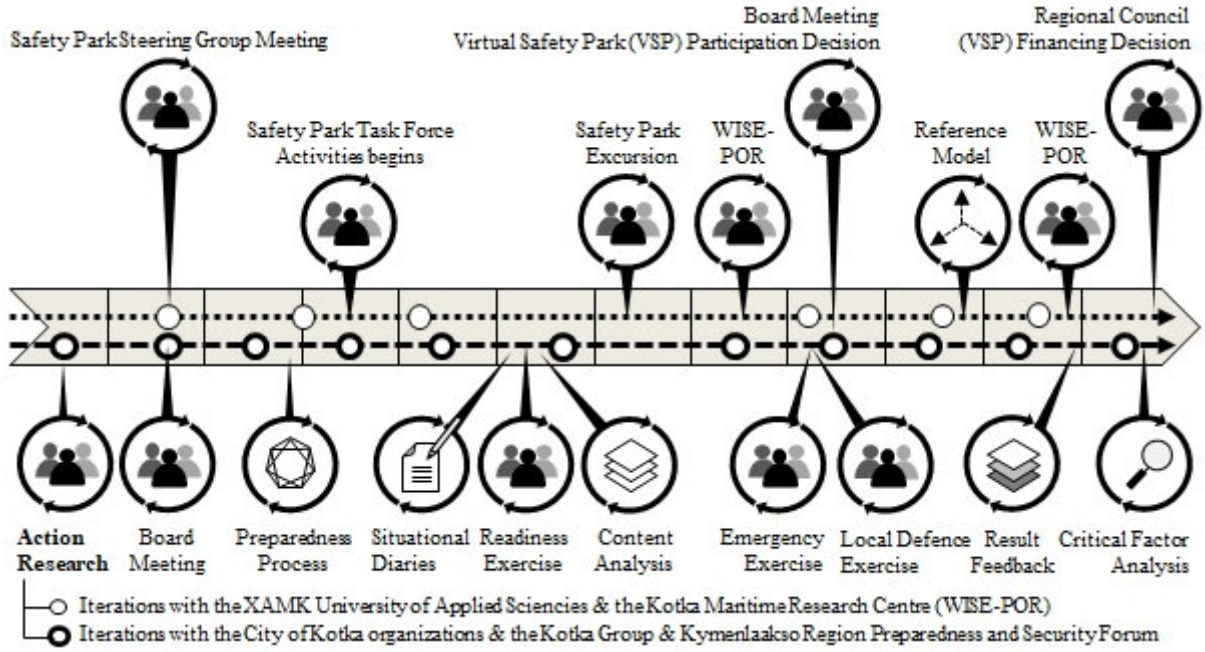


Figure 3 dashboard of iterations in the study's timeline

Knowledge of the procedure above is useful, without compromising the security of classified information. Thus, the study conducted in a manner that does not open the detailed content of the diaries or exercises. The decision limits a bit the degree of freedom of the study. For example, the mutual evaluation of daily logs content with operational priorities in the Analytical Hierarchy Process [15] present in figure 4 left out. The paper describes developed procedure and feedback from decision-makers indicates the qualitative correctness of the choices made.

The readiness exercise lasted two days at June of 2019 and produced two situation diaries. The diaries maintained by the two of divisions' employees who had good knowledge of their field of expertise. Situational factors are issues, which representatives of all divisions in the city, the city group and authorities discuss and make decisions.

The purpose of producing diaries was to effectively contextualize the situation, evaluate the significance of data obtained, and successfully manage the division. At this stage, it is important to note the role of assistant personnel. There is a risk associated to the frequency of debriefing exercises. Many valuable findings can forget unless topics addressed as part of value generating process to the shareholders and stakeholders. Communication is a part of the management of public trust, as Port of HaminaKotka Ltd did [16].

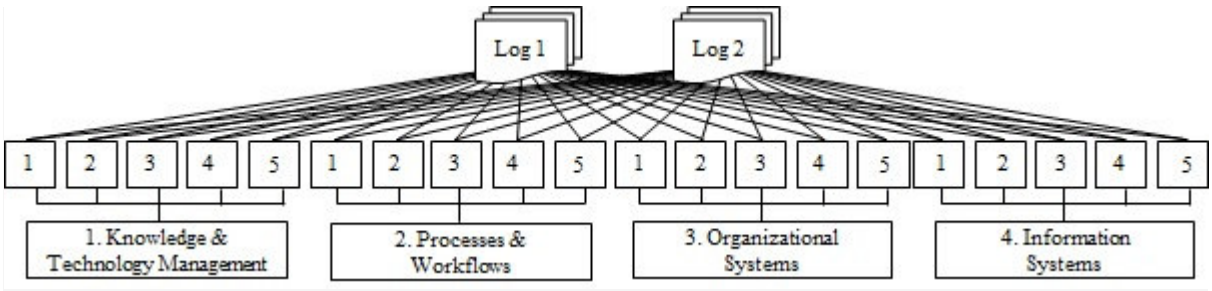


Figure 4 link between operational priorities and content of daily logs

Table 1 presents the attributes of operations priorities for the management of technical services' division. In the action research, content analysis tells you what the text of the situation diaries are. The method is part of qualitative research [17]. The procedure proceeds in such a way that the text is partitioned, processed and finally organized into a new whole.

Table 1 key management areas 1-4 and attributes 1.1 – 4.5

1	Knowledge & Technology Management	1.1	Training the staff of our organization
		1.2	Innovative research and development
		1.3	Communication from unit to unit and level to level in hierarchy
		1.4	Adaptation to changes in knowledge and technology
		1.5	Dissemination of knowledge and technology within the organization
2	Processes & Work Flows	2.1	Short and fast delivery times for order fulfillment
		2.2	Reducing unprofitable time
		2.3	Timely delivery to stakeholders (customers)
		2.4	Inventory optimization
		2.5	Customizing changes to requirements and orders
3	Organizational Systems	3.1	Organizational leadership and management systems
		3.2	Quality control of service processes and operations
		3.3	Well defined tasks and responsibilities in the operations
		3.4	Utilizing teams and other ways of organizing
		3.5	Code of conduct on information security
4	Information Systems	4.1	Information systems support processes
		4.2	Visibility in information systems
		4.3	Availability in information systems
		4.4	Reliability and quality in information systems
		4.5	Functionality and usability in information systems

Content analysis is an efficient alternative for tracking public opinions, the direction of demand fluctuations over a given period of time, political tendencies, or mapping emerging ideas in the aforementioned iteration rounds.

Microsoft Excel spreadsheet software used to classify the content analysis issues. The data categorized in relation to the four key management areas. Table 2 shows the principle of contents of daily logs integration with technical services management.

Table 2 connection chart of content analysis and operation priorities

Content of the Daily Logs	Content Applies to Knowledge & Technology Management					Content Applies to Processes & Work Flows					Content Applies to Organizational Systems					Content Applies to Information Systems				
	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	4.4	4.5
Day 1, # 1																				
…																				
Day 2, # n																				
Day 1 ∑n/N:																				
Day 2 ∑n/N:																				

The methodology section of the study works as a discourse analysis of the mechanism how the text and results obtained [18]. Iteration runs with stakeholders', and works as a continuous quality improvement model, consisting of a logical series of four key phases: Plan, Do, Study, Act. Implementing multi-strategies requires strategic choices, collaboration and interoperability from the supplier of critical public services to secure value chains. Figure 5 illustrates the discourse analysis utilized with the SIPOC strategy map [19].

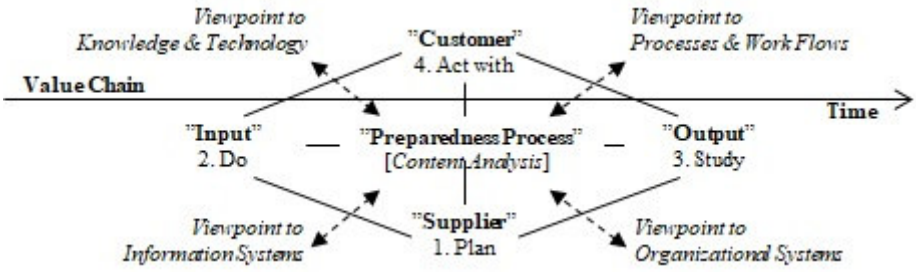


Figure 5 SIPOC strategy map for discourse analysis (Adapt Kaplan & Norton 2004, Vornanen 2017)

The diagram tells how the critical public services supplier plans to utilize resources, in other words, the inputs. The information systems needs to produce situational awareness of these. The order-fulfilment progress, when the process works by studying outputs and acting with stakeholders. Common awareness increases reliability and mutual trust, and thus joint performance: as a result the value chain being secured by preparedness process.

The Balanced Critical Factor Index (BCFI) analysis is a strategic decision support tool [20], which is based into Sense & Respond method [21]. The tool shows, which feature is critical and which is not. In this case, the criticality of the difference between expectation and experience arises from the gap between these two factors: is the direction of development worse or better. The calculations are sensitive to the behaviour of statistical data. Table 3 presents the questionnaire sample. [22]

Table 3 questionnaire sample of the BCFI –analysis

			Expectations 1-3 year	Experiences 1-3 year	Direction of Development								
					Evaluate the future (Tick the box)			Evaluate the past (Tick the box)			Compare to competitors (Tick the box)		
			Rate 1…10	Rate 1…10	Worse (W)	Same (S)	Better (B)	Worse (W)	Same (S)	Better (B)	Worse (W)	Same (S)	Better (B)
1	Knowledge & Technology Management	1.1											
		…											
		1.5											

The calculations are based formulas (1), (2), (3) and (4), as shown below.

$$I_{Imp} = \overline{x}_{Ep}/10 \quad (1)$$

$$I_{Gap} = |(\overline{x}_{Er} - \overline{x}_{Ep})/10 - 1| \quad (2)$$

$$I_{DoD} = |(C_B - C_W)/100 - 1| \quad (3)$$

$$I_{CF} = \frac{s_{Ep} \times s_{Er}}{I_{Imp} \times I_{Gap} \times I_{DoD}} \quad (4)$$

Parameters
$\overline{x}_{Ep} = Mean\ of\ expectations$
$\overline{x}_{Er} = Mean\ of\ experiences$
$s_{Ep} = Standard\ deviation\ of\ expectations$
$s_{Er} = Standard\ deviation\ of\ experiences$
$C_B = Better\ performance\ than\ expected$
$C_W = Worse\ performance\ than\ expected$
$I_{Imp} = Importance\ index$
$I_{Gap} = Gap\ index$
$I_{DoD} = Direction\ of\ development\ index, percent\ values$
$I_{CF} = Critical\ Factor\ index$

The author expected to receive at least three responses from both of the key service processes. In December 2019, a questionnaire distributed to all participants at the division's management briefing. The response time was two weeks and everyone allowed responding anonymously.

3 Result and discussion

3.1 Creating situational awareness by content analysis and discourse analysis

The results of the content analysis shown in the following two figures. Figure 6 illustrates clustered keyword entities showing trends in demand. On the second day of the readiness exercise, the Executive Team's Summary Surveys increased. This is a reason why the sum of the percentages for the second game day is greater than 100%. Figure 7 shows the distribution of the completely analysed material in relation to the division's operational priorities.

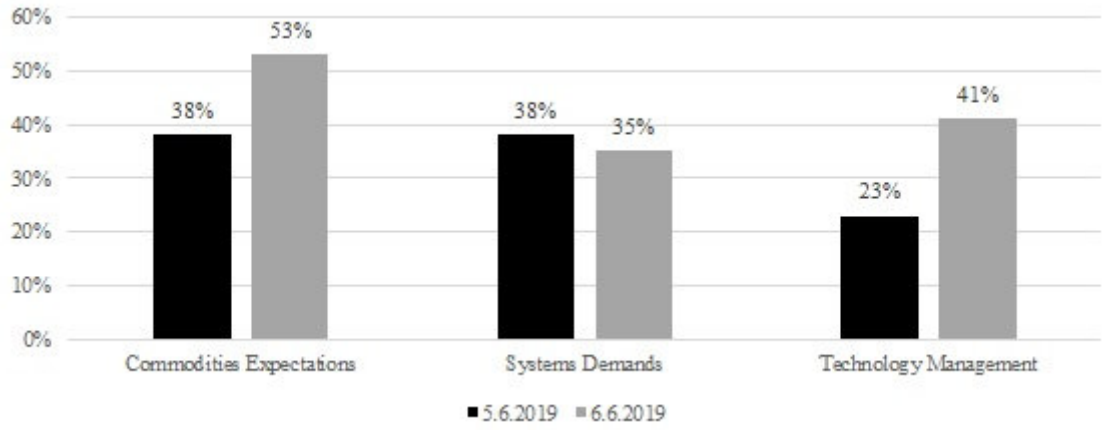


Figure 6 grouping game feeds based on content analysis

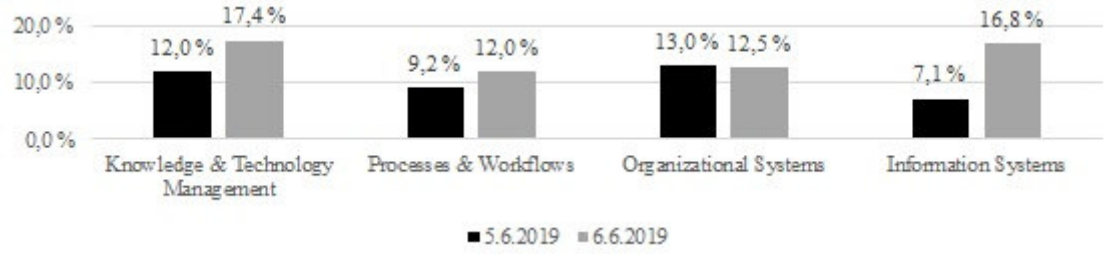


Figure 7 grouping game feeds to operations priorities based on content analysis

3.2 Evaluation of BCFI analysis responses

Total number of respondents was 14 of 65. Six replies received from different municipal engineering units and eight from different construction units. Not a single answer came from the division's administration. The respondents represent managers, experts and supervisors. The amounts are sufficient to describe the method. Reliability and validity of this study assessed by public feedback from stakeholders. Figure 8 shows the answers of all respondents.

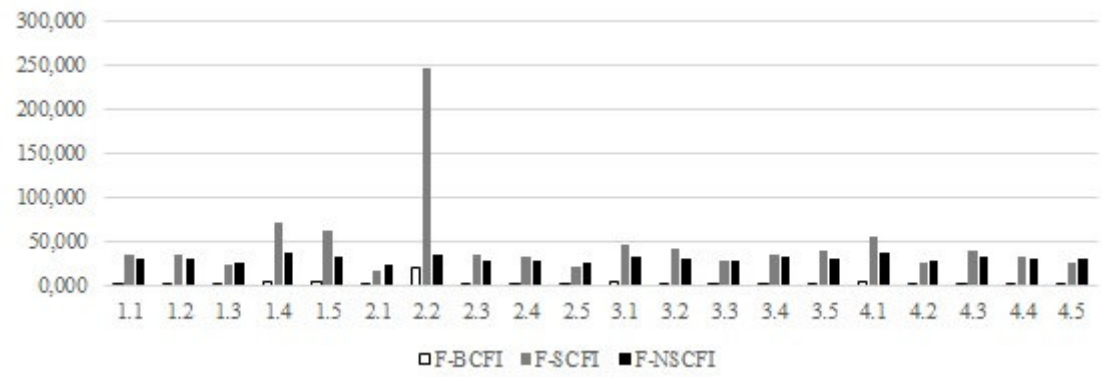


Figure 8 operations priorities for the division's management process

The figure compares a balanced CFI-analysis, a scaled CFI-analysis, and a normalized scale CFI-analysis. The difference between analyzes is in their sensitivity to statistics. The purpose of using three CFI analyses is more

easily to identify so-called weak signals among the indicators. The highest peak among the attributes of Processes & Workflows is number 2.2 *reducing unprofitable time* in subprocesses, In Knowledge & Technology Management the strongest feature is *adaptation* (1.4). In Organizational Systems, the strongest feature is *leadership* (3.1), and in Information Systems, *processes support* (4.1). The four factors point to the root cause.

On the other hand, these refer also to the need for change management and research on manufacturing strategy (Quality, Cost, Time, and Flexibility). Facility Management and Municipal Engineering organizations has been scattered across buildings in the city for more than a decade. A common identity could hardly form. There is a need for a division headquarters. To clarify the organizational structure, the director assembled nine units into a management process and two core service processes. The operating units in the processes are the Common services unit, the Infrastructure unit, and the Buildings unit.

Figures 9 and 10 demonstrate the respondents' view. The attributes with the biggest gap between past and future are the strongest ones. In fact, due to amount of basic and core technology in the units, some priorities that stands out. The Infrastructure unit, as known as the first core process emphasized adaptation to knowledge and technology (1.4), and reducing unprofitable time (2.2). The Buildings core process emphasized innovativeness and performance of research and development (1.2), timely delivery to stakeholders and customers (2.3), and reducing unprofitable time (2.2).

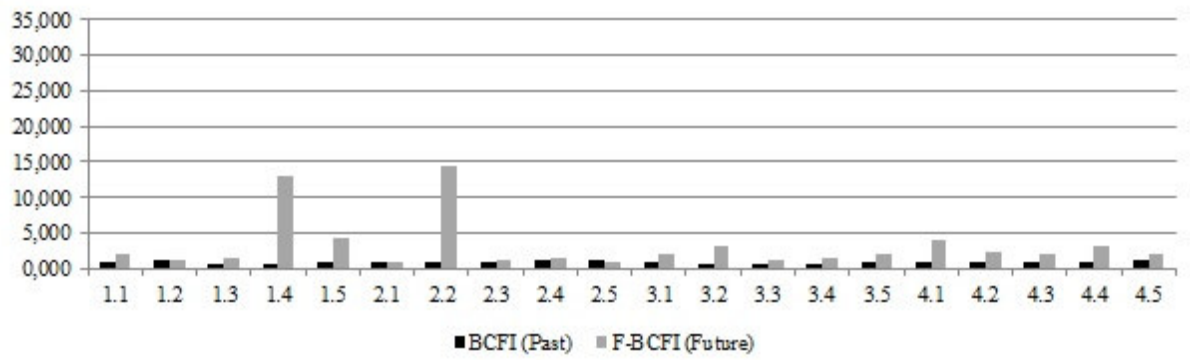


Figure 9 direction of development by experiences and expectations in the Infrastructure unit

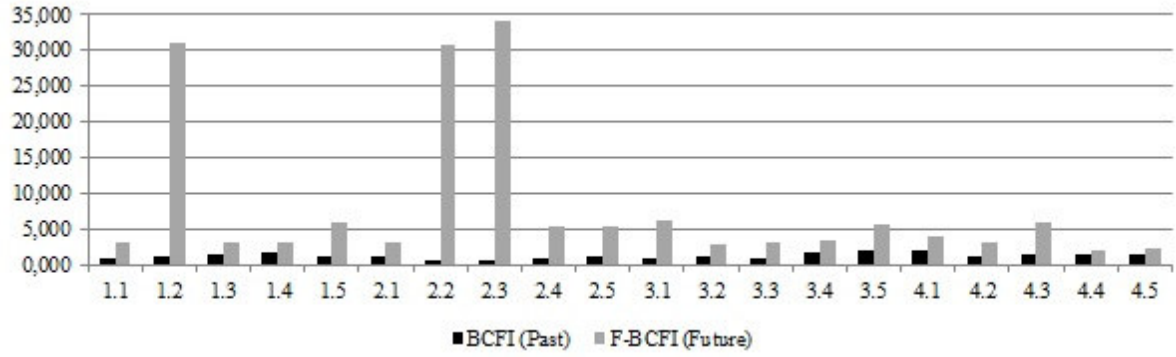


Figure 10 direction of development by experiences and expectations in the Buildings unit

The answers given by the division's staff suggest that the customer expectations and experiences in the service taken into account. The critical factors point to the aspects of the knowledge and technology management as well as the process and workflows. There are aligning with the findings from the city's command centre. Content analysis linked expectations and demand fluctuations to these. Improvement requires, for example the use of information technology, and usability of common systems.

On the other hand, looking at the holistic picture at the timeline, there are broader expectations to the information systems than those in the division's core processes not identified as critical. The exercises in the preparedness process generated and deepened a stakeholder-based view of expectations. Responding to these requires updating the Code of conduct.

3.3 Continuity management overview

The "paper & pen" content production method is reliable, deployment is fast, and it works in all circumstances. However, very exceptional circumstances are rare although possible. On the other hand, a diary is not

dynamic, and basic office application skills do not provide a competitive edge. Advanced Excel use is desirable because the program is widely used. Data exported to Excel can generate Gantt allocations, dynamic maps, and an interactive dashboard for the management team in the city's command centre.

Since it is not possible to do everything at once, choices have to make. There were not many critical factors in this study. If there were many, it would have been necessary to analyse mutual criticality in order of implementation. Then the AHP method needed. Competitive review is important. The corresponding author and the safety park task force made an excursion to Finland's oldest safety park. The joint-development project got so-called "meat around the bones" during the iteration rounds. Discussions and visits provided insight into what security-related activities could be, what should avoided, and how the actions selected would improve the observations made during the readiness exercise. As the preparedness process progressed, the findings taken into account in the emergency and local defence-training plan, and tested in the exercises.

The implementation of Security Strategy for Society and its concept for comprehensive security formed a common direction for technical services' development. Figure 11 gathers integration themes and viewpoints from iterations rounds into an EFQM-based [23] and evolving quality development model.

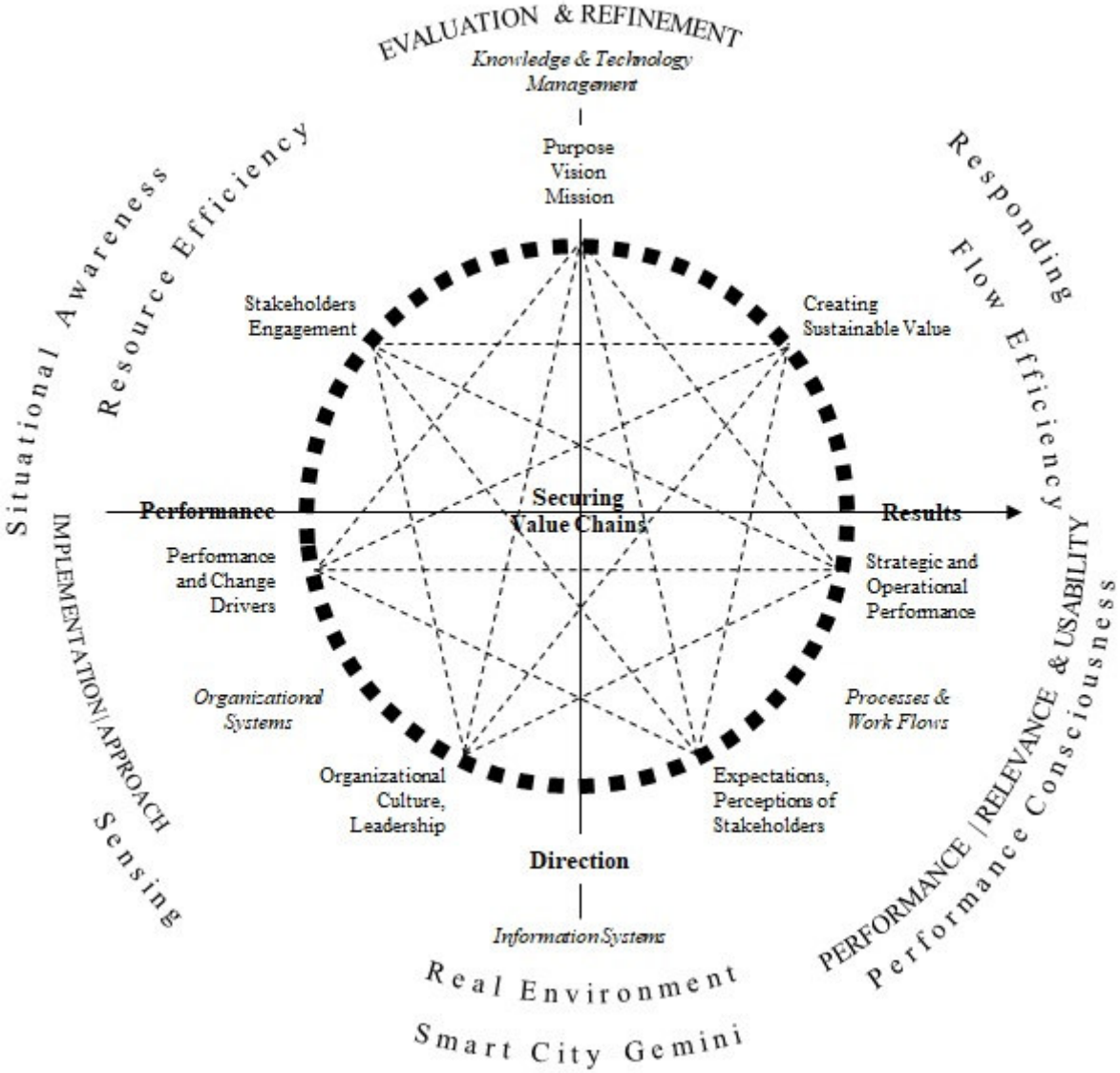


Figure 11 viewpoint integrator for the technical services division operating in the city by the sea

3.4 Public feedback and recognitions from stakeholders

According to risk management manager Kiiski the City of Kotka received a lot of positive feedback from the KYMI19 readiness exercise. Director general of Regional

state administrative agency of Southern Finland and actors from the Helsinki-Uusimaa Region, its 26 municipalities and a wide network of stakeholders, including YLE News, and HUS Helsinki University Hospital reported that the measurement (in the preparedness process) considered an extraordinary merit in practice [24].

The city of Kotka decides to participate in the Virtual Port Logistics Safety Park joint-development project with the Southeast Finland University of Applied Sciences. The aim of the project is to provide occupational health and safety education for port and industrial logistics companies, to create lasting conditions for a virtual development environment, and to find a financial solution to manage the safety park [25].

Referring to the three-year funding for the Virtual Port Logistic Safety Park joint-development project decision, the reasons for the decision are as follows. The applicant and the content of the project meet the specific objectives. The project supports the Kymenlaakso Smart Specialization Strategy by making a significant contribution to the development of industries important to the region (Logistics and Digitalization). There is a clear continuity in the exploitation of the project results. The project activities will launch and lay the foundations for the operation and further development of a physical safety park of port logistics.

Particular interest is the utilization of the virtual reality environment to manage the risks of a physical safety park and to develop new features or processes. The project received a score of 43/60 in the evaluation [26].

4 Conclusions

Approaching to management and implementing the city strategy of a 400-person organization involves identifying, evaluating, and in some cases redefining actions. In redefining, content analysis is important. In a year, the division found a purpose, direction and vision which are in line with the ones of the city. At the end of 2019, the technical services division launched co-operation negotiations to update the Code of conducts and restructure. Nine units will merge to three, and organizational levels will lower five to three closer to the customer interface.

The conclusion of action research is, a content analysis of situational factors creates certainty of interpretation about the direction of development of operational priorities. The phase plays a key role in the preparedness process like the PDSA cycle from content analysis (Planning phase) to discourse analysis (Doing phase), and to BCFI analysis (Studying phase) to strategic decision-making (Action phase). The value chain becomes secured in the process in a measurable and sustainable way, transforming intangibles assets into tangible assets.

The study identified the need for deeper research. Analysing the manufacturing strategy would give the city an insight into other organizations studied in different countries around the world. In order to realize the city's vision of being the gateway to new opportunities, carry out further research is well founded.

Acknowledge

The city of Kotka has an example of turning intangibles into tangible benefits: visionary park architecture that utilizes its maritime war history. It is interesting how marine environment and especially many praised parks, contributes to the identity of the transforming hybrid organization. The whole region benefits from the values of sustainable development. The work on the parks has been going on for decades, and the culmination of the work can see as having received three simultaneous Green Flag Awards at 2019 [26]. These three city parks represent 60 % of all five awarded parks in Finland. It can say that the city by the sea is a real capital of parks in Finland. A significant environmental activity that has influenced the quality of life the residents is the Catharine Sea Park. The former oil industry area of the Port of HaminaKotka Ltd has transformed into a seaside park. The park attracts 250,000 visitors every year. In this context, it is good to acknowledge Mr. Heikki Laaksonen, the City Gardener of Kotka, whose work for the city and society been recognized with the Finnish honorary title of *puutarhaneuvos* [27]. Successful examples of sustainable development invite others, like Google Ltd, to establish themselves to the very good marketplace [28].

References

[1] 21 Cities, Government Program Goals 2019, [Online], Available: https://www.hel.fi/static/kanslia/Julkaisut/2019/Hallitusohjelmatavoitteet-2019-C21.pdf, [20 Feb 2020], 2019. (Original in Finnish)

[2] Statistic Finland, Share of Foreign Background-%, [Online], Available: http://pxnet2.stat.fi/explorer/Maahanmuuttajat_2017/kuntakartta.html [22 Feb 2020], 2017. (Original in Finnish)

[3] Kotka-Hamina District Council, Kotka-Hamina Region Proceedings 2018, Kotka, 2019. (Original in Finnish)

[4] The World of Logistics, Freight terminals – Port of HaminaKotka, [Online], Available: http://www.logistikanmaailma.fi/huolinta-terminaalit/satama/haminakotka-satama/ [22 Feb 2020], 2018. (Original in Finnish)

[5] City of Kotka Budget 2020, Financial Plan 2020-2022, pp. 33-49, Kotka, City Council § 131, 2019. (Original in Finnish)

[6] Ministry of Defence, the Security Strategy for Society, Helsinki, Government Resolution, 2017.

[7] VORNANEN, V-J.: *Joint Performance – Preparedness in the Municipal Transformation 2009-2015: Securing the Value Chain by Operations Strategy Implementation*, Doctoral thesis by publication, Acta Wasaensia, 369, University of Vaasa, 2017. (Original in Finnish)

[8] VORNANEN, V-J, YANG, L., TAKALA, J.: Implementing Sustainable Competitive Advantage to

the Public Sector's Management System – by Sense and Respond Methodology in Facilities Services Unit's Preparedness, *Management and Production Engineering Review*, Vol. 4, No 3, pp. 76-86, 2013. Doi: 10.2478/mper-2013-0031.

[9] VORNANEN, V-J., SIVULA, A., YANG, L., TAKALA, J.: *Mutual Trust: Joint Performance of an Operations Strategy Implementation – Securing the Value Chain by Preparedness*, in KOZUCH, B., MAGALA, S.J., PALISZKIEWICZ, J. (ed.) *Managing Public Trust*, Cham, Palgrave Macmillan, 2018.

[10] Global Environmental Management Initiative, Clear Advantage: Building Shareholder Value, [Online], Available: http://gemi.org, [24 Feb 2020], 2004.

[11] AVERILL, D.: *Lean Sustainability. Creating Safe, Enduring, and Profitable Operations*, Boca Raton, CRC Press, 2011.

[12] VORNANEN, V-J., TAKALA, J.: Towards Joint Performance: Building Dynamic Capabilities for Public Critical Asset Maintenance, *Management,* Vol. 9, No. 3, pp. 239-257, 2014.

[13] VORNANEN, V-J., SIVULA, A., TAKALA, J.: Hybrid Management in Preparedness: Utilizing Cooperation and Crowdsoursing to Create Joint Performance in the Logistic Society, *Management,* Vol. 11, No. 2, pp. 152-170, 2016.

[14] TUOMI, V.: *Quality Management in Public Sector. What Kind of Quality Management There Is and How It Is Implemented – Some Cases from Universities Academic Libraries and Health Care Services Between the Years 2000–2010,* Doctoral thesis by publication, Acta Wasaensia, 266, University of Vaasa, 2012. p.18.

[15] SAATY, T.L.: *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*, New York, McGraw-Hill International Book Co., 1980.

[16] News from Port of HaminaKotka, KYMI 219 local defense exercise at Port of HaminaKotka, p. 4, Kotka, Loiste, Online publishing, 2019.

[17] KRIPPENDORF, K.: *Content Analysis: An Introduction to Its Methodology*, 2nd edition, Thousand Oaks, CA: Sage, 2004.

[18] TUOMI, J., SARAJÄRVI, A.: *Qualitative Research and Content Analysis*, Jyväskylä, Gummerus Kirjapaino Oy, 2004. (Original in Finnish)

[19] KAPLAN, R.S., NORTON, D.P..: *Strategy Maps: Converting Intangible Assets into Tangible Outcomes*, Boston, MA, Harvard Business School Press, 2004.

[20] NADLER, D., TAKALA, J.: *The Development of the Critical Factor Index Method*, University of Vaasa, Department of Production, 2008.

[21] HAECKEL, S.H.: *Adaptive Enterprise: Creating and Leading Sense-and-Respond Organizations*, Harvard Business Press Books, 1999.

[22] RANTA, J.M, TAKALA, J.: A Holistic Method for Finding out Critical Features of Industry Maintenance Services, *International Journal of Services and Standards,* Vol. 3, No. 3, pp. 312-325, 2007.

[23] EFQM, EFQM Model, [Online], Available: https://www.efqm.org/index.php/efqm-model/, [7 March 2020], 2020.

[24] KIISKI, R.: Kotka receives a lot of positive feedback about the KYMI19 process, e-mail to corresponding author (vesa-jukka.vornanen@kotka.fi), 28 Nov [28 Nov 2019], 2019. (Original in Finnish)

[25] Urban Board of the City of Kotka, the participation decision § 125, [17 Sep 2019], 2019. (Original in Finnish)

[26] Kymenlaakso Regional Council, the funding decision § 10/2019, [16 Dec 2019], 2019. (Original in Finnish)

[27] YLE News, Three manicured parks in Kotka receive Green Flag Award, [Online], Available: https://yle.fi/uutiset/osasto/news/three_manicured_parks_in_kotka_receive_green_flag_award/10880541, [2 March 2020], 2019.

[28] YLE News, Heikki Laaksonen got the Finnish honorary title of puutarhaneuvos, [Online] Available: https://yle.fi/uutiset/3-5866569 [4 March 2020], 2009. (Original in Finnish)

[29] Business Finland, Google praises Finland's business environment and invests another EUR 600 million to expand data centres, [Online], Available: https://www.businessfinland.fi/en/whats-new/news/invest-in-finland/2019/google-praises-finlands-business-environment-and-invests-another-eur-600-million-to-expand-data-centres/, [2 March 2020], 2019.

Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 7 2020 Issue: 3 Pages: 155-166 ISSN 1339-5629

doi:10.22306/al.v7i3.165 *Received: 03 Apr. 2020; Revised: 20 July 2020; Accepted: 20 Sep. 2020*

DESIGN LOGICAL LINGUISTIC MODELS TO CALCULATE NECESSITY IN TRUCKS DURING AGRICULTURAL CARGOES LOGISTICS USING FUZZY LOGIC

Ievgen Medvediev
Volodymyr Dahl East Ukrainian National University, Department of Logistics Management and Traffic Safety in Transport, 59-a, Central Ave., Sievierodonetsk, 93400, Ukraine, medvedev.ep@gmail.com
Dmitriy Muzylyov
Kharkiv Petro Vasylenko National Technical University of Agriculture, Department of Transport Technology and Logistics, 44, Alchevskyh St., Kharkiv, 61002, Ukraine, murza_1@ukr.net
Natalya Shramenko
Kharkiv Petro Vasylenko National Technical University of Agriculture, Department of Transport Technology and Logistics, 44, Alchevskyh St., Kharkiv, 61002, Ukraine, and too
Ukrainian State University of Railway Transport, Department of Operational Work Management, 7, Feierbakh Square, Kharkiv, 61000, Ukraine, nshramenko@gmail.com
Pavlo Nosko
National Aviation University, Mechanical Engineering Department, 1, Lubomir Husar Ave., Kyiv, 02000, Ukraine, nosko_p@ukr.net
Peter Eliseyev
Volodymyr Dahl East Ukrainian National University, Department of Machine Science and Industrial Enterprises Equipment, 59-a, Central Ave., Sievierodonetsk, 93400, Ukraine, peter_eliseyev@ukr.net
Vitalii Ivanov
Sumy State University, Department of Manufacturing Engineering, Machines and Tools, 2, Rymskogo-Korsakova St., Sumy, 40007, Ukraine, ivanov@tmvi.sumdu.edu.ua (corresponding author)

Keywords: fuzzy logic, transportation, terms, harvesting and transport complex, fuzzification, membership function
Abstract: The study is aimed to develop the logic-linguistic models to design a number of rules for the correct calculation of the vehicles needed, taking into account the technical, technological, and weather and climate conditions of the harvesting and transport complex. The article has shown that the construction of the design of logic-linguistic models was not performed earlier to solve the problem of the agro-industrial production transportation support, considering the opportunity of forecasting size of influences of the weather and climatic factors on improving the productivity of the harvesting and transport complex elements. It is determined that the experience of applying the fuzzy logic theory in many practice situations confirms the universality of the mathematical apparatus. This toolkit provides better results than classical approaches (set theory, probability theory). This aspect indicates the expediency of the chosen mathematical apparatus for solving the tasks. The article using fuzzy logic explores the relationship and interdependence of technical, technological factors and weather and climate conditions for modeling transport support in harvesting and transport complex. Fuzzification of the parameters is carried out, based on the compiled equations using trapezoidal and triangular membership functions. The set of rules necessary for the creation of logical-linguistic models (LLM) for each factor has been arranged. LLMs were developed for dependent parameters, which will allow further modeling of the transport support of the harvesting and transport complex in the Fuzzy Logic Toolbox application of the MATLAB package.

1 Introduction

Transport support in agriculture, as in other industries, plays a key role. The consumer price of products largely depends on the efficiency planing of the transportation process. This is because the share of the cost of transportation is 20-30% of the final cost [1,2]. This trend is especially clearly seen in the delivery of agricultural goods during harvesting.

This period is characterized by the intensification of the use of rolling stock and harvesting equipment (combines, tractors, etc.). Therefore, the complexity of the organization of transport services at a sufficient quality level increases. In this case, the main factor for improving the reliability of the logistics system is the accuracy of determining the required number of trucks for the transportation of agricultural goods.

Based on the practice of functioning and interaction of the harvesting and transport complex (HTC) elements during the harvest, there is a problem of ensuring uninterrupted operation between harvesting equipment and vehicles. There is an option to solve this problem by applying standard technological solutions [3,4]. It is

possible to take into account technological aspects using probabilistic approaches [5-8], as well as risk theory [9]. However, in order to properly plan the operation of the harvesting and transport complex, it is necessary to predict the harvesting time and possible timing. To do this, the model should include parameters that take into account weather and climatic conditions.

Therefore, the use of fuzzy logic to build logical-linguistic models is the most correct. Indeed, the application of this approach allows fully reducing the fuzziness in the system under consideration, which will allow us to determine the required number of trucks with a smaller error for various scenarios than with the use of probability theory [10].

The study aims to develop the logical and linguistic models that allow creating a set of rules for the correct calculation of the necessity of the vehicle, taking into account the technical, technological, and weather and climatic conditions of the harvesting and transporting complex.

2 Literature Review

The experience of using fuzzy logic in logistics and transport systems proves the appropriateness of using this mathematical apparatus when it is necessary to consider fuzzy parameters during model building.

One of the first problems that were successfully solved using the fuzzy logic apparatus were tasks in the medical field. Today, this issue is also significantly reflected in modern research, additionally using neural-network models [11]. Similar approaches are used in logistics and to improve the functioning of various types of transport systems.

Fuzzy logic has been successfully applied to increase the safety of vehicles on the road network sections in the settlements [12] at the beginning of the 21st century. Several works were carried out in the area of smart transport systems, where the issues of timely determination of congestion [13,14] and general problems of managing saturated traffic flows were solved, using the hierarchy method to assess the different levels of control [15,16]. Another practical area of application of fuzzy logic, according to the results of research in the sphere of road transport, is designing an evolutionary-type model for the prediction of possible traffic accidents in city networks [17].

The next study was based on an approach that would maximize profits when planning the transportation of solid materials using pipelines. The solution to the problem was made possible by creating a new design of fuzzy logic systems (IT2FLS) type interval 2 [18].

Separately, it is worth noting the use of the fuzzy logic apparatus in solving the multiobjective nonlinear transportation problem (MNOTP), where the weighting coefficients of the membership functions are presented particularly [19]. Fuzzy logic is also used in large-scale research, for example, in determining the overall level of security of transport infrastructure. It can be done only by fixing the uncertainty of environmental threats the transport infrastructure faces, as well as its resistance to damage and the consequences of damage [20]. Such approaches are often used in the absence of the possibility of obtaining the necessary statistics or complete lack of data.

Often the fuzzy models are used to organize traffic routes of various modes of transport: automobile [21,22], rail transportation [23], and ship navigation [24]. Routing aspects are important enough to determine the best option for transport support of any industry [25]. An innovative solution to this problem was the use of a modified ant algorithm [26]. It should be noted that when building a supply chain that includes a distribution center, a fuzzy theory application is also possible [27].

As for the issues of transport support for the agricultural sector, these tasks were considered using the fuzzy logic apparatus of the fleet of vehicles, primarily involved in harvesting [28]. A similar study was conducted to optimize the work of the farm in growing tomatoes [29]. The fundamental research in terms of the transport process planning in agriculture was a study designed to solve the main transportation problems by adjusting the membership functions to the specifics of the system under study. In this case, only three factors were considered that were associated only with the technical aspects of transportation [30].

When planning the delivery of agricultural products, the key role is played by the issues of coordinated work of harvesting and transport equipment. At the same time, ensuring coordinated interaction can be achieved using the theory of fuzzy sets and neural networks to obtain accurate forecasts in difficult to predict operating conditions. From this point of view, studies were conducted for determining the transshipment volumes of grain in logistics systems [31-32], as well as the calculation of demand in ports of departure depending on soybean production [33]. Moreover, according to studies, in general, supply chain management should be based on the use of models with the necessary data coverage [34]. A similar sample is shown when constructing supply chain options for the delivery of grain cargo by three transport modes [35]. However, a classical approach is presented here, using the Petri nets apparatus, which does not always allow finding an unambiguous optimum.

Regardless of the specifics of the fuzzy logic apparatus application, the key aspect was the correctness of the formulation of many terms and, as a result, the correctness of constructing a logical-linguistic model (LLM). In the paper [36] an example of the logical-linguistic models' development with the programming languages using the classical Zadeh theory is shown.

It should be noted that LLMs are used along with mathematical ones and are the most productive for the efficient presentation of data. Based on logical-linguistic models, it is possible to implement the creation of an

intelligent interface of computer programs and the operating system as a whole [37].

The logical-linguistic models are the most acceptable type of models used in intelligent systems for processing complex structures of diverse types of data and knowledge. A typical example of the LLM is the concept that reflects the laws inherent in classes of objects [38].

The information sources and scientific literature analysis showed that the construction of the logical and linguistic model was not carried out earlier for the transport support of agricultural production, considering the results of forecasting values of the weather and climate factors influence on improving the efficiency of the HTC elements functioning.

The diversity of the fuzzy logic theory application testifies to the universality of the mathematical apparatus, which, when solving various problems, shows better results than classical approaches. Therefore, this is another proof of the relevance of the selected tools for solving the given tasks.

3 Research Methodology

3.1 Research tasks

To achieve the goal, a research structure has been developed, according to which must be resolved the next problems:

1. Segregation of the future model parameters into dependent and independent according to the formed logical chains;
2. Definition of the influential dependent parameters and those affected by the system elements;
3. Formation of the logical chains that show the interconnection and interdependence of the parameters when modeling the transportation support for the HTC;
4. Assignment of terms for each term-set of linguistic variables;
5. Fuzzification for each system parameter;
6. Development of logical-linguistic models. Adjustment of the set of rules for each model.

The final step is the result of this study. At the same time, the constructed logical-linguistic models with the formed individual set of rules will act as initial information at the next stage of the study - computer simulations using the Fuzzy Logic Toolbox profile package in the MATLAB simulation shell.

3.2 Parameters classification

The classification of parameters was performed in order to develop a matrix for constructing logical chains. At the same time, an object-independent approach is practiced. It involves a third-party assessment of the objects presented for classification. They should be assessed objectively, which is possible with the involvement of independent experts [39-41]. As a result, dependent and independent parameters are highlighted. Independent parameters are marked with "-" and dependent parameters are marked with "+". The results are presented in Table 1.

Table 1 Classification of dependent and independent parameters

Dependent parameter "+"	Independent factors "-"
Soil condition	Rain
	Dew
Crop productivity	Hail
Crop moisture	Field size
Lodging	Soil moisture content
Quantity of harvesters	Harvester header width
Harvester speed	Road type
Harvester efficiency	Load capacity of vehicles (trucks)
Quantity of vehicles (trucks)	Distance from field to the threshing-floor
Vehicles (trucks) operating speed	
Vehicles (trucks) turnover time	
Method of harvesting	

The presented classification fully reflects the objective opinion of various expert groups on the degree of influence or independence of each parameter from the set of proposed factors. Table 1 allows establishing the influence levels of both dependent factors and independent ones. This will allow us to more correctly formulate the future logical-linguistic model, which in the conditions of fuzziness makes it possible to reduce the error in obtaining the final result – the number of vehicles involved in the transport support.

3.3 Definition of influence levels of independent to dependent parameters

The classification of the basic conditions for the HTC operation and consideration of the experts' recommendations made it possible to identify the levels of the interdependence of parameters. Thanks to this aspect, it is possible to determine the dependence of the studied factors. It should be noted that the dependence of the parameters will occur both in the context of "dependent parameters – independent parameters", and in the logical chain "dependent parameters – dependent parameters". Dependent parameters are listed, and their dependence on independent parameters is indicated (Table 2):

Table 2 Influence levels of independent to dependent parameters

Independent factors which influence	Influenced dependent parameters
Rain	Soil condition
	Crop moisture
	Lodging
	Vehicles (trucks) operating speed
Dew	Crop moisture
Hail	Lodging
Field size	Quantity of trucks
Soil moisture content	Soil condition
Combine header width	Combine efficiency
Road type	Vehicles (trucks) operating speed
Load capacity of vehicles (trucks)	Vehicles (trucks) turnover time
Distance from field to the threshing-floor	Vehicles (trucks) turnover time

Based on Table 2, we can conclude that the most significant (from the point of view of the number of influence levels) is the independent parameter "Rain". This factor affects four elements of the system under study. Therefore, when constructing logical chains, "Rain" should be reflected in the largest number of them.

Similarly, the study performed the formation of levels of interconnections in the logical chain "dependent parameters – dependent parameters". The results of the procedure were reflected in the development of the final logical chains presented in the matrix (Table 3).

3.4 Formation of logical chains

When developing future logical-linguistic models, it is important to pay attention to the primary technological, technical, and weather-climatic aspects in which the transport support of the harvesting and transport complex takes place [42,43]. For this, matrix-forming logical chains were created (Table 3).

Based on Table 1, three alternatives for constructing logical chains are identified, which are built on, apart from the technical and technological aspects of the HTC operation, weather, and climatic factors. The latter primarily affect the start time of the harvesting and its duration, which ultimately determines the quantitative need for rolling stock. Moreover, the largest number of construction chains are based on the weather conditions of the harvesting and transport complex. This will naturally affect the construction of logical-linguistic models in subsequent stages.

3.5 Definition of fuzzy term-sets and finding values of linguistic variables

The preparatory stage should be carried out in order to complete the fuzzification (the transition from a clear set to a fuzzy one) [44]. It consists of the development of term sets for each model and, accordingly, the definition of the values of linguistic variables for a particular term. The results of the procedure are presented in Table 4 for independent factors.

The results of parametric identification are performed for dependent factors in Table 5.

Table 3 Matrix of logical chains for design linguistic models

Kind of factor	Initial parameter	Transit chain	Result
Weather conditions	Rain	Lodging-method of harvesting-harvester speed-harvester efficiency-quantity of harvesters	Quantity of trucks
		Soil condition- harvester speed-harvester efficiency-quantity of harvesters	
		Lodging- crop productivity-quantity of harvesters	
		Vehicles (trucks) operating speed-vehicles (trucks) turnover time- quantity of harvesters	
	Hail	Lodging-method of harvesting-harvester speed-harvester efficiency-quantity of harvesters	Quantity of trucks
		Lodging- crop productivity-quantity of harvesters	
	Dew	Crop moisture-method of harvesting-harvester speed-harvester efficiency-quantity of harvesters	Quantity of trucks
		Crop moisture- crop productivity-quantity of harvesters	
Technical aspects	Soil moisture content	Soil condition-harvester speed-harvester efficiency-quantity of harvesters	Quantity of trucks
	Harvester header width	Harvester efficiency-quantity of harvesters	Quantity of trucks
	Load capacity of vehicles (trucks)	Vehicles (trucks) turnover time-quantity of harvesters	Quantity of trucks
Technological aspects	Road type	Vehicles (trucks) operating speed-vehicles (trucks) turnover time-quantity of harvesters	Quantity of trucks
	Distance from field to the threshing-floor	Vehicles (trucks) turnover time-quantity of harvesters	Quantity of trucks
	Field size	Quantity of combine harvesters	Quantity of trucks

It should be noted that to highlight the values of linguistic variables, both expert recommendations and mathematical expediency were used at the same time. The latter refers to the minimum possible allocation of the number of ranges (terms) by the factor to prevent the massiveness of the final model. Indeed, this can reduce the speed of calculations or lead to the inability to experiment as a whole.

3.6 Parameter system fuzzification and designing of membership functions

The next step is the process of fuzzification of system parameters. Thanks to this procedure, it is possible to convert fuzzy parameter values to linguistic truth-values [45].

A comparative assessment between membership functions has shown that triangular and trapezoid membership functions will best represent dependencies. A similar type of function is often used in solving logistic problems. Confirmation of this is one of the latest studies performed when choosing a route in the formation of the supply chain in fisheries [46].

Fuzzification was performed for all dependent and independent parameters using the classical approaches of the theory of fuzzy logic,. As an example, this article discusses a procedure based on the logical link “Dew” (independent factor) “Crop moisture” (dependent factor). The choice of this pair is because the independent factor (“Dew”) is harder to predict than the three aspects of the considered weather and climate conditions. In this case, the dependent parameter (“Crop moisture”) plays a key role in choosing the start time of the harvest and the total duration of the harvesting and transport complex, at which the harvested crop will be of the best quality.

Triangular and trapezoidal membership functions are the simplest, according to the research study [47]. These functions are formed using the piecemeal-linear approximation. The trapezoidal membership function is a generalization of triangular function. It allows you to specify the core of a fuzzy set in interval form. Following convenient interpretation is possible in case of trapezoidal membership function: a core of a fuzzy set is an optimistic estimate; fuzzy set carrier – pessimistic evaluation. Triangular and trapezoidal membership functions are most widely used in practical applications according to the work of prof. Rothstein [48]. These two studies explain why such types of membership functions are expediently for using during the experiment.

Fuzzification for the parameter "Dew" will take the following form (Figure 1).

Table 4 Terms and values of linguistic variables for independent parameters

Parameters / conditions	Term	Index
Rain	Lingering	10-20 mm
	Heavy	10 mm
	Short term	5 mm
Dew	Long	7 hr
	Moderate	5 hr
	Short-term	2 hr
Hail	Heavy	10 mm
	Moderate	5 mm
	Small	2-3 mm
Field size	Large	500 ha
	Medium	200-300 ha
	Small	100 ha
Relative soil wetness	High	61,8 %
	Moderate	50 %
	Low	44 %
Header width	Large	11 m
	Medium	7-10 m
	Small	3-6 m
Road type	With improved coating	51-60 km/h
	Grader	35-50 km/h
	Steppe	18-35 km/h
	Field	12-18 km/h
Load capacity	High	20 t
	Higher than average	10-12 t
	Average	5-7 t
	Low	3 t
Distance from field to threshing floor	Long	40 km and more
	Higher than average	20-35 km
	Medium	10-19 km
	Short	2-9 km

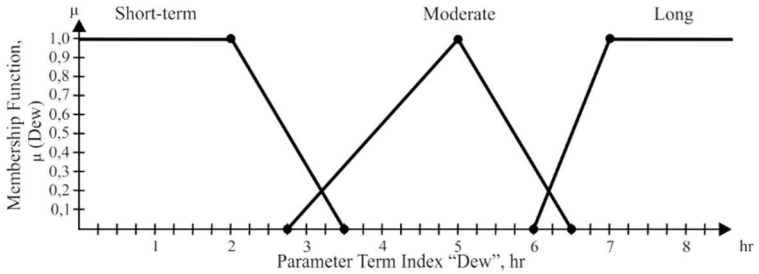


Figure 1 Graphic of fuzzification result for independent parameter 'Dew'

A calculation was also performed for trapezoidal and triangular) membership functions $\mu(u)$ for the parameter "Dew".

Table 5 Terms and values of linguistic variables for dependent parameters

Parameters / conditions	Term	Index
Soil Condition	Satisfactory	Dry
	Unsatisfactory	Wet
Crop productivity	The highest	50 c/ha and more
	Medium	37,5 c/ha
	Lowest	25 c/ha and less
Crop Moisture	High	25 % and more
	Medium	18 %
	Normal	16 %
Lodging	High	<25 %
	Medium	<15 %
	Low	5 %
Number of Combine Harvesters	High	5 units and more
	Medium	3-4 units
	Low	2 units
Combine Harvester Speed	High	10 km/h
	Normal	5-7 km/h
	Low	2-3 km/h
Combine efficiency	High	5,5 ha/h
	Medium	4,5 ha/h
	Low	3 ha/h
Number of transport means	Above normal	6 units and more
	Normal	3-5 units
	Insufficient	2 units
Vehicles (Automobile) Operational Speed	High	51-60 km/h
	Higher than average	35-50 km/h
	Average	18-35 km/h
	Low	12-18 km/h
Vehicles (Automobile) Time of Turnover	Fast	10-20 min
	Satisfactorily	21-40 min
	Slow	41-60 min
Harvesting Method	Direct	1
	Separate	0

$$\mu(u)=\begin{cases}0, & u\le 0 \text{ if } u\ge 3,5\\ 1, & 0\le u\le 2\\ \dfrac{3,5-u}{3,5-2}=\dfrac{3,5-u}{1,5}, & 2\le u\le 3,5\end{cases}, \quad (1)$$

$$\mu(u)=\begin{cases}0, & u\le 2,75 \text{ if } u\ge 6,5\\ \dfrac{u-2,75}{5-2,75}=\dfrac{u-2,75}{3}, & 2,75\le u\le 5\\ \dfrac{6,5-u}{6,5-5}=\dfrac{6,5-u}{1,5}, & 5\le u\le 6,5\end{cases} \quad (2)$$

$$\mu(u)=\begin{cases}1, & 7\le u\le 8{,}5\\ \dfrac{u-6}{7-6}=\dfrac{u-6}{1}, & 6\le u\le 7\end{cases} \quad (3)$$

where u – considered fuzzy parameter; $\mu(u)$ – membership function.

Fuzzification for the "Crop moisture" parameter is shown in Figure 2.

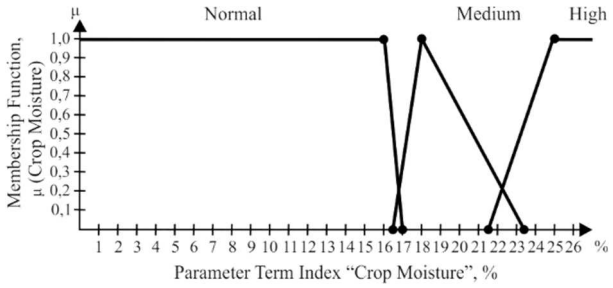


Figure 2 Graphic of fuzzification result for independent parameter "Crop moisture"

Similarly to the "Dew" factor, the membership functions were calculated $\mu(u)$ for "Crop moisture".

$$\mu(u)=\begin{cases}0, & u\le 0 \text{ if } u\ge 17\\ 1, & 0\le u\le 16\\ \dfrac{17-u}{17-16}=\dfrac{17-u}{1}, & 16\le u\le 17\end{cases} \quad (4)$$

$$\mu(u)=\begin{cases}0, & u\le 16{,}5 \text{ if } u\ge 23{,}25\\ \dfrac{u-16{,}5}{18-16{,}5}=\dfrac{u-16{,}5}{1{,}5}, & 16{,}5\le u\le 18\\ \dfrac{23{,}25-u}{23{,}25-18}=\dfrac{23{,}25-u}{5{,}25}, & 18\le u\le 23{,}25\end{cases} \quad (5)$$

$$\mu(u)=\begin{cases}1, & 25\le u\le 27\\ \dfrac{u-21{,}5}{25-21{,}5}=\dfrac{u-21{,}5}{3{,}5}, & 21{,}5\le u\le 25\end{cases} \quad (6)$$

The final table with a set of rules for each of the 11 developed logical-linguistic models can be represented as follows (Table 6).

The presented example allows building a logical-linguistic model of the dependent variable "Crop moisture". The fuzzification procedure was carried out similarly for the other factors of the functioning of transport services during the harvesting period described in Section 3.1.

4 Results and Discussion

Eleven logical-linguistic models were built as a result of the study. At the same time, for example, the fuzzy mathematical model of "Crop moisture" in the form of a linguistic model consists of 9 rules and will take the following form:

$$\begin{cases}IF\text{ "Rain }Short\ term\text{"}\rightarrow THEN\text{ "Crop moisture }Normal\text{"}\\ IF\text{ "Rain }Heavy\text{"}\rightarrow THEN\text{ "Crop moisture }Medium\text{"}\\ IF\text{ "Rain }Lingering\text{"}\rightarrow THEN\text{ "Crop moisture }High\text{"}\\ IF\text{ "Dew }Short\ term\text{"}\rightarrow THEN\text{ "Crop moisture }Normal\text{"}\\ IF\text{ "Dew }Moderate\text{"}\rightarrow THEN\text{ "Crop moisture }Medium\text{"}\\ IF\text{ "Dew }Long\text{"}\rightarrow THEN\text{ "Crop moisture }High\text{"}\\ IF\text{ "Dew }Short\ term\text{"}\rightarrow AND\text{ "Rain }Short\ term\text{"}\rightarrow THEN\text{ "Crop moisture }Normal\text{"}\\ IF\text{ "Dew }Moderate\text{"}\rightarrow AND\text{ "Rain }Heavy\text{"}\rightarrow THEN\text{ "Crop moisture }Medium\text{"}\\ IF\text{ "Dew }Long\text{"}\rightarrow AND\text{ "Rain }Lingering\text{"}\rightarrow THEN\text{ "Crop moisture }High\text{"}\end{cases} \quad (7)$$

Table 6 Resulting table with rules quantities for each logical linguistic model

Fuzzy logical linguistic model	Rules quantity
Soil condition	9
Crop productivity	3
Crop moisture	9
Lodging	9
Quantity of harvesters	15
Harvester speed	4
Harvester efficiency	11
Quantity of vehicles (trucks)	6
Vehicles (trucks) operating speed	6
Method of harvesting	11
Vehicles (trucks) turnover time	15

Table 6 shows that the most cumbersome is LLM, which determines the technology of the transportation process and the harvesting equipment operation. These models consist of 15 rules, which makes it necessary to take into account more conditions when calculating the number of harvesting combines needed, as well as planning the turnover time for trucks involved directly in the transportation of the HTC. Therefore, in order to avoid the disruptions in possible operation, these two indicators should be agreed upon to exclude both the downtime of the combine waiting for the truck and, conversely, the formation of a queue of empty trucks near the field.

5 Conclusion

The paper studies the interconnections and interdependencies of the technical, technological factors and weather and climate conditions for further modeling of the transport support for the harvesting and transport complex. A classification is made with finding mutual influence between the variables of the system under study. Based on this, the matrix of logical chains between the parameters (weather, climate, technical, and technological) is developed.

The process of assigning terms to each of the dependent and independent parameters was carried out, and the values of linguistic variables were assigned. Parameters were fuzzified based on the equations made using trapezoidal and triangular membership functions. The set of rules necessary for creating logical-linguistic models (LLM) for each factor has been compiled.

The logical-linguistic models have been developed to solve the problem of transport support for agro-industrial production, considering the opportunity to forecast values of the weather and climatic factors that influence the efficiency increase of the harvesting and transport complex elements functioning.

The developed LLM for dependent parameters will allow further modeling of the transport support of the harvesting and transport complex in the Fuzzy Logic Toolbox application in the MATLAB package. According to the results, you can get a set of rules for all the elements of the fuzzy system, in which the required number of trucks is more accurately calculated under various, even the most implicit, conditions of operation of the HTC.

Acknowledgment

The authors express their gratitude to Vasyl Hromyak, Ph.D. (Agricultural Sciences), Associate Professor, Head of Laboratory of Protection and Rational Use of Lands National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky.

References

[1] MUZYLYOV, D., SHRAMENKO, N., SHRAMENKO, V.: Integrated business-criterion to choose a rational supply chain for perishable agricultural goods at automobile transportations, *International Journal of Business Performance Management*, Vol. 21, No. 1/2, pp. 166-183, 2020. doi:10.1504/IJBPM.2020.10027634

[2] SHRAMENKO, N., MUZYLYOV, D., HRAMENKO, V.: Methodology of costs assessment for customer transportation service of small perishable cargoes, *International Journal of Business Performance Management*, Vol. 21, No. 1/2, pp. 132-148, 2020. doi:10.1504/IJBPM.2020.10027632

[3] MUZYLYOV, D., SHRAMENKO, N.: Mathematical Model of Reverse Loading Advisability for Trucks Considering Idle Times. In: Karabegović I. (eds) New Technologies, Development and Application III. NT 2020, Lecture Notes in Networks and Systems, Vol. 128, pp. 612-620, Springer, Cham, 2020. doi:10.1007/978-3-030-46817-0_71

[4] STRAKA, M., LENORT, R., KHOURI, S., FELIKS, J. Design of Large-Scale Logistics Systems using Computer Simulation Hierarchic Structure, *International Journal of Simulation Modelling*, Vol. 17, No. 1, pp. 105-118, 2018. doi:10.2507/ijsimm17(1)422

[5] MAKAROVA, I., SHUBENKOVA, K., MAVRIN, V., MUKHAMETDINOV, E., BOYKO, A., ALMETOVA, Z., & SHEPELEV, V.: Features of Logistic Terminal Complexes Functioning in the Transition to the Circular Economy and Digitalization,

Explorations in Technology Education Research. In: Sładkowski A. (eds) Modelling of the Interaction of the Different Vehicles and Various Transport Modes, Lecture Notes in Intelligent Transportation and Infrastructure, Springer, Cham, pp. 415-527, 2019. doi:10.1007/978-3-030-11512-8_10

[6] KABASHKIN, I.: Heuristic Based Decision Support System for Choice of Alternative Routes in the Large-Scale Transportation Transit System on the Base of Petri Net Model, *Procedia Engineering*, Vol. 134, pp. 359-364, 2016. doi:10.1016/j.proeng.2016.01.020

[7] GATH, M.: *Optimizing Transport Logistics Processes with Multiagent Planning and Control,* Book, Mobile Research Center, Bremen, Germany, 2016. doi:10.1007/978-3-658-14003-8

[8] STRAKA, M., HRICKO, M. Software System Design for Solution of Effective Material Layout for the Needs of Production and Logistics, *Wireless Networks*, 2020. doi:10.1007/s11276-020-02267-6

[9] WANG, Y.-L., & YANG, D.-L.: *A Heuristic Method for Logistics Supply Chain Coordination and Risk Control,* 2006 5th IEEE International Conference on Cognitive Informatics, pp. 866-870 (2006). doi:10.1109/coginf.2006.365605

[10] MEDVEDIEV, IE., LEBID, I., ELISEYEV, P.: Rationale for Fuzzy Logic Toolbox applying in transport processes for wheat harvesting. *Technical service of agriculture, forestry and transport systems,* No. 11. Pp. 269-279, 2018. (Original in Ukrainian)

[11] OLIINYK, A., SUBBOTIN S. A.: The decision tree construction based on a stochastic search for the neuro-fuzzy network synthesis, *Optical Memory and Neural Networks (Information Optics)*, Vol. 24, No 1, pp. 18-27, 2015. doi:10.3103/S1060992X15010038

[12] NARANJO, J.E., GONZÁLEZ, C., GARCÍA, R., DE PEDRO, T.: Fuzzy Logic for Transportation Guidance: Developing Fuzzy Controllers for Maintaining an Inter-Vehicle Safety Headway, In: Bai Y., Zhuang H., Wang D. (eds) Advanced Fuzzy Logic Technologies in Industrial Applications, Advances in Industrial Control. Springer, London, pp. 129-143, 2006. doi:10.1007/978-1-84628-469-4_9

[13] KALINIC, M., & KRISP, J. M.: Fuzzy inference approach in traffic congestion detection, *Annals of GIS*, Vol. 25, No. 4, pp. 329-336, 2019. doi:10.1080/19475683.2019.1675760

[14] UGWU, C., BALE, D.: An application of fuzzy logic model in solving road traffic congestion, *International Journal of Engineering Research & Technology,* Vol. 3, No. 2, 2014.

[15] VASSILYEV, S. N., KELINA, A. Y., KUDINOV, Y. I., & PASHCHENKO, F. F.: Intelligent Control System, *Procedia Computer Science*, 103, pp. 623-628, 2017. doi:10.1016/j.procs.2017.01.088

[16] ACHARYA, S., DASH, K.K., CHAINI, R.: Fuzzy Logic: An Advanced Approach to Traffic Control. In: Nayak J., Balas V., Favorskaya M., Choudhury B., Rao S., Naik B. (eds) Applications of Robotics in Industry Using Advanced Mechanisms, ARIAM 2019, Learning and Analytics in Intelligent Systems, Vol 5. Springer, Cham, pp. 176-186, 2020. doi:10.1007/978-3-030-30271-9_17

[17] NIKOLAEV, A.B., SAPEGOA, YU.S., JAKUBOVICH. A.N., BERNERB, L.I., STROGANOVC, V. YU.: Fuzzy Algorithm for the Detection of Incidents in the Transport System, *International Journal of Environmental & Science Education*, Vol. 11, No. 16, pp. 9039-9059, 2016.

[18] SAHOO, P., JANA, D.K., PANIGRAHI, G.: Interval Type-2 Fuzzy Logic and Its Application to Profit Maximization Solid Transportation Problem in Mustard Oil Industry, In: Castillo O., Jana D., Giri D., Ahmed A. (eds) Recent Advances in Intelligent Information Systems and Applied Mathematics. ICITAM 2019, Studies in Computational Intelligence, Vol. 863. Springer, Cham, pp. 18-29, 2020. doi:10.1007/978-3-030-34152-7_2

[19] DALMAN, H., SIVRI, M. A.: *Fuzzy Logic Based Approach to Solve Interval Multiobjective Nonlinear Transportation Problem*, Proceedings of the National Academy of Sciences, India Section A: Physical Sciences, 89, pp. 279-289, 2019. doi:10.1007/s40010-017-0469-z

[20] DOJUTREK, M.S., LABI, S., DIETZ, J.E.: A Fuzzy Approach for Assessing Transportation Infrastructure Security, In: Boulanger F., Krob D., Morel G., Roussel JC. (eds) Complex Systems Design & Management, Springer, Cham, pp. 207-224, 2015. doi:10.1007/978-3-319-11617-4_15

[21] NIAO-NA, Z., YI-BO, G.: Control Strategy for Hybrid Electric Vehicle Based on Fuzzy Logic, In: Jiang L. (eds) Proceedings of the 2011 International Conference on Informatics, Cybernetics, and Computer Engineering (ICCE2011) November 19–20, 2011, Melbourne, Australia, Advances in Intelligent and Soft Computing, Vol. 112. Springer, Berlin, Heidelberg, pp. 563-571, 2011. doi:10.1007/978-3-642-25194-8_68

[22] SZOLYÁK, Z.: Reducing the environmental pollution on transport in cities, *Acta Tecnología,* Vol. 5, No. 2, pp. 29-36, 2020. doi:10.22306/atec.v5i2.44

[23] YURENKO, K.I., KHARCHENKO, P.A., FANDEEV, E.I., YURENKO, I.K.: Train Operation Control on-based of Logical-Linguistic Model, EAI Endorsed Transactions on Energy Web, 2019. doi:10.4108/eai.13-7-2018.156388

[24] SEDOV V.A., SEDOVA, N.A., GLUSHKOV, S.V.: The fuzzy model of ships collision risk rating in a heavy traffic zone, *Vibroengineering PROCEDIA*, Vol. 8, pp. 453-458, 2016.

[25] OSORIO-GÓMEZ, J.C., MANOTAS-DUQUE, D.F.: Fuzzy QFD and TOPSIS for Dispatching Prioritization in Maritime Transportation

Considering Operational Risk, In: García Alcaraz J., Rivera Cadavid L., González-Ramírez R., Leal Jamil G., Chong Chong M. (eds) Best Practices in Manufacturing Processes, Springer, Cham, pp. 97-116, 2019. doi:10.1007/978-3-319-99190-0_5

[26] KHALIPOVA, N., PASICHNYK, A., LESNIKOVA, I., KUZMENKO, A., KOKINA, M., KUTIREV, V., KUSHCHENKO, YE.: Developing the method of rational trucking routing based on the modified ant algorithm, *Eastern-European Journal of Enterprise Technologies*, Vol. 1, No. 3 (91), pp. 68-76, 2018. doi:10.15587/1729-4061.2018.123862

[27] SADOVNYCHYY A., SADOVNYCHIY S., PONOMARYOV V. Computational Intelligence Models of the Distributed Technological Complexes. Theoretical Advances and Applications of Fuzzy Logic and Soft Computing, *Advances in Soft Computing,* Vol. 42, pp. 230-239, 2007. doi:10.1007/978-3-540-72434-6_24

[28] CIRIC, STOJIC, SEDLAK, MARCIKIC HORVAT, & KLEUT.: Innovation Model of Agricultural Technologies Based on Intuitionistic Fuzzy Sets, *Sustainability*, Vol. 11, No. 19, pp. 54-57, 2019. doi:10.3390/su11195457

[29] APHALE, L.R., RAJESH, S.: *Fuzzy Logic System in Tomato Farming*. Proceeding of 4th - Somaiya International Conference on Technology and Information Management (SICTIM'18). IOSR Journal of Computer Engineering, Vol. 1/12, No. 20, pp. 56-62, 2018.

[30] SARKAR, A.: Application of Fuzzy Logic in Transport Planning, *International Journal on Soft Computing,* Vol. 3, No. 2, pp. 1-21, 2012. doi:10.5121/ijsc.2012.3201

[31] SHRAMENKO, N., MUZYLYOV, D.: Forecasting of Overloading Volumes in Transport Systems Based on the Fuzzy-Neural Model. Advances in Design, Simulation and Manufacturing II. In: Ivanov V. et al. (eds) DSMIE-2019, LNME, pp. 311-320. Springer Nature, 2020. doi:10.1007/978-3-030-22365-6_31

[32] MUZYLYOV, D., SHRAMENKO, N.: Blockchain technology in transportation as a part of the efficiency in Industry 4.0 strategy, In: Tonkonogyi V. et al. (eds) Advanced Manufacturing Processes, InterPartner-2019. Lecture Notes in Mechanical Engineering, pp. 216-225. Springer, Cham, 2020. doi:10.1007/978-3-030-40724-7_22

[33] ABRAHAM, E.R., DOS REIS, J.G.M., DE SOUZA, A.E., COLOSSETTI, A.P.: Neuro-Fuzzy System for the Evaluation of Soya Production and Demand in Brazilian Ports, In: Ameri F., Stecke K., von Cieminski G., Kiritsis D. (eds) Advances in Production Management Systems, Production Management for the Factory of the Future. APMS 2019, IFIP Advances in Information and Communication Technology, Vol. 566. Springer, Cham, pp. 87-94, 2019. doi:10.1007/978-3-030-30000-5_11

[34] SOHEILIRAD, S., GOVINDAN, K., MARDANI, A. ET AL.: Application of data envelopment analysis models in supply chain management: a systematic review and meta-analysis, Ann Oper Res 271, pp. 915-969, 2018. doi:10.1007/s10479-017-2605-1

[35] PAVLENKO, O., SHRAMENKO, N., MUZYLYOV, D.: Logistics Optimization of Agricultural Products Supply to the European Union Based on Modeling by Petri Nets, In: Karabegović I. (eds) New Technologies, Development and Application III. NT 2020, Lecture Notes in Networks and Systems, Vol. 128, pp. 596-604. Springer, Cham, 2020. doi:10.1007/978-3-030-46817-0_69

[36] KOVAL, A.A.: Logical-linguistic models in fuzzy systems, *Programming problems*, Vol. 2018, No. 2-3, pp. 375-378, 2008. (Original in Ukrainian)

[37] ZAIATC, V.M., ZAIATS, M.M.: Artificial intelligence systems are the basis of modern information technologies and their software, *Radioelectronics & Informatics Journal,* Vol. 2017, No. 3(78), pp. 33-41, 2017. (Original in Ukrainian)

[38] VELYCHKO, V.JU., PALAGIN, O.V.: Methods of effectiveness increase of application of growing pyramidal networks. *Computer Tools, Networks and Systems*, Vol. 2010, No. 9, pp. 106-114, 2010. (Original in Ukrainian)

[39] TVEREZOVSKAYA, N.T., NELEPOVA, A.V.: *Information technologies in agronomy*, Textbook, Ukraine, Kyiv, 2013. (Original in Ukrainian)

[40] VAIČIŪTĖ, K., SKIRMANTIENĖ, J., DOMANSKA, L.: Assessment of Transport Specialists' Competencies in Transport/Logistics Companies, *Procedia Engineering*, Vol. 187, pp. 628-634, 2017. doi:10.1016/j.proeng.2017.04.423

[41] YUAN, L., LI, J., LI, R. ET AL.: Mapping the evaluation results between quantitative metrics and meta-synthesis from experts' judgements: evidence from the Supply Chain Management and Logistics journals ranking, *Soft Computing*, Vol. 24, No. May, pp. 6227-6243, 2020. doi:10.1007/s00500-019-03837-3

[42] MEDVEDIEV, I.E., LEBID, I., BRAGIN, M.: Assessment of the weather and climate conditions impact on the organization and planning of transport support for wheat harvesting, *TEKA of the Commission of Motorization and Energetics in Agriculture*, Vol. 17, No. 2, pp. 45-54, 2017.

[43] AULIN, V., LYASHUK, O., PAVLENKO, O., VELYKODNYI, D., HRYNKIV, A., LYSENKO, S., HOLUB, D., VOVK, Y., DZYURA, V., SOKOL, M.: Realization of the logistic approach in the international cargo delivery system, *Communications - Scientific Letters of the University of Zilina*, Vol. 21, No. 2, pp. 3-12, 2019.

[44] HASHMI, N., JALIL, S.A. & JAVAID, S.: A model for two-stage fixed charge transportation problem with multiple objectives and fuzzy linguistic preferences, Soft Computing, Vol. 2019, pp. 12401-12415, 2019. doi:10.1007/s00500-019-03782-1

[45] SUBBOTIN, S.O.: *Representation and processing of knowledge in the artificial intelligence and decision support systems,* Textbook, Ukraine, Zaporizhzhia, In: ZNTU, 2008. (Original in Ukrainian)

[46] DJATNA, T., GINANTAKA, A.: Traceability of Information Routing Based on Fuzzy Associative Memory Modelling in Fisheries Supply Chain, International Journal of Fuzzy Systms, Vol. 22, pp. 724-734, 2020. doi:10.1007/s40815-019-00754-3

[47] SHTOVBA, S.D.: *Design of fuzzy systems by means of Matlab*, Moscow, Hotline-Telecom, 2007. (Original in Russian)

[48] ROTHSTEIN, A.P.: *Intelligent identification technologies: fuzzy logic, genetic algorithms, neural networks,* Ukraine, Vinnytsia, Universum-Vinnytsia, 1999. (Original in Russian)

Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 7 2020 Issue: 3 Pages: 167-174 ISSN 1339-5629

doi:10.22306/al.v7i3.170 *Received: 30 Apr. 2020; Revised: 06 Sep. 2020; Accepted: 21 Sep. 2020*

THE PRACTICES OF LOGISTICS SERVICE PROVIDERS IN MOROCCO: THE PARADOX OF COLLABORATION/COORDINATION

Nohade Ben kaddour
Abdelmalek Essaadi University, Faculty of Science, Avenue of Sebta, Mhannech II 93002, Tetouan, Morocco, benkaddour.nohade@gmail.com (corresponding author)
Mohammed Rajaa
Abdelmalek Essaadi University, Faculty of Law Economics and Social Sciences, Avenue Hassan II, Martil 93150, Tetouan, Morocco, mohammedrajaa@yahoo.fr
Abdellatif Medouri
Abdelmalek Essaadi University, National School of Applied Sciences, Avenue of Palestine, Mhannech I 93002, Tetouan, Morocco, amedouri@gmail.com

Keywords: outsourcing, performance, logistics service provider, logistics practice, supply chain management
Abstract: This article examines the practices of logistics service providers (LSP) and the most outsourced services in Morocco through an empirical study based on a questionnaire answered by various foreign and Moroccan logistics service providers as well as dealing with the impact of outsourcing on the performance of industrial companies with increasing competitive pressures and globalization. These companies have developed the strategy of logistics outsourcing which is a process that companies are increasingly resorting to. It is for an industrial or commercial company means "entrusting all or part of a logistics chain, previously carried out internally, to an external service provider".

1 Introduction

The new context in which Morocco is evolving inevitably leads to increased competition on global markets. To fully grasp Morocco's competitive advantages, we are conducting a study on areas of improvement in logistics that could boost the Moroccan economy by bringing out new services that are essential to multinationals by bringing out new services that are indispensable to multinationals, such as the new trend 'outsourcing strategy' and the emergence of service providers with multiple levels of logistics services.

Significant work addresses the process of choosing to outsource, particularly in the company's international activities [1], or describes the process of purchasing logistics services [2]. Most often, the literature analyses the logistics service provider-customer relationship through one of the two players in the dyad. Thus, the approach to outsource from the customer's side is extensively analysed in terms of the customer's perception of the outsourcing of logistics activities [3] particularly on the European market [4], the purchase of services by the client and the prioritization of selection criteria [5], methodologies allowing the implementation of outsourcing and the transfer of outsourced activities to the service provider [2] or according to the performance perceived by the industrial client [6], or the perception of the skills and performance of the logistics service provider by the industrial client [7].

Since 1995, logistics outsourcing has been growing steadily in France and Europe [8] and confirms its development among industrialists [9]. In this context, logistics service providers are only one illustration of the creation of added value to the operation of a company. Since the start of the outsourcing strategy, the logistics service provider has played a key role in the company's logistics activity, it is always looking for the right provider who will do the job properly and comply with standards. In a competitive environment, this value creation is a way for companies to differentiate themselves from the competition expand their markets, win new customers, and, above all, better meet the demands of customers seeking high-performance service offerings.

There is now a renewed interest in the provision of logistics services. The main reasons for this are based on the steady growth of the logistics services market and the vital importance of logistics service providers (LSPs) in supply chains [10]. Logistics services can be defined as a succession or combination of complementary activities that contribute to the creation of added value [11]. These activities may concern load breaking operations (reception and control of materials and goods, handling, storage, etc.), para-industrial operations (after-sales service and repairs, assembly, finishing, etc.), para-commercial operations (preparation of orders, constitution of promotional lots, sales forecasts, price marking, tracing-tracking, etc.), management operations (monitoring of expiry dates, return of pallets, stock management, etc.), consulting activities and transport operations (traction, chartering, purchase/negotiation of freight, etc.)

In the United States, an annual survey carried out since 1991 shows the growing impact of logistics services among manufacturers [12-13]. In France and in Europe, due to the increasing diversification of the services offered by the LSPs, logistics services are highly scalable [14]. On the side of the principals, logistics outsourcing has become an unavoidable strategic dimension with the

implementation of new management rules, new skills and new social relations [10], the weight of contractualisation in the relationship [15], or providers' monitoring strategies [16].

While Logistics Service Providers (LSPs) have become key players in supply chain management. This chain is a system through which organizations deliver their goods and services to their customers. They form a network of interconnected organizations with a common purpose [17]. From the mid-1980s, many industrial or commercial companies disengaged from the operational realization of their logistics activities (transport, storage, etc.) which were not the core of their business. Thus, a new player emerged, the LSP. These operators therefore provide shippers (owners of the goods transported) with specific means of transport and storage, and this by expanding their service offer to other activities with higher added value, up to the operationalization and management of complex and personalized logistics and information systems. The speed and reliability of information exchange is crucial to coordinate, between the different actors in the supply chain, the precise time and place of services that guarantee the best results, and to provide the information that the manager needs to operate the system.

FULCONIS and PACHE [17] introduce this notion of service provider as an assembler of competence. Providers would no longer become mere executors in charge of ensuring the operational implementation of logistics activities, but "organizers (or pivots) of competence networks". This study by these two authors goes even further by shifting the centre of gravity of competence networks towards the service provider, all the more so if the degree of outsourcing is extensive and complex. The notion of LSP as a satellite is mentioned. Thus, the real drivers of the value chain would no longer be the industrialists, but the logistics providers, who would be at the heart of all the different "dynamic networks". In the extreme version of the phenomenon, it would no longer be a company that outsources its logistics, but the service provider that outsources other related activities such as production, marketing, etc. HESSE offers a different vision of the relationship between industrialists and logistics service providers. Indeed, for HESSE service providers are more like "coordinators and architects" within competitive strategies in industry-commerce relations [18]. Thus, contrary to what is developed by FULCONIS and PACHE [17], industrialists and service providers would not be against each other in a struggle for influence, but real partners with the aim of creating a definite competitive advantage towards other market companies.

The research in logistics and supply chain management is increasingly interested in issues related to practices in emerging markets [19] where few studies have been conducted. However, this research has largely overlooked the role played by LSPs, despite their role as facilitators of their clients' internationalization projects as the leading players in their target markets [20].

From this perspective, the article focuses first and foremost on the birth of the LSP. Using this perspective, we will then look at the strategic role of the LSP in the supply chain, which has been strengthened by the expansion of the range of logistics services that has encouraged the development of different categories of LSPs. Then in the third part, the exploitation of the result of the questionnaire answered by the interviewers through the empirical study carried out.

2 Evolution of logistics providers

Situated at the interface between production and the market, logistics service providers have quickly transformed themselves into true multi-service and multi-functional professionals in the context of a shift from industrial activities to service activities. The rise of these new players was first confirmed in the USA [21] and then returned to Europe. Their growth is due to their ability to develop technological innovations that make it possible to formulate solutions for the control and regulation of flows.

At the origin of this evolution are the new forms of organization of production/distribution which are manifested by new requirements. It is not limited to the classic need for a transport service, but now covers a wider range of conditions and services.

2.1 Traditional benefits: the change

The traditional services offered by service providers to commercial and industrial enterprises can easily be seen when it comes to discussing the evolution of the main components of these services, i.e. time, tracking, frequency and shipment.

- **Delay:** Previously, delays were long, routing cycles were staggered, and arriving a few days before or after the delay did not cause any concern. Today, all cycles have become much shorter, whether they are innovation, product life or simply supply cycles. Undergoing the logic of just-in-time, lead times are not going to be simply short, but very short depending on the strategies.
- **Monitoring:** this is done only at times of traffic flow, while at other times the loss of information on the flow makes the possibility of monitoring out of reach. In the new approach, monitoring is done in real time. At any time, the sender can ask the service provider to modify the route, change the flow and modify the flow structure.
- **Frequency:** In the classical approach, the frequencies of the flows are low, spaced and irregular. With the development of industrial logistic strategies aimed at eliminating stocks, shipping frequencies are high and regular [22].
- **Shipments:** Classically, shipments were made in full loads resulting in massive flows. The size of the batches will undergo a drastic reduction, giving rise to repetitive and diffuse shipments in order to respond to

the logic of variety which becomes the competitive weapon of all the partners in the physical circulation.

2.2 New services: outsourcing

With a preoccupation for improving performance and profitability, companies resorted to the direct appropriation of activities annexed to their principal activities. This approach, which propelled companies into business lines that they did not master, proved too costly. The option of using an outside companies to perform certain operations instead of doing it yourself is becoming a winning strategy for many companies. In defining this phenomenon, the literature most often tends to use the terms subcontracting and outsourcing as synonyms. On the other hand, we believe that these notions refer to two different relationships. Therefore, subcontracting is a very widespread activity that concerns all companies. It consists, for the principal, in entrusting outside companies with the task of carrying out certain tasks on his behalf, according to specifications, while retaining final economic responsibility for the subcontracted activity [23].

On the one hand, this relationship does not deal with situations where the principal subcontracts the entire production or services. On the other hand, it ignores situations in which the specifications of the principal are transmitted to the service provider without a real specification [24]. For its part, outsourcing represents a larger operation than conventional subcontracting, in that it consists of a service provider taking charge of one or more activities.

The choice of the client company to entrust all or part of its staff employed in the activity concerned, as well as the means of production associated with it, is secondary. In this relationship, the service provider retains a certain economic responsibility by becoming involved in an operating result (such as reducing inventory levels or improving customer service), which may have a direct effect on the remuneration system adopted. In addition, the outsourcing of logistics and other managerial operations is becoming more and more important as the advantages it brings to the shipper [25] are varied, namely: the reduction of logistics costs and the improvement of service quality by using a specialized service provider capable of achieving better productivity and reliability of operations instead of being paralyzed by inadequate means of its own, the shipper has a larger choice of service providers before it.

2.3 Logistics services: a new generation of stakeholders

Before asking ourselves about the origins of these stakeholders, we should first define this new activity that the Anglo-Saxon literature [21] describes as Third-Party Logistics (TPL). In the past, a company, in order to organize its logistics, had to call upon a consulting company to program, a transport rental company to execute and its own means to control. Currently, a TPL offers these three aspects of logistics management in a single service. According to a study by the Eurosiris [26] on the French case, logistics service providers have three main origins, the most important of which is the transport sector.

- **Providers from the transport sector:** The majority of providers from the transport sector come from the road transport industry.
- **Service providers from large manufacturing groups:** This type of service provider is made up of subsidiaries of companies with a high level of activity and which generate a large volume of flows, upstream (supply of materials and components) as well as downstream (delivery of finished products). It should be noted that the option of making a logistics service provider a subsidiary has tended to recede, giving way to the contractual route (subcontracting, partnership).
- **Providers of services to industry:** This category includes all the companies specializing in the execution of certain transactions for the benefit of industry. These operations, known as annexes, are often logistical in nature (industrial packaging, warehousing, etc.) [26].

2.4 The offering system of logistics service providers:

The supply system implemented by logistics service providers brings, especially in the field of physical distribution, a new concept of flow control. It is no longer a service that is assessed solely by its cost, but a systemically integrated and structurally multifaceted service capable of adding value to the cargo handled. However, setting up such a service requires a major logistical infrastructure that can only be provided by large companies.

The small company (often transport), for its part, will limit itself to a single-product offer, which consists of providing traction by subcontracting its service to logistics providers who require a high degree of professionalism and a significant capacity for expertise. This is how logistics service providers are going to focus on nodes (nodal points) to develop integrated and varied services capable of generating greater added value. "Traction activities thus form part of a larger set of physical distribution operations carried out, for the most part, on freight handling infrastructures such as warehouses and platforms" [26]. The latter have now become the target of investment by carriers wishing to offer logistics services. The rise of logistics service providers with their new offering system has contributed to a reconfiguration of the relationships between physical distribution partners.

First of all, it contributed to the decline in the dominant corporeal (or patrimonial) option until the 1970s by replacing it with the contractual option (subcontracting, partnership), which is not based on one-off transactions but on long-term transactions. It then changed the mechanism of market behaviour.

3 Methodology

Regarding the offer of logistics services of Moroccan companies, we designed a field study with a questionnaire (realized in the period between September 2019 and February 2020) for service providers, this empirical analysis is based on a database that includes targeted observations on 64 service providers. The table 1 presents the providers in different sectors of activity:

- Maritime, road, air transport,
- Shipping service,
- Storage & handling,
- Supply Chain Audit & Consulting.

Table 1 The sample targeted by the questionnaire of logistics service providers

Sector	Type	Sample size
Maritime transport	Large companies	10
Road transport	Large companies	21
	Small and medium companies	2
Air transport	Large companies	5
Rail transport	Large companies	1
Shipping service	Large companies	7
Storage & handling	Large companies	14
Audit & consulting in SCM	Large companies	4

The purpose of this study is to determine the activity of logistics service providers in Morocco. In addition, we would like to know the different types of services offered by service providers, and the logistics activities most outsourced by the principals as well as other information, which we will develop further in what follows.

4 Use of the questionnaire and interpretation of the results:

Figure 1 describes the types of companies currently in Morocco, it should be noted that 62% of the responses to the questionnaire for logistics service providers came from international companies located here in Morocco, while 38% came from Moroccan companies.

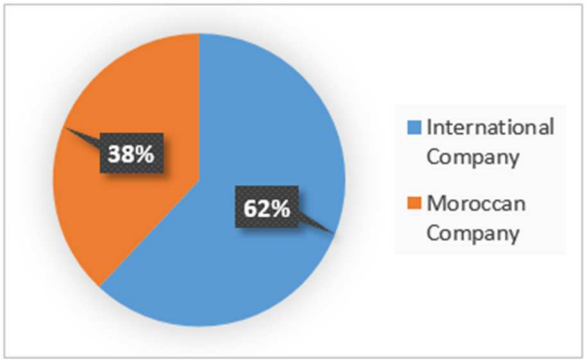


Figure 1 Distribution of providers surveyed by nationality

On the other hand, in figure 2, we note that the majority of the clients of these service providers are industrialists with a percentage of 54% compared to 36% for the mass distribution sector. The 10% refers to different clients, for example: the media, car rental agencies, etc.

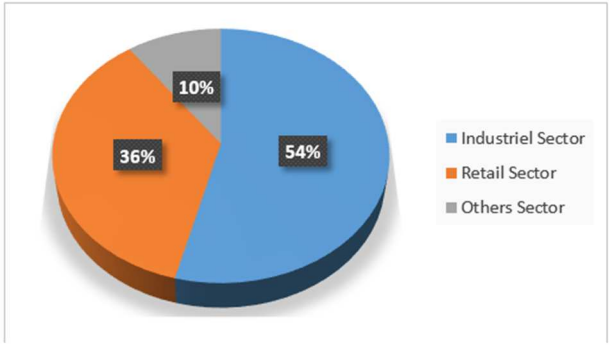


Figure 2 Distribution of the clients of the providers surveyed

As shown in the figure 3, the Distribution or downstream transport (88,23%) and warehousing (85%) are the two most proposed logistics services on the Moroccan market, the percentage of upstream transport is in third position with (64,7%), after comes the transit and customs clearance with the percentage (55,88%), labelling with (41,17%), packaging with (35,29%), however we note that IT solutions is low with a rate of 23.53%. The other unexplained services with a rate of 32.35% are: weighing, stuffing and stripping of containers, shipping service, etc.

THE PRACTICES OF LOGISTICS SERVICE PROVIDERS IN MOROCCO: THE PARADOX OF COLLABORATION/COORDINATION

Nohade Ben kaddour; Mohammed Rajaa; Abdellatif Medouri

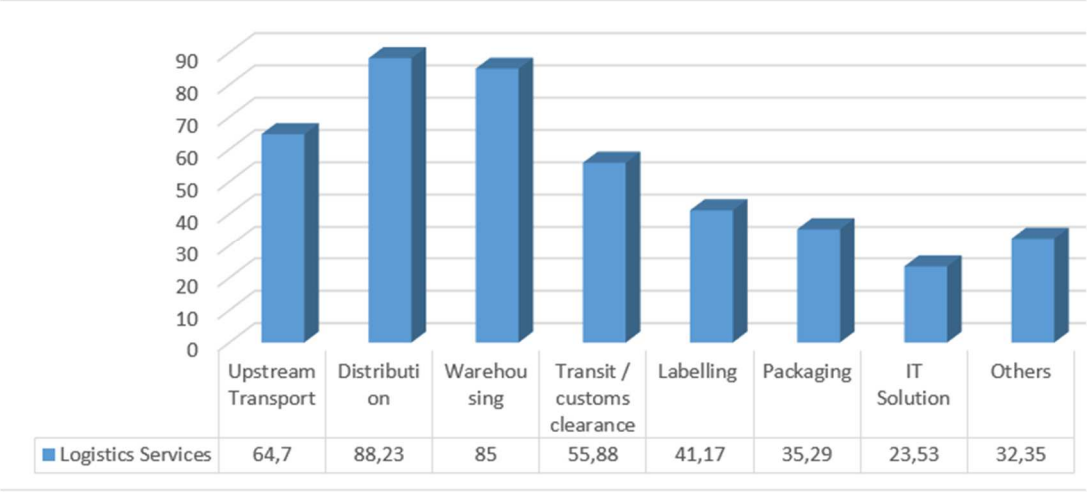


Figure 3 Existing logistics services on the Moroccan market

Figure 4 demonstrates that the majority of logistics service providers in Morocco claim to have direct contact with their clients' customers with a rate of 68%. While the remaining 32% have no relationship with them at all what may explain why Moroccan companies are conservative about entrusting their logistics activities to a third party is the fear of losing direct contact with their customers.

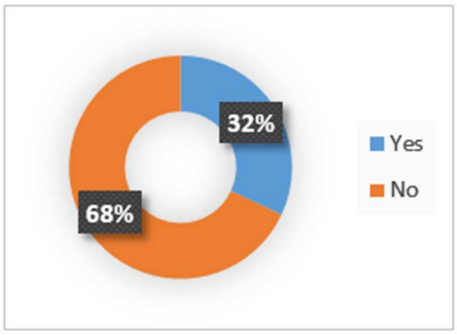


Figure 4 The direct contact between the logistics service provider and their customer's client

The figure 5 present the percentage of re-internalization of logistics activities, it should be noted that 65% of service providers have had no experience of re-internalization of logistics activities by their customers, because they have considered themselves satisfied with their partnership. So, let the 35% claim to have gone through such a situation.

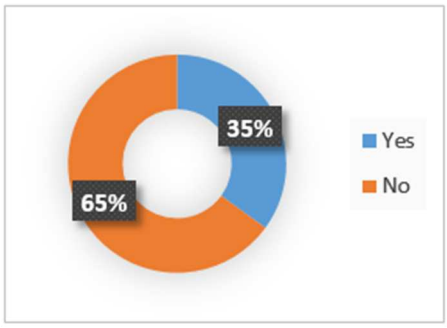


Figure 5 Percentage of re-internalization of logistics activities by the providers' customers.

Concerning the question for the causes of the re-internalization of outsourced activities according to the providers, the answer was for the following causes:

Cause 1- Customer's claim of a better control of the flows on his part.

Cause 2- Global strategic decision of outsourcing companies.

Cause 3- Failure of the service

Cause 4- Expensive logistics services.

Cause 5- Loss of market share by the customer.

The figure 6 below is a representative graph of the percentages of the results:

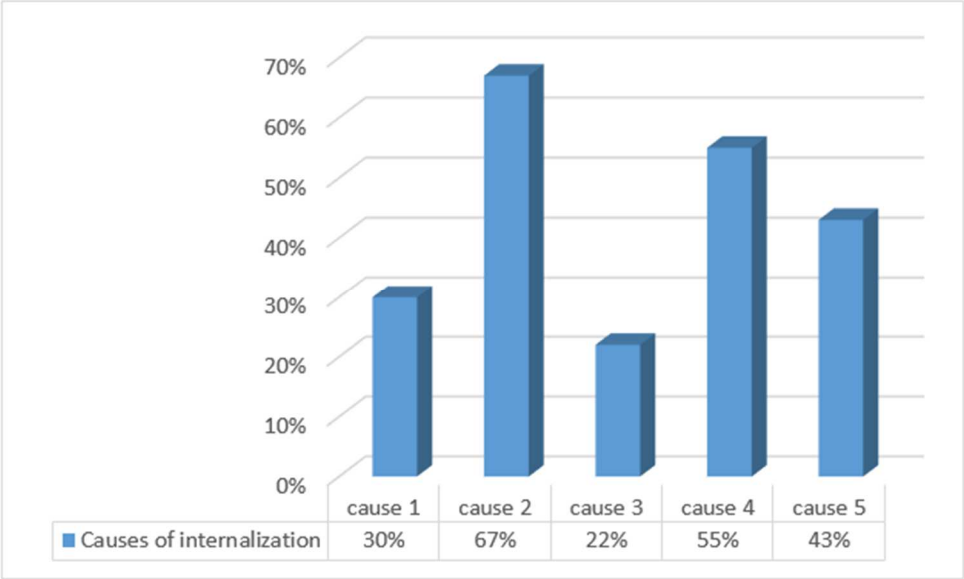


Figure 6 Causes of the re-internalization of outsourced activities according to the providers

5 Discussion

A database containing information on Moroccan logistics providers service has been used, the supply of logistics services is low and not very diversified in Morocco, and there are few companies offering a wide range of logistics services. However, companies offering a full range of logistics services are exclusively subsidiaries of European groups and most often have multinational companies as their customers.

Using information from several sources, we found that industrial and commercial companies in general prefer to internalize logistics activities, it is in this sense that the paradox of collaborating or coordinating with a provider where the question arises. Therefore, only some companies outsource the part relating to transport and storage. The internalization of logistics is due to the mistrust of these operators to entrust internal information concerning their business to third parties. While the transport and storage represent a substantial part of the market for logistics service providers. Unfortunately, the level of services offered is of relatively low quality and they are subject to technical conditions that are below standard.

Logistics subcontracting of the TPL type (Third part logistics: storage, stock management, order preparation, organization of physical distribution and information and value-added services) are mainly provided by foreign companies or companies oriented towards international trade, while the offers of Moroccan companies are focused on transport or simple storage.

Red tape and competition from the informal sector in road transport and warehousing make it difficult to develop the formal sector and meet high quality standards. Finally, information systems are poorly developed for the real needs of the supply chain. Certainly, the behaviour of Moroccan companies with regard to logistics is a function of their size, their fields of activity and the degree of competition. Large companies and those with externally oriented activities have started to broaden the scope of their logistics strategies (outsourcing, Logistics Information Systems, etc.).

In logistics services, Moroccan companies initially focused on the marketing of more or less complex transport services. However, the SDTM and La Voie Express have become real logistics integrators and have customers who are mostly Moroccan. They rely on warehouses in the main provincial cities where the grouping can be carried out. Marotrans is the only company that has made transport quality a priority. It has the exclusivity of road transport in Morocco for many foreign companies such as McDonald's, Cofarma, Carnaud, the transport of milk for Nestlé.

Logistics demand from Moroccan companies (especially SMEs) remains low. Generally, the only outsourcing done by Moroccan companies is for transport and storage. In addition, Moroccan logistics providers focus largely on transport.

The logistics and transport service market there is dominated by a majority of European service providers [27] such as Géodis, DHL, Kühne & Nagel, Dacsher where the majority of LSP are Small and Medium Enterprises (SMEs) specialized mainly in transportation services [27]. On the other hand, according to the Moroccan agency for the development of logistics [28], despite the difficulties related to the international economic situation. The market for logistics services and road transport of goods in Morocco has experienced an average annual growth of 5.2% between 2010 and 2016. The volume of activities and investments of companies in the sector is clearly evolving in Morocco encouraging the development of LSP.

6 Conclusion

This study thus aims to analyse how the LSP develops managerial capacities in order to develop in its market. Over the last decade, Morocco has embarked on a national logistics development strategy through several infrastructure development projects and multi-flow logistics platforms.

The purpose of this paper was to review the existing logistics service providers in Morocco, their practices as well as the most outsourced services. This field survey allowed us to synthesize the Moroccan market through a questionnaire and the analysis of various articles and reviews dealing with this issue. Due the gradual opening of borders and the massive arrival of foreign competition, Moroccan companies find themselves in two situations. Some companies have understood that the use of logistics service providers could be a lever for improving performance, but also a way to focus on areas of differentiation from competitors, and others hesitate to outsource their logistics activities because internal resistance or apprehension about the involvement of an external supplier in the company's activities. This work is divided into three parts. First, we have explained the principles of logistics outsourcing in emerging countries. Then, we have described the evolution of logistics service providers over time. Finally, we have presented our research approach and our results in the Moroccan market.

In this regard, several perspectives may emerge from our research and several questions deserve to be pursued and elucidated by future research. For example, research will be needed for the selection and evaluation of the choice of the appropriate logistics service provider for the principals.

References

[1] STANK, T.P., MALTZ, A.B.: Some Propositions on Third Party choice: Domestic vs. International Logistics Providers, *Journal of Marketing Theory and Practice*, Vol. 4, No. 2, pp. 45-54, 1996.

[2] SINK, H.L., LANGLEY, Jr. C.J.: A Managerial Framework for the Acquisition of Third-Party Logistics Services, *Journal of Business Logistics,* Vol. 18, No. 2, pp. 163-189, 1997.

[3] La LONDE, B.J., MATZ, A.B.: Some Propositions About Outsourcing the Logistics Function, *The International Journal of Logistics Management*, Vol. 3, No. 1, pp. 1-11, 1992.

[4] VAN DAMME, D.A., PLOOS VAN AMSTEL, M.J.: Outsourcing Logistics Management Activities, *The International Journal of Logistics Management*, Vol. 7, No. 2, pp. 85-94, 1996.

[5] MCGINNIS, M., KOCHUNNY, C. AND ACKERMAN, K.: Third Party Logistics Choice, *International Journal of Logistics Management, The*, Vol. 6, No. 2, pp. 93-102, 1995. doi:10.1108/09574099510805378

[6] DAUGHERTY, P.J., STANK, T.P., ROGERS, D.S.: Third Party Logistics Service Providers: Purchasers, Perceptions, *International Journal of Purchasing and Materials management*, Vol. 32, No. 1, pp. 23-29, 1996.

[7] MENON, M.K., MCGINNIS, M.A., ACKERMAN, K.B.: Selection Criteria for Providers of Third-Party Logistics Services: An Exploratory Study, *Journal of Business Logistics*, Vol. 19, No. 1, pp. 121-137, 1998.

[8] ESTAMPE, D., TSAPI, V.: L'européanisation de la logistique :les grandes tendances, *Logistique et Management*, Vol. 5 , No. 2, pp. 3-20, 1997. doi:10.1080/12507970.1997.11516649 (Original in French)

[9] SITL & CLM.: Enquête relative aux préoccupations des acteurs de la logistique en France, *Logistique et Management*, Vol. 12, No. 1, pp. 93-103, 2004. doi:10.1080/12507970.2004.11516802 (Original in French)

[10] SAUVAGE, T.: *Une taxinomie des relations de dépendance chez les prestataires logistiques*, Gestion 2000, 2001. (Original in French)

[11] VAN LAARHOVEN, P.: *Third Party Logistics: The Provider and the Shipper Perspective, Faire de la recherche en logistique et distribution*, Vuibert Fnege, 2000.

[12] LIEB, R., KENDRICK, S.: The Use of Third Party Logistics Services by Large Américan Manufacturers, the 2002 survey, *Supply Chain Forum: an International Journal*, Vol. 3, No. 2, pp. 2-11, 2002. doi:10.1080/16258312.2002.11517100

[13] LIEB, R.,SCHWARZ, B.: TheYear 2001 survey/ Ceo Perspectives On the Current Status and Future Prospects of The Third Party Logistics Industry in the United States, *Supply Chain Forum: an International Journal*, Vol. 2, No. 2, pp. 36-44, 2001. doi:10.1080/16258312.2001.11517089

[14] LUCQUIN, C.: Les évolutions actuelles de la logistique de distribution, *Revue Française de Gestion Industrielle*, Vol. 21, No. 2, pp. 49-65, 2002. (Original in French)

[15] VAN HOEK, R.: The Purchasing and Control of Supplementary Third Party Logistics Services, *The Journal of Supply Chain Management*, Vol. 36, No. 3, pp. 14-26, 2000.

[16] FABBE-COSTES, N., ROUSSAT, C.: Les pratiques de veilles technologiques en Logistique, le cas des prestataires de services logistiques, *Logistique & Management*, Vol. 8, No. 2, pp. 29-48, 2000. doi:10.1080/12507970.2000.11516731 (Original in French)

[17] FULCONIS, F., GILLES, P., ROVEILLO, G.: *La prestation logistique: origines, enjeux et perspectives*, Editions EMS - Management & Société, Collection "Les essentiels de la gestion"., G. Charreaux, P. Joffre et G. Koenig., 2011. (Original in French)

[18] HIESSE, V.: L'intermédiation du PSL dans les canaux de distribution: quels schémas logistiques émergents?, *Logistique & Management*, Vol. 23, No. 4, pp. 79-92, 2015. doi:10.1080/12507970.2015.11758624

[19] GRÖßLER, A., TIMENES LAUGEN, B., ARKADER, R., FLEURY, A.: Differences in outsourcing strategies between firms in emerging and in developed markets, *International Journal of Operations & Production Management*, Vol. 33, No. 3, pp. 296-321, 2013. doi:10.1108/01443571311300791

[20] DARKOW, I.-L., WEIDMANN, M., LORENTZ, H.: Adaptation of Foreign Logistics Service Providers' Resources and Capabilities to a New Institutional Environment, *Journal of Supply Chain Management*, Vol 51, No. 1, pp. 27-51, 2015. doi:10.1111/jscm.12068

[21] CHOW, G., GRITTA, R.: *The North american logistics service industry proceedings of the fourth international meeting for research in logistics*, Lisbon Portugal, CD ROM, 2002.

[22] COLIN, J., SAVY, M.: *Logistique, transport et prestations de services: les flux rapides*, Logistique Magazine, Paris, 1990. (Original in French)

[23] STEFANELLY, J.J.: *Les problèmes posés par la sous-traitance*, Avis et rapport du Conseil économique et social, 1973. (Original in French)

[24] GRAND, L.: *La sous-traitance en transport routier de marchandises : causes, formes, effets*, Celse, Paris, 1999. (Original in French)

[25] TIXIER, D., MATHE, H., COLIN, J.: *La logistique d'entreprise,* Dunod, Paris, 1996. (Original in French)

[26] PACHE, G.: Pratiques et théorie de l'externalisation : le cas des prestataires logistiques, *Logistique & Management*, Vol. 2, No. 1, pp. 19-29, 1994. (Original in French)

[27] EL BAZ, J., LAGUIR, I.: Third-party logistics providers (TPLs) and environmental sustainability practices in developing countries: The case of Morocco, *International Journal of Operations & Production Management*, Vol. 37, No. 10, pp. 1451-1474, 2017. doi :10.1108/IJOPM-07-2015-0405

[28] AMDL (AGENCE MAROCAINE DE DEVELOPPEMENT DE LA LOGISTIQUE).: Guide de l'externalisation des activités logistiques, [Online], Available: https://www.amdl.gov.ma/amdl/wp-content/uploads/2020/02/Guide-d%E2%80%99externalisation-des-activit%C3%A9s-logistiques.pdf, [Octobre 2016], 2020. (Original in French)

Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 7 2020 Issue: 3 Pages: 175-186 ISSN 1339-5629

doi:10.22306/al.v7i3.173 *Received: 07 May 2020; Revised: 10 June 2020; Accepted: 15 Sep. 2020*

DISTRIBUTION METHODOLOGY IN SMALL BREWERY COMPANY TO OBTAIN PROFITS IN SHORT TIME

Irma-Delia Rojas-Cuevas
Instituto Tecnológico de Puebla, Av. Tecnológico No. 420, Colonia Maravillas, 72220, Puebla, Mexico, rojascid@yahoo.com.mx
Diana Sánchez-Partida
Universidad Popular Autónoma del Estado de Puebla A.C., 17 Sur 901, Barrio de Santiago, 72410, Puebla, Mexico, diana.sanchez@upaep.mx (corresponding author)
José-Luis Martínez-Flores
Universidad Popular Autónoma del Estado de Puebla A.C., 17 Sur 901, Barrio de Santiago, 72410, Puebla, Mexico, joseluis.martinez01@upaep.mx
Santiago-Omar Caballero-Morales
Universidad Popular Autónoma del Estado de Puebla A.C., 17 Sur 901, Barrio de Santiago, 72410, Puebla, Mexico, santiagoomar.caballero@upaep.mx

Keywords: traveling salesman problem, Knapsack problem, Greedy algorithm, brewery industry, profits in short-term
Abstract: This paper presents a methodology oriented to obtain profits in the short-term and is applied to the brewery industry for distributing goods. It is composed of two models of Operations Research (OR), the Knapsack Problem (KP), and the Traveling Salesman Problem (TSP). Also, the Greedy Algorithm is used. In the first step, the KP modified model is used in the choice of the product to give priority to products, which maximize the profit of the Company, making the load assignments for each route respecting the constraints of volume and weight of vehicle capacity. The volume of the vehicle considers full boxes, and its weight and profit are calculated in bottles. As a result, the product loaded is prioritized, where the highest profit product is delivered first and then the low-profit product. Subsequently, the TSP model was used to select the best route for the distribution of the products. Finally, with the Greedy Algorithm and results obtained previously, the customers to be visited are determined.

1 Introduction

In Mexico, 2014, the number of Micro, Small, and Medium Enterprises (SMEs) were more than four million, according to [1]. Moreover, according to [2], the SMEs are 99% of the businesses that exist in Mexico. The SMEs generate 80% of current jobs and more than 36% of Gross Domestic Product (GDP), for this reason, it is the economic sector that has one of the most significant social impacts. To accelerate and to improve their competitiveness, any federal programs support the entrepreneur, where they can obtain advice, services, and credits. The support offered focuses on solves economic problems or develops strategies to make the SMEs grow. Nevertheless, there are no programs to analyze the internal process of each one of the SMEs.

There are international studies that report problems to implement development projects and low success rates [3,4]. A good strategy that SMEs can use to obtain the analysis and the improvement of their processes is to interact with universities because, after all, education and research are keys in the formation of worldwide markets [5]. On the other hand, in Mexico, the universities, especially those that are offering postgraduate studies, are developing investigation [6] based on the case study method and using data from SMEs in order to develop the application of knowledge to real-world situations [7]. In this way, the case presented and improved is a result of this relationship.

Within the improvement to the brewing company, the knapsack Problem (KP), the Traveling Salesman Problem (TSP), and the Greedy Algorithm are used to solve the problem of distribution of goods to customers incurring in the lowest possible costs. The problem is tackled because the Company is not complying with the deliveries to customers promptly, and the priority of the Company is to attend the customers that represent more income. The current delivery of the company process consists of supplying the customers as soon as possible, which incurs unnecessary costs because they do not have a delivery plan.

The KP or also known as the Backpack Problem is a Combinatorial Optimization Problem (COP) and is used to define objects to fit into a backpack, so that optimizes the total value, without exceeding the weight and/or volume of the backpack [8] proposed a solution of 0-1 in the KP (non-viable - viable) while several processors run at the same time, it was a way to achieve better time solution of the problem of this nature for the NP-Hard solution. Besides, [9] proposes three levels of the knapsack algorithms that minimize the errors of the best solution for small problems. These algorithms are discarded and made a selection of the best solutions that were defined as Hyper-heuristics.

On the other hand, [10] propose a heuristic be able to

generate a common knapsack problem considering that the products can do rotations in two and three dimensions. While the TSP model is approached from the street vendor, he wishes to visit exactly once each of a list of cities and return to origin.

Now, the importance of the TSP model is that it is representative of a larger class of problems known as COP too. It belongs to the class of problems known as NP-complete. Specifically, it is possible to find an efficient algorithm that can give the solution (i.e., that run in polynomial time). Also, the TSP model has practical implications for issues as seemingly diverse as drilling of printed circuit boards [11], x-ray crystallography [12], and the robotics assembly [13]. Some practical problems involving laser drilling of printed circuit boards [14] or movements in the manufacture of chips mean the TSP model up to a million nodes.

Nevertheless, as noted above, it has not discovered any effective algorithm that can find the optimal solution to the TSP model, and a guaranteed-search method exhaustive because it becomes more impractical as it increases the number of points (n). Increases the number of possible solutions to a TSP model (n - 1)! / 2 (if the direction of travel is ignored), so, to find all the possible solutions to a problem of 20 nodes, a computer-generated by, say, 100 solutions per second would require more than 19 million years [15].

Also, the application of the Greedy Algorithm was used to find the best solution for every step, with the hope that, at some point, to obtain a better solution. [16] defined that this algorithm seeks the best solution from a selection of possible solutions. [17], who defined an algorithm to optimize again to obtain the solution of Greedy Algorithm nature based on partial solutions and reach the best solution more quickly with fewer resources.

For a vast instance, the exact methods are inefficient regarding resolution times, and here is where the metaheuristics help us to solve them. It is possible to build an effective solution using the Greedy algorithm; some of the solutions reported with this algorithm have an error of 5% [18].

2 Background

This section is separated into two subsections: the first subsection is about the analysis of the companies according to their sizes, the number of employees and the entities as they are located, and the second subsection is about the beer companies in Mexico.

2.1 Companies in Mexico

According to the information of the National Institute of Statistics and Geography (INEGI) [19], the companies are classified into four types based on the number of employees and their sales expressed in US dollars with an exchange rate of 21.92.

1. ***Micro Industry***. This type of industry has a maximum of 15 employees, and their sales are a maximum of USD 1,387,808.10.
2. ***Small Industry***. This type of industry has a maximum of 100 employees, and their sales are a maximum of USD 18,504,108.03.
3. ***Medium Industry***. This type of industry has a maximum of 250 employees, and their sales are a maximum of USD 50,886,297.08.
4. ***Big Industry***. This type of industry has more than 250 employees, and their sales are more prominent than USD 50,886,297.08.

In Mexico, the manufacturing sector is considered the companies that make beer, the steel industry, the automotive industry, and others.

According to INEGI (2018)[20], the manufacturing sector generates 27 % of the national total, with 39% of total employees. It makes the manufacturing sector one of the most important for the country. These data are shown in Figure 1.

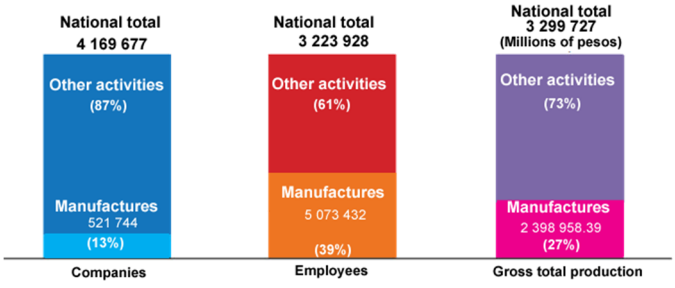


Figure 1 Importance of Manufactures in the Economy (source: INEGI, 2018)

There is not enough data to analyze the behavior of manufacturing companies by their size; for this reason, the INEGI 2014 data will be employed for the analysis. The manufacturing sector from 2008 to 2013 in the number of companies grow a 12.1% in total, but the strata that most grow was the micro with a 13.3% and the small decrease in 8.5%, while the medium and the big grew 4.5% and 9.7%. The decrease of 8.5% shows that small companies have trouble to survive and that is the reason to focus the present work to help in the improvement of one small Company. These data are presented in Table 1.

The indicator of increase or decrease in the number of companies needs to be accompanied by the analysis of evolution in the number of employees. It because although the companies show the evolution and the perception of economic growth, the number of employees shows the social impact of each one of the strata in the country.

Table 1 Evolution of companies by stratum 2008 and 2013 (source: economic census of INEGI, 2014)

Strata	Companies			Percentage growth
	2008	2013	2018	2008-2013
Total manufactures	**436 851**	**489 530**	**521 744**	**12.1**
Micro	404 156	458 096		13.3
Small	22 349	20 455		-8.5
Medium	7 113	7 431		4.5
Big	3 233	3 548		9.7

The total growth of employees in the manufacturing sector was 8.8 %. It is contrary to the growth observed in Table 1. In micro manufactures, the number of employees decreased by 2.2%. In the small strata, the decrease was 4.5%; in the medium strata, the growth was 6.7%, and the best strata were in big manufacturers with a growth of 17.4%. These data are shown in Table 2. Table 1 shows the growth of companies from 2008 to 2013 in quantity and percentage associate with this. While Table 2 shows the growth in quantity and percentage of employees affected directly with the growth (positive or negative) of the companies. In Table 1, the micro-companies grow 13.3% while in Table 2, the micro-companies decrease in 2.2%, one of the reasons for these data could be that to survive small companies are now micro-companies with fewer employees and fewer profits, and that could explain the growth of micro-companies. In comparison, other small companies conserved their profits but had fewer employees, that could explain that the percentage of micro-companies grew and the percentage of employees decreased. The reality that tables show is those small companies are a vulnerable sector that needs help, the rest are only assumptions, that need more in-depth analysis.

Table 2 Evolution on the number of employees by stratum 2008 and 2013. (source: economic census of INEGI, 2004)

Strata	Employees		Percentage growth
	2008	2013	2008-2013
Total manufactures	**4 661 062**	**5 073 432**	**8.8**
Micro	1 080 713	1 057 456	-2.2
Small	467 197	446 181	-4.5
Medium	797 907	851 506	6.7
Big	2 315 245	2 718 289	17.4

According to INEGI, Mexico (Country) is divided into five regions, South-southeast, Center-West, Center, Northeast, Northwest. Each one of these regions was analyzed by INEGI to know the number of Companies, Employees, and the Gross Total Production. The region of interest is the Region South-southwest, where Puebla located. This region contributes to the country with 36.9% of the Companies, 14.2% of the Employees, and 18.4% of the Gross Total Production. The percentage of each one of these regions in the Total National is presented in Table 3. Puebla is located in the south-southeast region, the region that brings more companies to the total Nacional (According to Table 3).

Table 3 Economic regions of Mexico. (Source: economic census of INEGI, 20014)

Regions	Companies	Employees	Gross Total Production
	Percentages		
Total nacional	**100.0**	**100.0**	**100.0**
South-southeast	36.9	14.2	18.4
Central-west	24.0	22.1	20.8
Center	24.5	24.9	26.6
Northeast	8.6	27.5	26.7
Northwest	6.0	11.3	7.5

Puebla is the City with the most quantity of companies in the Region south-southeast. With a grew total from 2008 to 2013 of 22.8%. The micro-companies grew 22.4%, small companies grew 38.6%, medium companies grew 46.4%, and big companies grew 38.2%, being Puebla, who grew more in the region. The input of each City in the region south-southeast is presented in Table 4.

The information about the contribution of Puebla in the economy of México is vital because the Company to be analyzed is a beer manufacturing company settled in Puebla. This Company is of small size because it has 32 employees. This Company is active in superstores, coffee shops, restaurants, and lodging houses.

Table 4 Companies by Entity according to their size, 2013. (source: economic census of INEGI, 2014)

Strata	Total		Micro		Small		Medium		Big	
	Absolute	%	Absolute	%	Absolute	%	Absolute	%	Absolute	%
South-southeast	**180 574**	**100.0**	**176 471**	**100.0**	**2 976**	**100.0**	**834**	**100.0**	**293**	**100.0**
Campeche	3 440	1.9	3 349	1.9	63	2.1	18	2.2	10	3.4
Chiapas	16 856	9.3	16 580	9.4	215	7.2	44	5.3	17	5.8
Guerrero	26 774	14.8	26 627	15.1	120	4.0	23	2.8	4	1.4
Oaxaca	36 964	20.5	36 712	20.8	210	7.1	29	3.5	13	4.4
Puebla	41 114	22.8	39 467	22.4	1 148	38.6	387	46.4	112	38.2
Quintana Roo	3 043	1.7	2 894	1.6	122	4.1	23	2.8	4	1.4
Tabasco	5 075	2.8	4 898	2.8	128	4.3	34	4.1	15	5.1
Veracruz	24 674	13.7	23 893	13.5	551	18.5	153	18.3	77	26.3
Yucatán	22 634	12.5	22 051	12.5	419	14.1	123	14.7	41	14.0

2.2 The beer industry in Mexico

There are two Mexican corporations in the beer-market, that dominate more than 97% of the market in Mexico Grupo Modelo and Cervecería Cuauhtémoc Moctezuma (CCM), part of Grupo Femsa. Grupo Modelo had a market share of 57%, while CCM had a market of 42% [21]. It left a very reduced market to other breweries in the national market. Also, it is necessary to take into account that foreign breweries corporations are interested in the national market; this makes harder the competition for small companies. The product of the Company to study is available in supermarkets, restaurants, and bars. These products share the market with a lot of different beer-brands, also with foreign beer-brands.

According to [22], there are 55 economic units in the country dedicated to brewing, which generate 1.2% of total gross production with a total gross production of 78,403 million Mexican pesos. In the brewery industry work 11,834 persons, of which 7.3% are women and 92.7%, are men. The brewery industry is number 14 in order of importance in Mexico, as can be seen in Table 5.

According to [22], the primary entities that produce beer are Zacatecas with 18%, Coahuila with 15%, DF with 12%, Nuevo Leon with 11%, Oaxaca with 11%, the other 33% is distributed among other entities.

Table 5 Position of the importance of Brewing Companies in Mexico (source: economic census of INEGI, 2015)

Position of importance	Industry
1	Petroleum refining
2	Truck and Tractor Truck Manufacturing
3	Manufacture of basic petrochemicals of natural gas and refined oil
4	Manufacture of cars and trucks
5	Manufacture of other parts for automotive vehicles
6	Preparation of soft drinks and other soft drinks
7	Pharmaceutical industry (Manufacture of pharmaceutical preparations)
8	Manufacture of electrical and electronic equipment and parts for motor vehicles
9	Steelmakers complexes
10	Manufacture of gasoline engines and their parts for automotive vehicles
11	Manufacture of other iron and steel products
12	Manufacture of interior seats and accessories for motor vehicles
13	Food processing for animals
14	**Brewing**

Mexico ranks as the fourth largest beer-producing country in the world, after China, the United States of America and Brazil.

Since 2010, Mexico is the leading exporter of beer worldwide. Currently, one in five beers exported in the world is produced in Mexico.

The production of beer is essential in the beverage industry because brewing, according to gross production, is among the 14 most important activities of the country's manufacturing production, among a total of 291 activities, below oil refining, the manufacture of cars and trucks, among others.

Brewing represents 29.3% of the total gross production of the Beverage Industry, being the second most important economic activity within it, as is shown in Table 6.

Table 6 Importance of brewing in the beverage industry source: economic census of INEGI, 2015)

SCIAN Code	Economic activity	Economic units	Busy staff	Gross production
Branch 3121	Beverage industry	100	100	100
Class 312111	Preparation of sodas and other soft drinks	1.5	39.2	54.9
Class 312112	Water purification and bottling	89.9	40.1	4.8
Class 312113	Ice making	4.1	5.2	1.3
Class 312120	**Beer making**	**0.3**	**7.2**	**29.3**
Class 312131	Elaboration of alcoholic beverages based on grapes	0.3	1.3	1.8
Class 312141	Elaboration of rum and other distilled cane drinks	0.2	0.4	0.6
Class 312142	Elaboration of distilled agave drinks	2.9	5.9	7.2
	Other activities	0.8	0.7	0.1

According to the history, The Cuauhtémoc brewery group (Grupo Cuauhtémoc Moctezuma, 2012) emerges on November 8, 1890, in the City of Monterrey, Nuevo León and because of the needs of this group they start to create companies to provide them, like Vidriera Monterrey, Hylsa Factories Monterrey, Packaging Carton Titan, Grafo Regia, and Malta. With this history, it is easy to show how the born of new companies helps other companies to born or to grow, improving with this the economy of the country and also if any company broke other companies are affected.

3 Problem Description

Company A is a brewery company that serves local and national markets. The national market is served by courier service, while the local market is served directly by the Company, for which the Company has its transportation. The Company has the problem of not having a plan to optimize the distribution of their product at the local level, so this document focuses on solving this problem. The Company has 17 small local customers in the City of Puebla. The Company sells two types of beer, and there are two presentations for each one, bottles and barrels. The weekly customer's demand is 1364 bottles of beer type 1 and 2021 bottles of beer type 2, the content of the bottle is 350 ml, and are packed in groups of 12 in boxes.

On the other side, there is a demand for one of 19 liters' barrels of beer type 1 and demand of one of 29 liters' barrels of beer type 2. This Company supplies individually bottles of products type one (*y1*) and type (*y2*), but these bottles are carrying on boxes, even if there are less than 12 bottles. The mentioned data are shown in Table 7.

Table 7 Weekly demand per customer

Product	Customer																	Total	Units
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
y1	28	54	296	80	54	41	82	78	41	54	28	270	28	54	41	135	0	1364	Bottles
y2	54	108	1044	80	54	26	67	79	41	28	26	270	32	54	67	0	0	2021	Bottles
y3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	Barrels
Y4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	Barrels

In Table 8, four variables are used, where *y1*, *y3* represents beer type 1, with bottles and barrel presentations of 19 liters, respectively, while *y2*, *y4* represent the beer type 2 in bottles and 29-liters barrel presentations respectively. The same table shows the volume, the weight, and the profit obtained by the Company from its sale. In the case of *y1* and *y2*, the volume is per box, while the profit and the weight is per bottle.

Table 8 Volume, weight, and profit of each product

Variable	Volume	Weight	Profit	Units
y1	574	4.2	USD 1.4	Box
y2	574	4.2	USD 1.4	Box
y3	2215	24	USD 78.1	Barrel
y4	2286.3	38.1	USD 117.5	Barrel

4 Research Methodology

Because product distribution is required, and there is only one truck, planning the distribution as done in three steps, which are detailed below:

- The KP model was used to obtain the load of the truck, assigning first the products that provide more excellent utility to the Company, respecting the volume, and the weight that can stand the truck. The KP was used first because it considers the volume and weight of the products. It looks for first select products that grant higher profit to the Company, thereby ensuring that the first routes to provide more profit to the Company — after that, the Company will continue distributing the products with less profit, giving attention to all customers, but prioritizing to customers that have a more significant impact on the company profits.
- Then, the TSP model was used to find the optimal route that would minimize the distances, looking for fuel economy.
- Moreover, for last, the Greedy Algorithm was used to assign the product to the customers. According to the TSP model of the previous step, it was respecting the loads assigned with the KP.

5 Case study

The data necessary to solve the problem were the demand of the customers, the capacity of the vehicles, the distance from the warehouse to customers and between customers, the volume and the weights of the products, the cost of the fuel, the value associate to each one of the products. The case study was solved in three steps following the methodology of section 4.

5.1 Knapsack Problem (KP)

The KP model is a problem that searches for the best solution among a finite set of possible solutions to a problem. It models a situation like filling a backpack that can have constraints of weight or volume or both. Objects in the backpack will have their weight and specific volume and will be selected so that putting them in the backpack maximizes the total value, without exceeding the maximum weight or volume.

Since the standard Knapsack selecting from existing products, those that could be placed in the truck, not exceeding the volume and weight, the algorithm suggested place to *y1, y2, y3,* and *y4* product, (a part of each) which as we shall see, do not exceed the capabilities of the truck, since they are considered unique products. i.e., its amount is not considered, and if the total amount of each of the products is considered, the amount would not fit in the pickup truck in a single route.

Therefore, the KP model developed by [23] was modified according to the volume, weight, and profit of each of the presentations of the products chosen and the total of each product the truck should carry. The proposed model is presented below:

Objective Function:

$$Max \sum_{k=1}^{n} P_k Q_k \quad (1)$$

Constraints:

$$Q_k \le D_k \qquad k = 1,2,3 \quad (2)$$

$$B_k = \left\lceil \frac{Q_k}{T} \right\rceil \qquad k = 1 \quad (3)$$

$$B_k * 12 = Q_k \qquad k = 2,3 \quad (4)$$

$$\sum_{k=1}^{n} w_k Q_k \le W \quad (5)$$

$$\sum_{k=1}^{n} v_k B_k \le V \quad (6)$$

$$Q_k \in \mathbb{Z} \quad k = 1,\ldots,n \quad (7)$$

$$B_k \in \mathbb{Z} \quad k = 1,\ldots,n \quad (8)$$

Where:

k are the products that assume values from 1 to n.
n is the number of different types of products.
P_k is the value associated with each product.
T is the number of bottles per box (T=12).
w_k is the weight associated with each product k.
v_k is the volume associated with each product.
x_k acquires the value of 1 if the product k is chosen and 0 otherwise.
W is the total weight of the vehicle.
V is the volume that the vehicle supports.
D_k is the total quantity of the product k.

Q_k is the quantity of product (in bottles) k assigned to each route.

B_k is the quantity of product (in boxes) k assigned to each route.

The objective function (1) seeks to maximize the profit obtained from the selected products and their quantity. The constraint (2) allows selecting an amount of each product that does not exceed the total amount to be transported. The constraint (3) determines the number of boxes in integer numbers. The constraint (4) establishes the number of barrels in integer numbers. The constraint (5) verifies that the weight of the selected products does not exceed the weight limit that can be supported by the vehicle. The constraint (6) verifies that the quantity of products does not exceed the limits on the volume of the vehicle. The constraint (7) verifies that the variable Q_k for k=1, 2, 3 is an integer, to ensure that the bottles and the barrels are not considered on fractions. The constraint (8) verifies that the variable B_k is an integer, to ensure that boxes and barrels for the calculation of volume, are not considered on fractions.

However, since the program seeks to fill a vehicle each time optimally, some steps were cyclical, as shown in Figure 2.

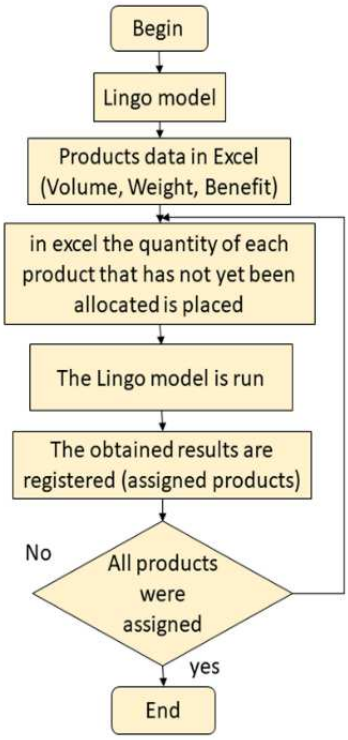


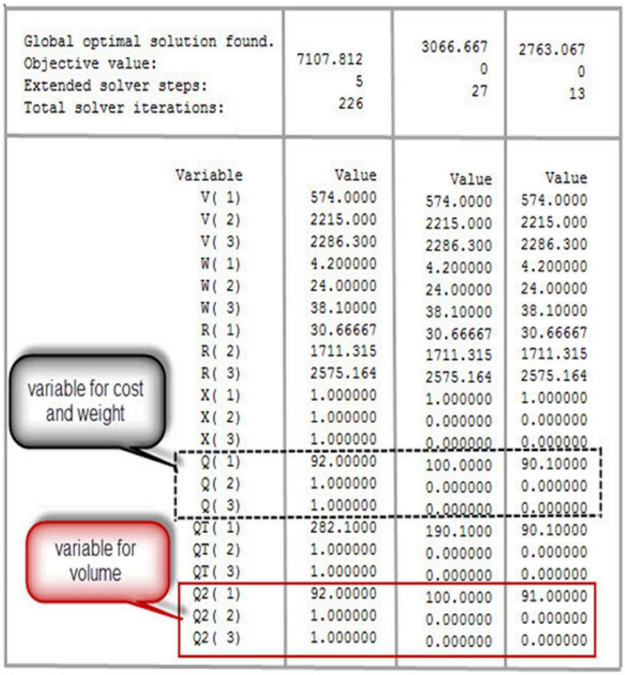
Figure 2 Flowchart of the process of assigning modified Knapsack

The modifications to the KP in Lingo model are shown in Appendix A; these modifications allowed the model to assign the maximum amount to be transported in the truck, respecting the constraints of volume and maximum weight that it can hold the truck in each route and they are considered complete boxes for the route, even if bottles are moved. Lingo code *QT* variable receives the full amount of each presentation of the product, while the variable *Q*, allows fewer of each product, to accomplish with the restrictions of weight and volume of the truck.

The *y1* and *y2* products were joined to obtain the Knapsack since they provide the same utility to the Company. In order to assign the products to the truck, there were three runs, where the KP respects the constraints of weight and maximum volume of the truck that was 1143 Kg and 57400 m^3, respectively. The volume, weight, and profit for each of the presentations of the beer can be seen in Table 6.

In Figure 8 for each product is shown the variables, where the variable *v* is the volume, *w* is the weight, *R* is the profit, *Q* is the quantity to calculate the cost and the weight of the products, *QT* is the total quantity to transport in all the three tours, *Q2* is the number of complete boxes (even if they are not full) and barrels to calculate the volume that the vehicles will transport.

Also, to hold the assignment to give priority to products that provide more profit, so that the first route was scheduled to carry the load that maximizes profit. Barrels (*y3*, *y4*) were assigned to the first route, and the rest of the space was assigned to boxes of beer type 1 and type 2 (*y1*, *y2*), with a weekly profit of USD 326.5; route two charges *y1* and *y2* with a weekly profit of USD 141. Furthermore, finally, route 3 comes with *y1* and *y2* with a weekly profit of USD 129.5. With three routes covering the total weekly demand, as is shown in Figure 3.



(a)

	Load distribution		
	Tour 1	Tour 2	Tour 3
y1,y2	92	100	90.1 / 91
y3	1	0	0
y4	1	0	0
Utility	326.5	141.0	129.5
Volume	57309.3	57400	52234
Weigth	448.5	420	378.42

(b)

Figure 3 (a) LINGO runs to assign cargo to 3 routes (b) Distribution of products per route

5.2 *Traveling Salesman Problem (TSP)*

Karl Menger conceived the idea of the TSP model in the 1930s. This model seeks to minimize the total distance of a route that connects all nodes of a network, visiting each node once and returning to the starting point. The TSP model is shown below:

Objective Function:

$$Min \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}x_{ij} \quad (10)$$

onstraints:

$$\sum_{i=1, i\neq j}^{n} x_{ij} = 1, \quad j = 1,\ldots,n \quad (11)$$

$$\sum_{j=1, j\neq i}^{n} x_{ij} = 1, \quad i = 1,\ldots,n \quad (12)$$

$$(n-1)x_{ij} + u_i - u_j \leq (n-2), \quad i, j = 2,3,\ldots,n \quad (13)$$

$$x_{ij} \in \{0,1\}, \quad i = 1,\ldots,n, \quad j = 1,\ldots,m \quad (14)$$

Where:

c is the distance traveled.

i, j are cities that take the value of 1 to n.

x_{ij} acquires the value of 1 if a vehicle goes from City i to city j and 0 in another.

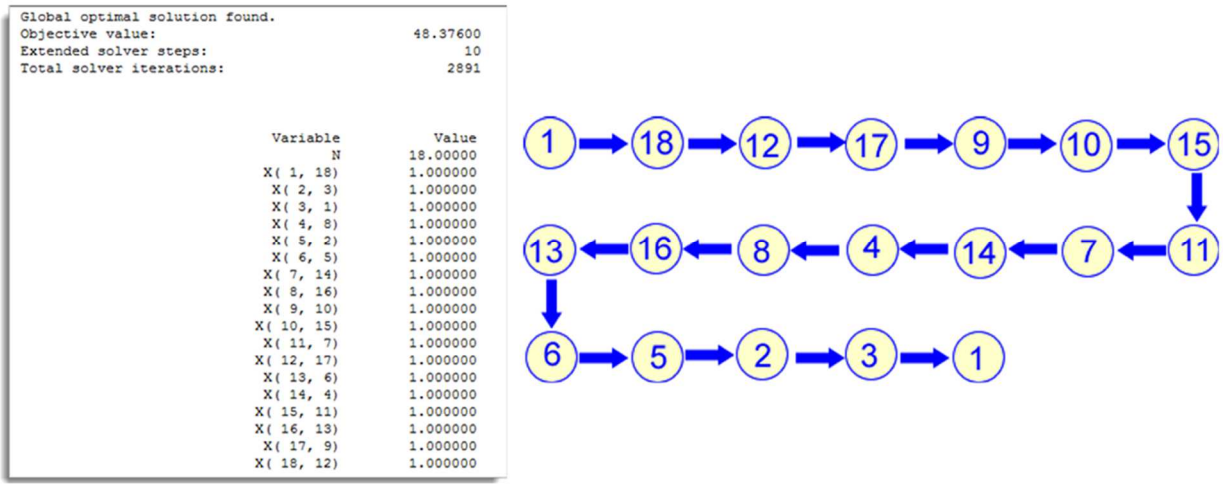
u_i, u_j define a sequence of visits to the problem cities, also representing the cities of origin and destination, respectively.

The objective function (10) seeks to minimize the distance traveled. Moreover, the constraint (11) forces the vehicle to leave only once from each City. The constraint (12) requires that the vehicle arrives only once to each City. The constraint (13) avoids sub-routes of length greater than 1. The constraint (14) ensures that the variable x_{ij} is binary.

The distances between the customers were obtained using Google Maps, to and from the Company, these distances are shown in Appendix B, where the depot is node one.

With the distances matrix, the TSP model is applied in Lingo, and the result of the best route is the next 1-18-12-17-9-10-15-11-7-14-4-8-16-13-6-5-2-3-1, where the depot is node one, as shown in Figure 11. In this figure, the variable X shows the route obtained. The route begins in node one and connects with node 18. Later, it is necessary to find node 18, and in the figure, it is observed that it is connected with node 12, following the route, can we appreciate that node 12 is connected with node 17. To complete the route is necessary to follow the connections to finally find that the node three return to node 1, with this the route ends. In Figure 4, the nodes that were not connected (with cero) were omitted to avoid use more space for the figure.

Until now, it has been obtained the quantity and type of product to carry each route and the route to follow for the deliveries.

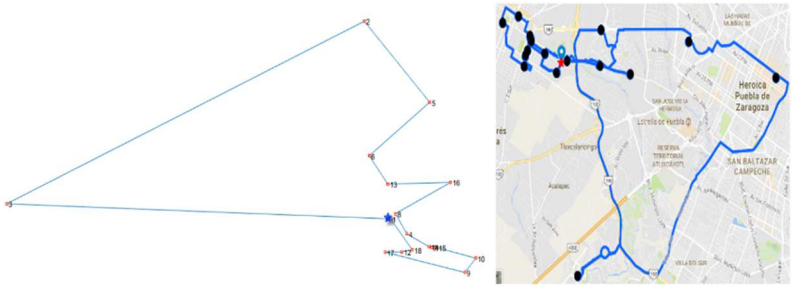


```
Global optimal solution found.
Objective value:                              48.37600
Extended solver steps:                           10
Total solver iterations:                       2891

                     Variable           Value
                            N        18.00000
                     X( 1, 18)       1.000000
                     X( 2, 3)        1.000000
                     X( 3, 1)        1.000000
                     X( 4, 8)        1.000000
                     X( 5, 2)        1.000000
                     X( 6, 5)        1.000000
                     X( 7, 14)       1.000000
                     X( 8, 16)       1.000000
                     X( 9, 10)       1.000000
                     X( 10, 15)      1.000000
                     X( 11, 7)       1.000000
                     X( 12, 17)      1.000000
                     X( 13, 6)       1.000000
                     X( 14, 4)       1.000000
                     X( 15, 11)      1.000000
                     X( 16, 13)      1.000000
                     X( 17, 9)       1.000000
                     X( 18, 12)      1.000000
```


Figure 4 LINGO runs to get the TSP model results and the route obtained

The route obtained with the TSP algorithm was modeled in MATLAB using strength lines to connect the customer points. Also, the customer points were connected in a map, using the streets and their direction. The route obtained with TSP to attend the customers is shown in Figure 5.



(a) (b)

Figure 5 The route obtained with the TSP algorithm. (a) drawn with MATLAB, (b) in a map

5.3 Greedy Algorithm

Finally, Greedy Algorithm is used to identify the data and sort it according to the route obtained with the TSP model, and select the customers according to their demand, verifying that the demand is as close as possible to the result obtained in the KP, this process is shown in Figure 6.

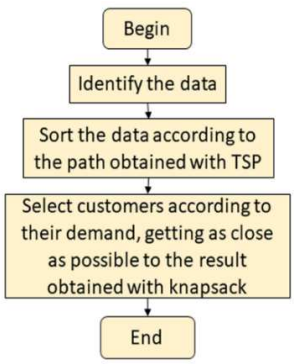


Figure 6 Flow Diagram of the Greedy Algorithm

The Greedy Algorithm was used to assign the products for each of the three routes. When making the assignment the customer's request, the goods of customer four are divided into two routes, because the customer demand exceeds the capacity of the truck. Taking into account the result of the TSP model, and the allocation of boxes and barrels obtained with the KP, a Greedy Algorithm is performed for the specific allocation of products in each route.

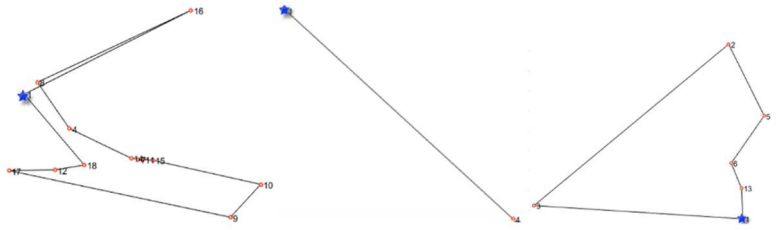
In Table 9, (customer column), the route designated by the TSP model for delivery is observed. In the following columns, the quantities of the product to be delivered by the KP are written.

Table 9 Assignment of the Greedy Algorithm

Customer	Route 1				Route 2				Route 3			
	y1 [a]	y2 [a]	y3 [b]	y4[b]	y1 [a]	y2 [a]	y3 [b]	y4[b]	y1 [a]	y2 [a]	y3 [b]	y4[b]
1												
18	0	0	0	1								
12	2.25	2.25	0	0								
17	11.25	0	0	0								
9	6.525	5.85	0	0								
10	3.375	3.375	0	0								
15	4.5	4.5	0	0								
11	4.5	2.25	0	0								
7	3.375	2.25	0	0								
14	2.25	2.7	0	0								
4	11.75	0	0	0	13	86.985	0	0				
8	6.75	5.625	1	0								
16	3.375	5.625	0	0								
1												
13									22.5	22.5	0	0
6									4.5	4.5	0	0
5									6.75	6.75	0	0
2									2.25	4.5	0	0
3									4.5	9	0	0
1												
Total	59.95	34.43	1	1	13	86.985	0	0	40.55	47.35	0	0
Volume	58643.55				57391.39				50368.5			
Weight	420.165				419.937				368.55			

[a] boxes, [b] barrels

The route one carries a load of products for twelve customers. The load is composed of 95 boxes of product *y1* and *y2,* delivery 1 barrel of *y3,* and 1barrel of *y4*. Route two delivery to customer 4 with 87 boxes *y1* and *y2*. Finally, route three delivery to 5 customers with 88 boxes. In Figure 7 are shown the routes obtained, using strength lines for the union of customer points.



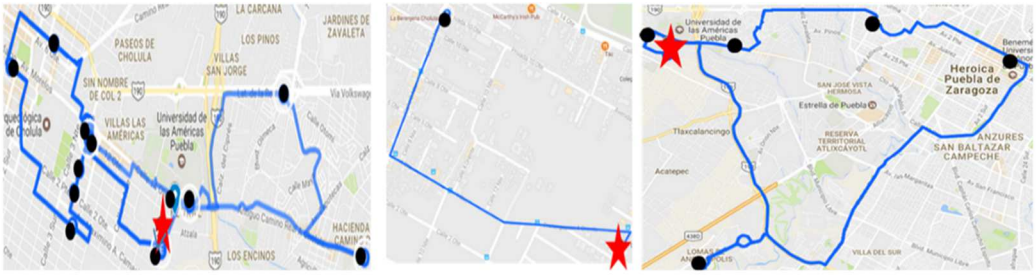
(a) (b) (c)

Figure 7 Routes obtained with Greedy Algorithm - route 1 (a), route 2 (b), route 3 (c)

5.4 Results discussion

The combination of these three models helps us to solve the problems of deliveries by first delivering the products that generate the highest profit to the Company and optimizing the route to make those deliveries. In route one, it supplies 12 customers and delivers 95 boxes of which 60 boxes are of type 1, and 35 boxes are of type 2, one barrel of 19 liters of beer type 1, and one barrel of 29 liters is of beer type 2. The route two was done for a customer, 100 boxes are delivered, which 13 boxes of beer type 1 and 87

boxes of beer type 2. The route 3, supplies five customers, and 89 boxes are delivered, which 41 boxes are of type 1 beer and 48 boxes are of type 2. The route of each of the three routes is added, where the depot is the red star, and the black spots are the customers, as can be seen in Figure 8.



(a) (b) (c)

Figure 8 Route 1 (a), route 2 (b), route 3 (c)

The vehicle used for the Company is a truck with a capacity of 1143 kg of weight. The dimension of the back of the pickup truck is 225 cm x 135 cm. The boxes can carry one on top on another, stocking a maximum of two boxes. With the maximum boxes stocked, the volume that the vehicle can carry is 57400 cm^3. The median fuel consumption is 7.3 Km/liter. The current cost of diesel is USD 0.84.

In Table 10, the kilometers per route and the total kilometers of the three routes are presented.

Table 10 Kilometers to cover the three routes.

Route	Km
1	14.734
2	2.37
3	37.151
Total	54.255

According to the total kilometers cover by the three routes and the median of fuel consumption of the vehicle, the vehicle needs 7.432 liters of diesel to cover the routes. With the current cost of diesel, the Company will spend USD 6.2.

The routes that the Company follows typically are random, but the median of the costs incurs per week were USD 8.7; with this improvement, the saving per year is USD 130.

6 Conclusions and future research directions

To help the small companies to survive, it is necessary for the interaction between the schools and the companies. In Table 1, the decrease of small companies from 2008 to 2013 is 8.3. The idea of helping small companies is to avoid them continue decreasing. The small companies contribute to jobs, and if they decrease, the number of employees will decrease, as can be seen in Table 2.

The proposed model is based on the combination of the knapsack problem, the Traveling Salesman Problem, and the Greedy Algorithm. The proposed model satisfies the demand of customers, focusing on the profits according to the needs of the Company.

The scheduling of delivery days to the customer supports production to keep track of a demand history and to carry out the production schedule, so that in the future, they may have optimal delivery routes established. It is improving the attention to customers, avoiding the shortage, and being able to give information on delivery dates according to the scheduling of previously established routes. Moreover, it also supports production planning to maintain a suitable make to stock (MTS). As a future work can be used, the Capacity Vehicle Routing Problem (CVRP) instead of the TSP model.

References

[1] B. INEGI, INADEM: *Boletín de prensa Núm*, 285/16, [OnLine] Available: http://www.inegi.org.mx/saladeprensa/boletines/2016/especiales/especiales2016_07_02.pdf [6 Nov 2018], 2016.

[2] Crédito Real MX. Importancia de las PYMES en la economía mexicana, [OnLine] Available: http://www.creditoreal.com.mx/contenidos/pymes-2/importancia-de-las-pymes-en-la-economia-mexicana [6 Oct 2018], 2015.

[3] BEER, M., NOHRIA, N.: Cracking the code of change, *Harvard Business Review*, Vol. 78, No. 3, pp. 133-141, 2000.

[4] KOTTER, J. P.: Leading Change: Why transformation efforts fail, *Harvard Business Review*, pp. 59-67, 1996.

[5] MARGINSON, S., VAN DER WENDE, M.: *Globalisation and Higher Education*, OECD Education Working Papers No. 8, Francia, 2007.

[6] ROJAS BERRÍO, S. P., SÁNCHEZ TORRES, M., TOPETE BARRERA, C.: *Modelos de evaluación del desempeño de actividades científicas*, Casos Colombia y México, Politécnico Gran Colombiano, Bogotá Colombia, 2014. (Original in Spain)

[7] Secretary-General of the OECD, Education in China: A Snapshot, OECD, Paris, France, pp. 7-55, 2016.
[8] GOPALAKRISHNAN, P. S., RAMAKRISHNAN, I. V., KANAL, L. N.: Approximate algorithms for the knapsack problem on parallel computers, *Information and Computation,* Vol. 91, No. 2, pp. 155-171, 1991. doi:10.1016/0890-5401(91)90063-8
[9] PARADA, L., HERRERA, C., SEPÚLVEDA, M., PARADA, V.: Evolution of new algorithms for the binary knapsack problem, *Natural Computing*, Vol. 15, pp. 181-193, 2016. doi:10.1007/s11047-015-9483-8
[10] JENS, E., PISINGER, D.: Heuristic approaches for the two-and three-dimensional knapsack packing problem, *Computers & Operations Research*, Vol. 36, No. 4, pp. 1026-1049, 2009. doi:10.1016/j.cor.2007.12.004
[11] K. FUJIMURA, S. F. A. H. T.: Optimization of high speed Chip-mounter using SOM-TSP method, *Computer Science*, Vol. 84, No. 6, pp. 1194-1202, 2001.
[12] BLAND, R. G., SHALLCROSS, D. F.: Large travelling salesman problems arising from experiments in X-ray crystallography: a preliminary report on computation, *Operations Research Letters*, Vol. 8, No. 3, pp. 125-128, 1989. doi:10.1016/0167-6377(89)90037-0
[13] HSIN-PIN, F., CHAO-TON, S.: A Comparison of search techniques for minimizing assembly time in printed wiring assembly, *International Journal of Production Economics*, Vol. 63, No. 1, pp. 83-98, 2000. doi:10.1016/S0925-5273(99)00004-3
[14] ADEL T., A., ALY, M. F., HAMZA, K.: Optimum drilling path planning for a rectangular matrix of holes using ant colony optimisation, *International Journal of Production Research*, Vol. 49, No. 19, pp. 5877-5891, 2011. doi:10.1080/00207543.2010.507608
[15] JAMES N., M., ORMEROD, T.: Human performance on the traveling salesman problem, *Perception & psychophysics*, Vol. 58, No. 4, pp. 527-539, 1996.
[16] SHARON A, C.: The classification of greedy algorithms, *Science of Computer Programming*, Vol. 49, No. 1, pp. 125-157, 2003. doi:10.1016/j.scico.2003.09.001
[17] DUBOIS-LACOSTE, J., PAGNOZZI, F., STÜTZLE, T.: An iterated greedy algorithm with optimization of partial solutions for the makespan permutation flowshop problem, *Computers & Operations Research,* Vol. 81, pp. 160-166, 2017. doi:10.1016/j.cor.2016.12.021
[18] CERRONE, C., CERULLI, R., GOLDEN, B.: Carousel greedy: A generalized greedy algorithm with applications in optimization, *Computers & Operations Research*, Vol. 85, pp. 97-112, 2017. doi:10.1016/j.cor.2017.03.016
[19] INEGI: Micro, pequeña, mediana y gran empresa, Instituto Nacional de Estadística y Geografía, México, 2014.
[20] INEGI: Encuesta Nacional sobre Productividad y Competitividad de las Micro, Pequeñas y Medianas Empresas (ENAPROCE) 2018, [OnLine] Available: https://www.inegi.org.mx/programas/enaproce/2018/ [04 Jun 2020], 2018.
[21] VARGAS, J., CAMBRONI, A.: Business Strategy in Mexican Beer Industry: A Case Applying Game Theory, *Journal of Asian Business Strategy*, Vol. 2, No. 10, pp. 198-205, 2012.
[22] INEGI: Censos económicos 2014, Resultados Definitivos, [OnLine] Available: https://www.inegi.org.mx/contenidos/programas/ce/2014/doc/pprd_ce2014.pdf [22 Nov 2018], 2014.
[23] DANTZIG, G. B.: Discrete-Variable Extremum Problems, *Operations research,* Vol. 5, No. 2, pp. 266-288, 1957. doi:10.1287/opre.5.2.266

Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 7 2020 Issue: 3 Pages: 187-193 ISSN 1339-5629

LOGISTICS, ECO-INNOVATIONS AND PANDEMIC
Erika Loučanová; Miriam Olšiaková

doi:10.22306/al.v7i3.175 Received: 15 May 2020; Revised: 25 June 2020; Accepted: 18 Sep. 2020

LOGISTICS, ECO-INNOVATIONS AND PANDEMIC

Erika Loučanová
Technical University in Zvolen, T.G. Masaryka 24, Zvolen 96001, Slovak Republic, EU,
loucanova@tuzvo.sk (corresponding author)
Miriam Olšiaková
Technical University in Zvolen, T.G. Masaryka 24, Zvolen 96001, Slovak Republic, EU, olsiakova@tuzvo.sk

Keywords: innovation, eco-innovation, GDP, Slovakia, pandemic
Abstract: The paper presents results of the evaluation of the development of eco-innovations in Slovakia in relation to GDP and the current situation in terms of logistics and COVID-19 pandemic. The issue is based on the analyses of overall eco-innovation index of the Slovak Republic in relation to GDP growth of Slovakia. The calculation regards the current state of logistics during the pandemic where GDP belongs to the main elements associated with effective eco-innovation supporting. The correlation and regression analysis are used to examine the degree of interdependence between economic growth and total eco-innovation index. The results from applied regression and correlation analysis of total eco-innovation index and GDP point to the fact that GDP belongs to key factors enabling effective eco-innovation supporting.

1 Introduction

The whole world economy is exposed to changes associated with the world economy globalization. Nowadays, the success in the business environment is strongly connected with innovations and it also applies to Slovakia. Moreover, it is really significant to understand that an innovative open society and knowledge are a condition of a modern economy. This is due to the fact that innovation affects present life as well as future occasions or living conditions interfering all life activities.

Now, there is a strong emphasis on innovation and its importance is constantly increasing. A strong emphasis is also placed on sustainability associated with ecological innovation. Effectiveness of innovation and efficient performance of organizations significantly depends on the skills and abilities of employees to create, design and apply innovation, but on many other factors, too. One of the most influencing factors is the coronavirus COVID-19 pandemic that actually impacts our lives in various areas.

The pandemics negatively affected economic growth, as well as gross domestic product (GDP). Therefore, the paper is aimed to analyse the relation of performance of eco-innovation in the Slovak Republic and its GDP with regard to pandemic situation that significantly affects economic situation as well as logistics.

2 Eco-innovation and pandemics in context with logistics

The economic development of new economy is generally aimed at increasing the life quality of its population which depends mainly on the economy performance, on the GDP level as well as on the growth in economy. Its growth is represented by economic changes. They are expressed in the elementary macroeconomic variables increase over time. From the short-term point of view, the economic growth is measured with respect to real GDP growth. Within the long-term period it is related to the potential product growth [1].

Mankiw et al. [2] presents that the growth of the economy belongs to the substantial goals of economic policy leading to population standard increase and better and more diverse consumption. Research, innovation, university education and other factors, including logistics belong among the most important factors supporting sustainable economic growth.

However, in recent times, it is not sufficient only to innovate. The more importance is placed on the innovation creation applied on the fundamentals of sustainability which represent eco-innovation. The EU [3] states that it is essential to apply eco-innovations which afford increasing environmental protection and the EU industry ability to be competitive, to introduce technologies, operations and business procedures using environmental sources much more effectively.

The Innovation Management introduces eco-innovation by innovation activities in the area of sustainable resources and used materials from the environment, taking into account the increasing significance of social and economic development [4-7]. The eco-innovation performance across the EU Member States illustrate Eco-Innovation Index. They aim at capturing the different aspects of eco-innovation by applying 16 indicators grouped into five dimensions: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource efficiency and socio-economic outcomes. The Eco-Innovation Index shows how well individual Member States perform in different dimensions of eco-innovation compared to the EU average and presents their strengths and weaknesses. The Eco-Innovation Index complements other measurement approaches of innovativeness of EU countries and aims to promote a holistic view on economic, environmental and social performance [8].

As it is presented by Straka [9] the distribution logistics provides the organizational, information and physical interface between the innovation process and resources. It is associated with the significant role to arrange the most appropriate way how to select, analyse and transport these sources within the innovation process based on the principle of sustainable development and eco- innovations.

Eco-innovation belongs to the issues discussed within the goals in the European Union (EU). It is solved within the Eco-Innovation Action Plan (EcoAP) [10]. It is a significant integrant of all economic policies [11,12]. The extent of environmental issues and also challenges related to competitiveness within in individual global economies require higher care in the area how to recover current technological production as well as social patterns of behaviour. The situation is similar in Slovakia.

However, the question is how the state of eco-innovations in Slovakia will progress because the world as well as our country is currently affected by the COVID-19 pandemic and modern production is not able to operate without completely organized material processing and transport, because they are the prerequisite for functional logistics [13,14]. However, there is a question how the state of eco-innovation in Slovakia will progress because it has to face the problems caused by the COVID-19 pandemic.

Nowadays, the pandemic-related measures have caused the closure of the largest automobile factories in Slovakia. The automotive industry has become an important engine connected with the growth of the Slovak economy for several years. Its significance also results from the fact that it directly employs circa 120,000 people.

After calculating the money that companies spend and people engaged in the passenger cars production as well as number of participated occupations increase to 200,000. Automobile production contributed up to 44% of the Slovak industry and passenger cars export presents 35% of overall domestic exports last year. Slovakia has become a leader in the amount of produced cars per thousand inhabitants during previous years [15,16].

This is the reason why we are interested in how these facts influence eco-innovations in the Slovak Republic. The paper´s objective is to evaluate eco-innovations in Slovakia with regard to the GDP and current situation in terms of logistics and the COVID-19 pandemic.

3 Methodology

Subsequently after the theoretical findings consideration, we have analysed the necessary and relevant information relating to the area of innovation as well as eco- innovation (total eco-innovation index) and GDP. The considered data are acquired from the database server Eurostat (2019) [17], European Commission, Environment, Eco-innovation Action Plan, The Eco-Innovation Scoreboard and the Eco-Innovation Index (2019) [18].

Relevant indicators from the point of view of the applied analysis of the relation between eco-innovation and GDP are organized with regard to the selected examined indicators. Then the correlation and regression analysis is used in order to find out dependencies between total eco-innovation index and the gross domestic product growth.

"With regression we analyse the relationship among variables. The dependent variable is denoted Y, the independent variable X. The variables will never be perfectly related, so there is always an error term. Variation from the regression line can be thought of as having two parts: explained variation, which is accounted for by the independent variable, and unexplained variation, which is unaccounted for by the independent variable. That is, part of the change in a variable is due to another variable that we hypothesize, and part is due to other factors.

In regression analysis we are concerned with whether the relationship pattern between two values of variables can be described as a straight line, which is the simplest and most commonly used form.

$$Y = a + bX \tag{1}$$

where:

Y is the dependent variable, measured in units of the dependent variable, X is the independent variable, measured in units of the independent variable, and a and b are constants defining the nature of the relationship between the variables X and Y.

a or Y-intercept (also known as Yint) is the value of Y when $X = 0$.

b is the slope of the line and it is known as the regression coefficient and it is the change in Y associated with a one-unit change in X.

The greater the slope or regression coefficient is, the more influence the independent variable has on the dependent variable, and the more change in Y associated with a change in X.

The regression coefficient is typically more important than the intercept from a policy researcher perspective as we are usually interested in the effect of one variable on another" (Regression Analysis, 2019).

Because visual examinations are largely subjective, we need a more precise and objective measure to define the correlation between the two variables. To quantify the strength and direction of the relationship between two variables, we use the linear correlation coefficient:

$$r = \frac{\sum \frac{(x_i - \bar{x})(y_i - y)}{s_x \quad s_y}}{n-1} \tag{2}$$

where:

$\bar{x}$ and s_x are the sample mean and sample standard deviation of the x's, and $\bar{y}$ and s_y are the mean and standard deviation of the y's,

n is the sample size is.

This statistic numerically describes how strong the straight-line or linear relationship is between the two variables and the direction, positive or negative.

In ANOVA, we partitioned the variation using sums of squares so we could identify a treatment effect opposed to random variation that occurred in our data.

The sums of squares and mean sums of squares are typically presented in the regression analysis of variance table. The ratio of the mean sums of squares for the regression and mean sums of squares for error form an F-test statistic used to test the regression model.

The relationship between these sums of square is defined as

$$\text{Total Variation} = \text{Explained Variation} + \text{Unexplained Variation} \quad (3)$$

The larger the explained variation, is the better the model is at prediction. The larger the unexplained variation, the worse the model is at prediction. A quantitative measure of the explanatory power of a model is R^2, the Coefficient of Determination:

$$R^2 = \frac{Explained\ Vatiation}{Total\ Variation} \quad (4)$$

The Coefficient of Determination measures the percent variation in the response variable (y) that is explained by the model. Values range from 0 to 1. An R^2 close to zero indicates a model with very little explanatory power. An R^2 close to one indicates a model with more explanatory power [19].

Finally, the inductive-deductive method presents identified results and resultant conclusions based on the findings from prevenient analyses [8,17-20].

4 Result and discussion

Taking into account the values related to eco-innovation reached in 2018, Slovakia is one of the countries whose eco-innovation index reaches rather low level. Sweden, Finland, Germany and Luxemburg belong to the best-rated countries. The Slovak Republic occupies the eighth place within the group of countries with the lowest eco- innovation index [20].

At present, from the perspective of the COVID-19 pandemic, Slovakia has applied actions which, from the logistics point of view, meant closing important enterprises for the country's economy (such as industrial enterprises, various services, etc.). As Bibel states, telecom operators have noticed decreased movement of people by 30%, and some operators report a decrease in their clients' movements by as much as half [8] and according to the Google COVID-19 Mobility Report for Slovakia [21], Figure 1.

Figure 1 Google COVID-19 Mobility Report for Slovakia [21]

These facts have a significant impact on the economy of the Slovak Republic and therefore we have also examined the relation of eco- innovations and GDP by means of regression analysis.

Data from Eurostat [17] and the Eco-Innovation Index [18] are the basis for the correlation and regression analysis which we carry out with the intention of finding out the dependence between total eco-innovation index and GDP

in the case of Slovakia. Table 1 presents the values calculated on the base of realized statistical analysis.

Table 1 Calculated values from statistical analysis

SUMMARY OUTPUT	
Regression Testing	
Multiple R	0.890235
R Squared	0.792517
Adjusted R Squared	0.723357
Standard Error	7.55457
Observations	5

ANOVA

	Degrees of freedom	Sum of squares	Mean Square	F-value	Significance F
Regression	1	653.9854	653.9854	11.45905	0.042929
Residual	3	171.2146	57.07152		
Total	4	825.2			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-150.764	63.3563	-2.37962	0.097652	-352.392	50.86438
Eco-innovation	2.612389	0.771727	3.385122	0.042929	0.15641	5.068368

Source: authors' computation

At the beginning of the regression testing we have to compute the correlation analysis. The calculated correlation coefficient value is 0.890235. The closer the value is to 1, the more positive correlation (dependence) is between measured variables. The value calculated by us indicates a strong relationship between GDP and eco-innovations in the Slovak Republic.

The R-Squared represents the value of the coefficient of determination. Its calculated value is 0.792517. After multiplication this value by 100 it denotes that the determined regression line specifies the variability in average GDP growth to 79%. Other factors reflect unexplained variability and other unspecified effects such as the influence of random factors.

Adjusted R-squared regards the quantity of estimated parameters and the number of measurements, too. It is recommended to determine the Standard Error as small as possible. This analysis of the dependence between the monitored variables (GDP and eco- innovations) is carried out for the conditions of Slovakia.

Another part of testing includes the analysis of variance (known as ANOVA). It allows us to test a null hypothesis which considers that the selected model to explain dependency is not appropriate. An alternative hypothesis assumes the opposite statement. We applied the F test to evaluate this assumption. The significance value F = 0.042929 < 0.05. Because the calculated value is lower than 0.05 (α - significance level) it denotes that we reject the null hypothesis. It means that the model has been chosen correctly from which it follows that average GDP growth is dependent on eco-innovations.

We have also realized the regression analysis. Regarding its results where Intercept-b0 equals -150.764, we can assume that if the eco-innovation index were zero, the average GDP growth would be -150.764 euros.

From the relation of the eco-innovation index to average GDP growth results that X Variable is 2.612389. It means: If average GDP growth increases by 1%, the eco-innovation index will increase by almost 3 points. This statement is statistically significant with respect to the p-value for the eco- index and average GDP growth, where we have found out that its value is less than 0.05 (0.042929).

Moreover, this part of our calculations also takes into account a 95% confidence interval for b0 and b1. If the average GDP growth increases by 1%, the total eco- index increases in the range from 0.15641 to 5.068368 points with the probability of 95%.

Results from the given calculations acknowledge the theoretical findings. Lisý et al. [1] presents that economic growth signifies economic changes, which are expressed in an increment of essential macroeconomic variables over time. By presented calculations and their results it has been proven there is dependence between the examined parameters - average GDP growth and eco-innovation index [1].

The confirmed assumptions are also presented by Mankiw et al. [2]. He considers that research, innovation (eco-innovation as well) and many others are significant factors influencing as well as supporting sustainable economic growth.

However, the results also point to the fact that if GDP growth would be -150,764 euros then eco-innovations would reach 0. In the current situation accompanied by the closing of enterprises, representing the centrepiece of the Slovak economy, during the COVID-19 pandemic, this is supposed to be a positive finding for eco-innovation. If a recession occurs, economists currently estimate that Slovakia's economy will decline by 6% on average for the whole of 2020. The probability of a recession is 50% when we are talking about a strong recession [22]. Eco-innovations based on the analysis would also be realized during the recession or would remain at least 0.

This fact is caused by their nature, because eco-innovations present a selection of generally appropriate materials. They are also associated with distribution processes that require less energy, fewer natural sources, and complexly they do not burden the environment so much [23]. It means that if we do not burden nature with a negative impact of human, it can make some positive changes through its own regenerative ability, which are practically also eco- innovations, realized by nature itself.

This is also confirmed by actual images from the Copernicus satellites from the European Space Agency, where Sentinel-5P monitors air pollution around the world. Recent satellite data show that in January and February nitrogen dioxide pollution was significant. When restrictive measures began to apply, the amount of gas began to decline, see Figures 2 and 3. Compared to the same period a year earlier, the current values are much lower [24].

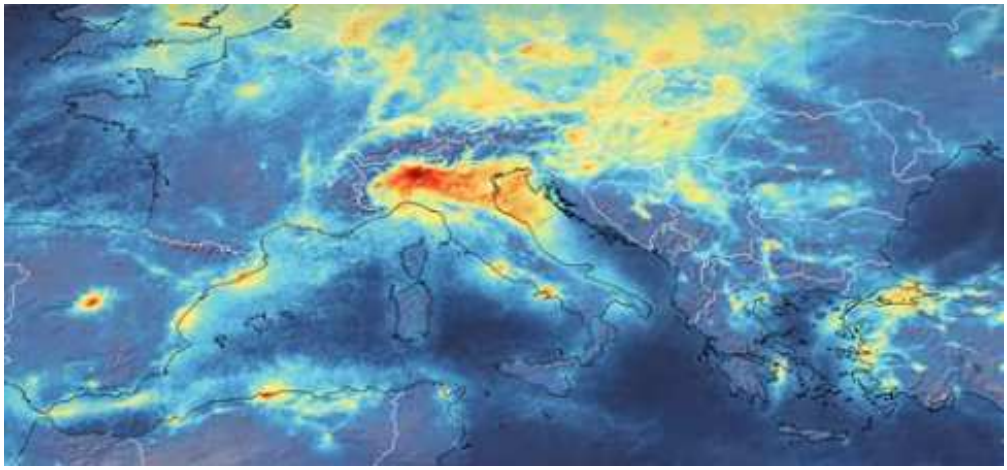


Figure 2 View on Europe showing air-pollution before launching measures related to the COVID–19 pandemic [24]

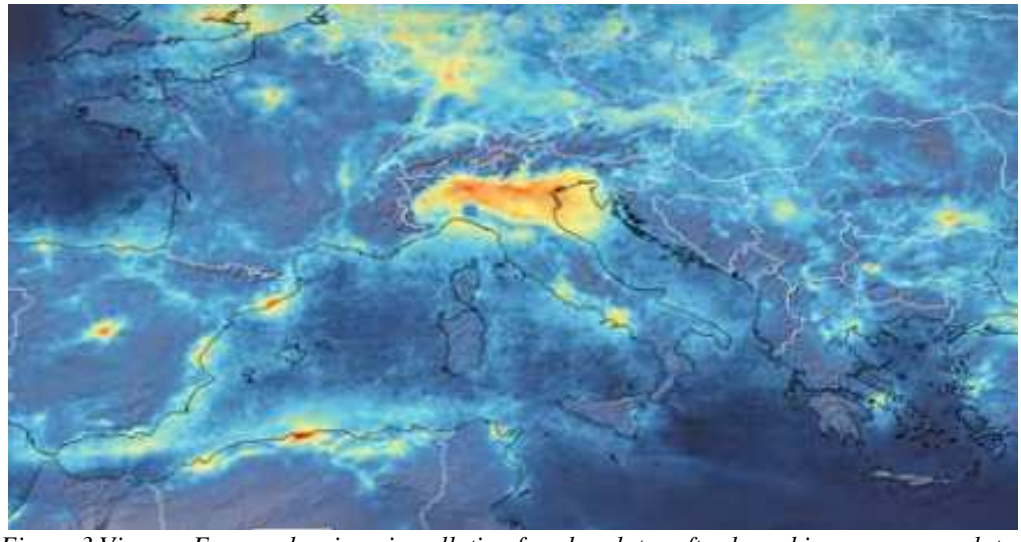


Figure 3 View on Europe showing air-pollution few days later after launching measures related to the COVID–19 pandemic [24]

These facts point to the regeneration of eco-innovations based on natural resources to a certain extent. The measures related to the COVID-19 pandemic have a strong global logistics impact and are now we are more focused on local logistics [25,26], which also positively affects eco-innovation.

5 Conclusions

This paper presents results of the evaluation of the development of eco-innovations in Slovakia in relation to GDP and the current situation in terms of logistics and COVID-19 pandemic. With respect to the carried-out analyses, we can state that:

- Slovakia is one of the countries within the European Union, characterized by the low eco-innovation index.
- GDP belongs to key factors enabling effective support for eco-innovation.
- The failure of global logistics replaces local logistics, which is also a positive factor for eco-innovation.

These facts are significant mainly these days, where the pandemic negatively affected economic growth, and mutual relationship GDP and eco-innovation can affect the sustainable economic development of Slovakia in the time of a pandemic.

Acknowledgement

The authors are grateful for the support of the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences, grant number 1/0674/19, "Proposal of a model for the eco-innovation integration into the innovation process of companies in Slovakia in order to increase their performance" in connection with the creation of this paper.

References

[1] LISÝ, J. et al.: *Ekonómia,* Bratislava, Iura Edition, 2016. (Original in Slovak)

[2] MANKIW, N.G, WEINZIERL, M., YAGAN, D.: Optimal Taxation in Theory and Practice, *Journal of Economic Perspectives*, Vol. 23, No. 4, pp 147-74, 2009.

[3] Ec.europa.eu, http://ec.europa.eu: Využívanie inovácií, [Online], Available: http://ec.europa.eu/environment/basics/green-economy/innovation/index_sk.htm [21 Dec 2018], 2018. (Original in Slovak)

[4] KOLLÁR, V., BROKEŠ, P.: *Environmentálny manažment*, Bratislava, SPRINT, 2005. (Original in Slovak)

[5] LOUČANOVÁ, E., TREBUŇA, P.: Eko-inovácie ako nástroj konkurencieschopnosti, *Transfer inovácií*, Vol. 29, pp. 76-80, 2014. (Original in Slovak)

[6] LOUČANOVÁ, E.: *Inovačné analýzy a stratégie*, Zvolen, Technická univerzita vo Zvolene, 2016. (Original in Slovak)

[7] TREBUNA, P., PETRIKOVÁ, A., PEKARČÍKOVÁ, M.: Influence of physical factors of working environment on worker's performance from ergonomic point of view, *Acta Simulatio*, Vol. 3, No. 3, pp. 1-9, 2017.

[8] BIBEL, B.: Pohyb ľudí sa znížil. Ak sa to zmení, môže nastúpiť drastické opatrenie, [Online], Available: https://www.ta3.com/clanok/1178827/pohyb-ludi-sa-znizil-ak-sa-to-zmeni-moze-nastupit-drasticke-opatrenie.html [18 March 2020], 2020. (Original in Slovak)

[9] STRAKA, M.: *Distribution and Supply Logistics*, Cambridge Scholars Publishing, UK, 2019.

[10] Enviroportal.sk, www.enviroportal.sk: Akčný plán pre environmentálne technológie, [Online], Available: https://www.enviroportal.sk/environmentalne-temy/starostlivost-o-zp/dobrovolne-nastroje-environmentalnej-politiky/environmentalne-technologie [21 March 2018], 2018. (Original in Slovak)

[11] HOJNIK, J., RUZZIER. M.: What drives eco-innovation? A review of an emerging literature, *Environmental Innovation and Societal Transitions*, Vol. 19, No. June, pp. 31-41, 2016. doi:10.1016/j.eist.2015.09.006

[12] ERYGIT, N., ÖZCÜRE, G.: Eco-Innovation as Modern Era Strategy of Companies in Developing Countries: Comparison Between Turkey and European Union, *Procedia - Social and Behavioral Sciences*, Vol. 195, pp. 1216–1225, 2015.

[13] PEKARČÍKOVÁ, M., TREBUŇA, P., KLIMENT, M.: Digitalization effects on the usability of lean tools, *Acta logistica*, Vol. 6, No. 1, pp. 9-13, 2019. doi:10.22306/al.v6i1.112.

[14] BACHÁR, M., MAKYŠOVÁ, H.: Evaluation of the impact of intelligent logistics elements on the efficiency of functioning internal logistics processes, *Acta Tecnología*, Vol. 5, No. 3, pp. 55-58, 2019.

[15] KALIŠ, R., LÁBAJ, M., LUPTÁČIK, M., MORVAY, K., STRACOVÁ, E.: Development trends and the importance of paper industry for the Slovak economy, *Journal of Economics*, Vol. 66, No. 9, pp. 861-887, 2018.

[16] MALÁKOVÁ, S., FRANKOVSKÝ, P., NEUMANN, V., KURYLO, P.: Evaluation of suppliers' quality and significance by methods based on weighted order, *Acta logistica*, Vol. 7, No. 1, pp. 1-7, 2020. doi:10.22306/al.v7i1.149.

[17] Eurostat, ec.europa.eu, [Online], Available: https://ec.europa.eu/eurostat [20.dec.2019], 2019.

[18] Ec.europa, https://ec.europa.eu: European Commission, Environment, Eco-innovation Action Plan, The Eco-Innovation Scoreboard and the Eco-Innovation Index, [Online], Available:

https://ec.europa.eu/environment/ecoap/indicators/index_en [20 Dec 2019], 2019.

[19] KIERNAN, D.: *Natural Resources Biometrics*, New York, SUNY College of Environmental Science and Forestry, 2007.

[20] LOUČANOVÁ, E., OLŠIAKOVÁ, M.: Supporting Eco- Innovation as a Factor for Economic Development, *Studia Universitatis „Vasile Goldis" Arad–Economics Series*, Vol. 29, No. 3, pp. 80-91, 2019.

[21] Google, www.google.com: Google COVID-19 Mobility Report for Slovakia, [Online], Available: https://www.google.com/covid19/mobility/ [02 Apr 2020], 2020.

[22] VALACH J., MAHÚTOVÁ M.: Prognóza ekonomiky ovplyvnenej ochorením Covid-19, Čo nás čaká?, [Online], Available: https://www.tatrabanka.sk/sk/blog/ekonomicke-analyzy/prognoza-ekonomiky-ovplyvnenej-ochorenim-covid-19-co-nas-caka/ [20 Mach 2020], 2020. (Original in Slovak)

[23] LOUČANOVÁ, E.: Ekologické inovácie, *Trendy a inovatívne prístupy v podnikových procesoch*, Vol. 20, 2017. (Original in Slovak)

[24] BEŇO, M.: Pre koronavírus je vo vzduchu menej emisií. Otázka je, dokedy?, [Online], Available: https://tech.sme.sk/c/22364200/pre-koronavirus-je-vo-vzduchu-menej-emisii-otazka-je-dokedy.html?ref=tit [20 Mach 2020], 2020. (Original in Slovak)

[25] HRONEC, I.: Ivan Hronec z Film Europe: Nič nebude ako predtým, ani kiná. Prežije ten, kto sa zmení, [Online], Available: https://kultura.sme.sk/c/22363491/ivan-hronec-z-film-europe-japonci-si-nepodavaju-ruky-uklanaju-sa-aj-my-musime-nieco-take-vymysliet.html [20 Mach 2020], 2020. (Original in Slovak)

[26] RUDY, V.: Innovation methods in structures of production systems designing, *Ovidius University Annual Scientific Journal*, Vol. 11, No. 1, pp. 15-18, 2009.

Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 7 2020 Issue: 3 Pages: 195-200 ISSN 1339-5629

ANALYSIS OF PRODUCT CONFIGURATORS USED IN THE MASS CUSTOMIZATION PRODUCTION
Dragan Peraković; Annamária Behúnová; Lucia Knapčíková

doi:10.22306/al.v7i3.177 Received: 02 July. 2020; Revised: 02 Sep. 2020; Accepted: 20 Sep. 2020

ANALYSIS OF PRODUCT CONFIGURATORS USED IN THE MASS CUSTOMIZATION PRODUCTION

Dragan Peraković
University of Zagreb, Faculty of Transport and Traffic Science, Department of Information and Communication Traffic, Vukelićeva 4, Croatia, dperakovic@fpz.hr
Annamária Behúnová
Technical University of Košice, Faculty of Manufacturing Technologies with the seat in Prešov, Department of Industrial Engineering and Informatics, Bayerova 1, Prešov, Slovak Republic, annamaria.behunova@tuke.sk
Lucia Knapčíková
Technical University of Košice, Faculty of Manufacturing Technologies with the seat in Prešov, Department of Industrial Engineering and Informatics, Bayerova 1, Prešov, Slovak Republic, lucia.knapcikova@tuke.sk
(corresponding author)

Keywords: product, product configurator, automotive industry, mass customization
Abstract: Nowadays, with the very rapid development of Internet possibilities and a large number of product variations on the market, the interest of shoppers is growing for a product that would meet all the required criteria and parameters. In the past, retailers of various types of products used product catalogues and brochures in printed form to present their portfolios. At present, the Internet is the most widely used primary information medium. Works in the way of product configurators are performing via the Internet. These are tailored to the requirements of customers to meet their needs and wishes. Automobile sellers realize that through product configurators, they can engage a potential customer more effectively and customize the resulting product with their production capabilities. Detailed and detailed product configurators are a step towards the keen interest of shoppers and consumers. An overview of product configurators in different types of use and with other manufacturers is not only necessary for customers, but also manufacturers. For customers, the analysis needs to be able to choose a better configuration offer; for manufacturers, the study is necessary for reasons of competitiveness. This article aims to present an analysis of the use of product configurators of automobiles manufactures operating in the Slovak Republic.

1 Introduction

Thanks to advances on the Internet, e-commerce and mass customization, the demand for product configurators is growing. Today, customers ask sellers for many product configurations options [1].

We define a product configurator as a Computer-Aided Manufacturing (CAM) system that produces its output - a product. The product configurator has evolved into an online guide that guides customers exactly after what they are looking for. A configurator platform is a tool used to create custom applications without custom encoding [2,3].

In the case of mass customization of products, the configuration system - configurator takes over an essential part of communication with the customer [4]. The configurator is an application whose task is to tailor the product to each customer according to his requirements [5]. Execution of a massive number of configurations in combination with excellent product variability cannot realize other than with the support of information technologies [6]. Compared to custom production, for cost reasons, the sale of a product cannot be accompanied by expert consultation at the same level. For this reason, there is a strong trend towards a full application of configuration systems, which using a web browser will help the customer to assemble the desired product interactively [7,8]. The customer usually works with the configurator in several phases of the sales cycle. In the first phase, it uses the configurator to get acquainted with the product. If the product addresses him, the customer applies the purchase configurator in the second phase. The configurator performs some tasks, such as monitoring the status of order equipment, re-ordering based on reconfiguration, providing support, service and other additional services [9,10].

The configurator should be integrated into the manufacturer information system focused on building a relationship with the customer. The information obtained from contact with the customer should not be forgotten; it should be preserved and reused for further communication with the customer. Current configuration systems often suffer from serious shortcomings that can cause the customer to feel confused, insecure, frustrated, and ultimately discouraged from purchasing [11].

We define the configurator as software with the analytical capabilities to create, maintain and use electronic product models that allow a complete definition of all possible product variants with a minimum of data entry operations and a minimum of services required by system maintenance [9].

The configuration system consists of two primary components, a database and configuration logic. The

database contains all optional parts of the product. The configuration logic determines which options can be combined [1].

The configuration system can be divided into primary and advanced according to the function. The main thing is that it must allow you to build a configuration. Logically follows the requirement for the validity of the created configuration, i.e. the configurator should include means for verifying component compatibility, for finding and resolving conflicts. The configuration system should provide the customer with at least necessary information about the individual selected components. The customer should be able to deliver the created assembly to the manufacturer [10]. The expanding functions of the configuration system include the assistance of the configurator based on the knowledge database, i.e. specific recommendations and further guidance of the customer through the process of creating the report. This group of functions also includes access to previously created configurations of our own as well as other customers, which provide inspiration based on collective know-how. The configuration system can also be connected to a live operator who can answer complicated atypical questions [11,12].

If the configuration system performs both basic and advanced functions well, it grows from a pure technical means for the one-time recording of components into a comprehensive communication tool for effective, high-quality and long-term contact with the customer [9].

1.1 Product configurator

Building a configuration is often a time-consuming activity in which the customer has to make many decisions. Some decisions can be made immediately, some need to be thought about longer, especially in the case of expensive products such as cars. For some arrangements, the customer needs brief information; for others, he needs very detailed information. Assembling the product can take several minutes, but it can also take hours and, including the customer's decision time, several days [6].

In the case of typically oral communication, this means that the customer comes to the store, the salesperson's employee compiles the configuration with him. If the seller does not have some information available, he will pass it on to the customer later. If the customer cannot make an immediate decision, he must visit the store several times. This process is lengthy and costs a lot of time for both the customer and the seller [8,13].

Internet configurators are a means of avoiding inefficient communication. The customer assembles the product as soon as time allows, he has the whole day available. Directly from the configurator, it can continuously obtain information at precisely the level it requires and gradually assemble the final product until it is delighted with the final product [4,10].

In the case of a fully integrated configuration system, it can start the execution of the production cycle at the moment of sending the order, again regardless of whether it is a standard time of sale or not. It saves on sales costs, and shorter order fulfilment times can be achieved [5,13]. The configuration system fulfils only its primary function, i.e. the possibility to assemble a right product from mandatory and optional components. But it can perform a number of other services and become a valuable marketing tool. Ideally, the customer does not need to contact a live seller, and therefore the company only obtains information about the customer through the configuration system [11]. The configuration system can store customer information and use it when repurchasing. If it offers functions that the customer will appreciate even after the completion of the transaction, he continues to visit the configurator, and this opens up the possibility of marketing for the customer. Long-term contact with the company and its configuration system increases customer loyalty and the likelihood of repurchase. A poorly developed configuration system can easily lead to a customer disincentive to purchase [8,9]. In the best case, it leads to a reduction in customer satisfaction during the purchase or to the selection of a product that does not meet its physical needs [11,14,15]. This will be reflected in a decrease in customer loyalty, its transfer to competition and a decline in sales and subsequent profits. Meeting all the requirements for configuration systems is not easy, and most existing configurators fall far short of them [16]. In practice, it is relatively common for the configurator to be at such a level that it directly discourages customers from purchasing. A common reason is a misconception with which the configurator is created, or an attempt to minimize costs [17]. This situation is sometimes exacerbated by the lack of standards, general advice and theoretical support. Properly designed and constructed configuration systems are, therefore, among the key factors in the success of implementing a mass customization strategy [14,18].

2 Methodology

The best known and most used product configurators include automobile configurators. Configurators for automobiles replaced various catalogues and brochures in paper form, which offered different graphical representations of elements and properties of automobiles.

The automobile configuration starts by selecting the type of automobile offered by the manufacturer. The choice of type defines its primary function and use. Subsequently, the configuration is usually divided into fundamental and individual steps in which the various characteristics of the automobile change. The different levels are related to the choice of automobile type. Necessary steps of automobile configuration:

Step 1 - engine and transmission selection,
Step 2 - a selection of equipment level,
Step 3 - choosing the colour of the interior and exterior,
Step 4 - a selection of additional and additional equipment,
Step 5 - representation of the final product and breakdown selected elements.

The configuration of automobile is also offered by automobile manufacturers whose production plants are located on the territory of the Slovak Republic and which have been the subject of research. Automobile manufacturers producing in Slovakia are Volkswagen Slovakia, KIA Motors Slovakia and PSA Peugeot Citroën Slovakia. The configurators of these cars are different. They offer a variety of options for motorization, equipment levels, optional equipment and post-configuration services. The possibilities of graphical display and the speed of its response are also different.

3 Result and discussion

The Volkswagen automobile configurator consists of six individual steps such as Model, Fuel, Variant, Design, Equipment and My Automobile. The first step "The model" consists of choosing the type of automobile from the Volkswagen offer, for example, the Golf Variant. Second step "Fuel" offers a choice of fuel type, transmission and drive. The third step "Variant" provides a selection of equipment levels. Fourth step "The design" provides a range of changing paintwork, wheels and seat covers. Step Five "The equipment" offers a choice of special equipment packages. Sixth and final step "My automobile" displays the ultimate configured automobile and a summary of the individual steps with a detailed listing of the selected equipment and its prices. The configurator offers a graphical display of the final automobile from several exterior and interior views, even in 360-degree rotation. The sixth step also offers additional steps, which are added such as saving the configuration to a profile, printing the shape in pdf, loading the configuration from the pattern, sharing the configuration on Facebook, contacting the seller and arranging a test drive.

The Kia automobile configurator consists of six individual steps such as Model Selection, Version, Colour, Wheels, Equipment and Summary. The first step "Model selection" includes selecting an automobile type from Kia's range, such as the Cee´d Sportswagon. The second step of the version offers a choice of level of equipment and motorization. The third step, "Colours", provides the option of changing the colour of the body. The fourth step, "Wheels", provides the possibility of changing the size and colour of the wheels. Step 5 "The equipment" offers a choice of equipment details, optional interior and exterior material. Sixth and final step "The summary" provides the possibility to print the configuration, save the configuration and buy the vehicle in the selected configuration. The right side of the configurator displays a review of the automobile with the final price, in which it is possible to "click" the details of the selected vehicle elements. The sixth step offers the additional step "Test drive", the possibility of arranging a test drive of the automobile and the option of "Login", for login and re-view of the configuration.

The Peugeot automobile configurator consists of six individual steps such as Select Version, Select Engine, Select Colour, Select Interior, Select Optional Equipment and Summary. Before starting the configuration, you have to first select a model from the Peugeot range, for example, 308 SW. Only after choosing the Peugeot vehicle model is it possible to create a configuration. The first step, "Select version", consists of selecting the equipment level. The equipment has a choice of Access, Active, Style, Allure and GT. After choosing an equipment such as Style, the configurator displays the critical material and different elements from the lower material. Click on Show key equipment to view all equipment elements Comfort, Design, Safety, Audio and on-board systems. From the first step, the configurator offers a graphical display of the automobile in the selected exterior and interior equipment in several views with the possibility of zooming in. From the first step, a summary of the configuration and the current final price of the automobile are displayed on the right side of the configurator, with the option of displaying details and technical parameters. The Second step is to select engine menu to select the choice of the engine according to the type of fuel. The third step, Choose the colour, offers the option of changing the body colour. The fourth step, "Choose interior", provides the option of changing the colour of the seat fabric and choosing additional equipment, like an audio and on-board systems such as CD player, a navigation system, navigation system + CD player. Fifth step Select option offers the option to select safety features such as reversing camera, front and rear parking assist, alarm, super lock, front and rear parking assist. Sixth and final step "The summary" provides information on the selected engine, exterior elements, interior and optional equipment with the possibility to change the specified details. The configurator offers the configuration Save as Pdf., Save, Print, Send to a friend. In the last step, the configurator creates a graphical display of the final configuration in the form of a video presentation.

Citroën automobile configurator starts by selecting an automobile model from the Citroën range, such as the C4 Picasso. The configurator consists of three individual steps such as Technique, Style and Optional Equipment. On the left side of the configurator, the current price of the vehicle is displayed from the beginning of the configuration, at which it is possible to save, open the previous setting or change the automobile model. The first step "The technique" consists of selecting the level of equipment and motorization. The equipment offers Live, Feel and Shine equipment. Engines are divided according to the type of fuel into gasoline and diesel with appropriate transmissions, either manual or automatic. The second step of the Style offers a choice of changing the colour of the car, upholstery and wheels. Third and final step "Optional equipment" provides a selection of optional equipment elements that the selected equipment level does not contain, such as LED taillights, a panoramic roof glass, xenon headlights, a keyless system and much more.

Throughout the configuration, the configurator offers the Show my Citroën option after selecting the required elements, providing Automobile Summary, Equipment and technical characteristics and a graphical display in several different exteriors and interior views.

Every year the use of product configurators increases, therefore the sellers offer the possibility to customize - to adapt the product to their requirements. Most vendors have individually created configurators, which differ in technical perfection and functions provided, which makes them diverse. The configuration options adapt to the possibilities of mass and automated production in the company. Configurators help users to get acquainted with the range of product features through a graphical display, to adapt the product to their ideas and to facilitate shopping.

In summary, it displays the base price of the automobile, the final cost of the configured vehicle, and the amount of each configuration step. The configurator offers the option to set save and download in Pdf format, or to book a test drive, receive an offer and receive a catalogue. When the Equipment and technical characteristics are displayed, it displays the individual equipment elements and the technical parameters of the engine.

The selected configurators used by our research of the Volkswagen, Kia, Peugeot and Citroën automobiles are different and differ in the configuration options on offer (Table 1). The configurators in the individual configuration steps offer various options for filtering, comparing, searching, selecting, displaying and the like. The configurator with several configuration options offers the potential customer easier to configure, more thoroughly display and adapt the car to his ideas and requirements. The table shows the offered summary of different options of all manufacturers, including and not containing the possibilities of the individual manufacturers being compared.

We consider the configurator, which provides the most significant sum of lively options, to be more thorough and sophisticated. According to the number of positive values, we can rank the configurators from best to worst (Figure 1). We consider the configurator of the Volkswagen automobile maker to be the best configurator, the configurator of the Peugeot automobile maker is in the second place, the configurator of the Citroën carmaker in the third place and the configurator of the Kia automobilemaker as the worst and least sophisticated configurator.

Table 1 Comparison of product configurators individual automobile

	Producer			
Options	Volkswagen	KIA MOTORS	PEUGEOT	CITROËN
Fuel Filtration, gearbox, drive	✓	✗	✗	✗
Unlimited choice of motorization according to equipment level	✓	✗	✓	✓
Comparison of motorizations	✗	✗	✓	✓
Choice of more than one petrol engine	✓	✓	✓	✗
Time-saving equipment	✓	✗	✗	✗
Comparison of equipment levels	✓	✗	✓	✗
Search for optional equipment elements	✓	✗	✗	✗
Choice of more than three trim levels	✓	✓	✓	✗
View the current price and selected elements during all steps	✗	✓	✓	✓
Choice of more than two alloy wheels	✓	✗	✗	✓
Selection of additional exterior elements (ski carrier, bicycles)	✗	✓	✗	✗
View more than two interior views	✓	✗	✓	✓
View more than two exterior views	✓	✗	✓	✓
360 ° rotation of the interior	✓	✗	✓	✓
Display of 360 ° rotation of the exterior	✓	✗	✓	✓
Display a video presentation of the final configuration	✗	✗	✓	✗
SUM OF POSITIVE OPTIONS:	12	4	11	8

Figure 1 Evaluation of product configurators

Volkswagen's configurator is the only one to offer fuel, transmission and drive filtration, time-saving equipment and search for optional equipment elements. With the best configurator, we lack the option of choosing additional exterior parts, such as a carrier for skis, snowboards and bicycles.

The Peugeot configurator is the only one to offer the possibility of displaying a video presentation of the final configuration. With the second-best configurator, we lack the opportunity of time-saving equipment.

The Citroën configurator does not offer any specific option. With this configurator, we lack the option of choosing from several petrol engines for given selected equipment.

The Kia configurator is the only one to offer a choice of additional exterior elements such as a ski, snowboard and bicycle carrier. With the worst configurator, we lack several options for displaying the interior and exterior.

After the results, the configurator must observe the following features:

- Simplicity- because compiling a configuration is complicated, it must seem like a simple matter.
- Intelligibility- the information must be provided in a language understandable to the customer.
- Clarity- there must be an easy orientation for the customer at every step and moment, he must know the next configuration step.
- Adequacy of images and information- the customer should see precisely the pictures, views and information he needs in the configurator. If he does not see them, he is frustrated, cannot decide and feels insufficiently informed. If the configurator is full of information, it takes the customer time.
- The logical layout-the layout must be easy to understand, and the individual configuration options should follow each other logically and be grouped into thematic units.
- Standard control-the customer will appreciate more standard than intuitive operation.
- Presentation style- it is necessary to use the appropriate element layout, the number of fonts used, and colour scheme.

4 Conclusions

Product configurators are indeed a fascinating form of implementing mass customization into production and adapting the product to customer requirements. With the growing progress on the Internet, online stores and mass customization, the demand of customers for the possibility of changing the product to their needs, after tailoring the product, is growing. The main goal of this article was to analyse and compare product configurators. In the analysis of configurators, we characterized and compared the configurators of automobiles whose production plants are located in the Slovak Republic - Volkswagen, Kia, Peugeot and Citroën. In the final evaluation, we took into account the offered, comprehensive, different options of configurators. According to the summary configuration options, we created a detailed report in the form of a table in which we compared the configurator options and assigned to them containing and not containing configuration options. Based on the sum of the positive possibilities, we then ranked the configurators from best to worst and described their specific and missing opportunities. Using a comparison of configurators, we came to the conclusion that the examined configurators can be continuously improved and innovated based on competitors' configurators.

The future direction of our next research will be focused primarily on the customer. Because customer often lacks basic knowledge and the experience required to build a configuration that optimally meets his needs. The product configurator has therefore provided the necessary and available information for decision in text or graphical form. Configurators are most often based on communication with one user and often forget about a person's social behaviour. The simplest way to alleviate this is to save the configuration, recall it, and modify it.

Manual configuration requires a lot of time and effort from the customer, especially if the product is complex. The task of the product configurator is to save time and effort of the customer. In particular, we can that verify the validity of the configuration, automatically generating clear choices and displaying only possible product combinations.

References

[1] GÁLA, L., POUR, J., TOMAN, P.: *Enterprise Informatics*, Grada, Praha, 2006. [online], Available: <https://books.google.sk/books?id=CRpMH-Ui7HkC&pg=PA136&dq=konfigurator&hl=sk&sa=X&ved=0ahUKEwi1w_2rsc_TAhVLtRQKHbqHApYQ6AEIMDAC#v=onepage&q=konfigurator&f=false/>. ISBN 80-247-1278-4 [10 Jun 2020].

[2] BACHÁR, M., MAKYŠOVÁ, H.: Evaluation of the impact of intelligent logistics elements on the efficiency of functioning internal logistics processes, *Acta Tecnología*, Vol. 5, No. 3, pp. 55-58, 2019. doi:10.22306/atec.v5i2.50

[3] BOŽEK, P.: Virtual production technology vs. environment, *Acta Tecnología,* Vol. 5, No. 4, pp. 109-114, 2019. doi:10.22306/atec.v5i4.68

[4] Mass Customization, [online], Available: http://www.investopedia.com/terms/m/masscustomization.asp/ [10 Jun 2020], 2017.

[5] KNOŠKOVÁ, Ľ., STRHAN, R.: *The Product Managering,* EKONÓM, Bratislava, 2011.

[6] MANDIČÁK, T., MESÁROŠ, P., TKÁČ, M.: Impact of management decisions based on managerial competencies and skills developed trough BIM technology on performance of construction enterprises,

Pollack Periodica, Vol. 13, No. 3, pp. 131-140, 2018. doi:10.1556/606.2018.13.3.13

[7] BLESKER, T., FRIEDRICH, G.: *Mass customization*, [online], Available: https://books.google.sk/books?id=OIUGLUUV-NIC&printsec=frontcover&dq=mass+customization&hl=sk&sa=X&redir_esc=y#v=onepage&q=mass%20customization&f=false. [10 Jun 2020], 2006.

[8] KOTLER, P.: *The Modern Marketing,* 4th edition, Grada, Praha, 2007.

[9] Definition of a Configurator, [online], Available: https://docs.oracle.com/cd/E16582_01/doc.91/e15086/und_configurator.htm#EOABC00001/ [03 Jun 2020], 2015.

[10] What is a product configurator? [online], Available: https://www.quora.com/What-is-a-product-configurator/ [03 Jun 2020], 2015.

[11] Communication Configurator, [online], Available: https://industrial.softing.com/uploads/softing_downloads/CommunicationConfigurator_D_DE_160601_200.pdf/ [03 Jun 2020], 2016.

[12] TŐRŐK, J.; VICEN, M.: *Management*, 2nd edition, SPU, Nitra, 2001.

[13] RUMYANTSEVA, S. Y.: The Economic Matter Movement and the Mechanism of Business Cycle, *TEM Journal*, Vol. 8 No. 2, pp. 507-515, 2019. doi:10.18421/TEM82-26

[14] Configurator database, [online], Available: http://www.configurator-database.com/definitions/ [03 Jun 2020].

[15] ČULKOVÁ, K., PAVOLOVÁ, H., CEHLÁR, M., KHOURI, S.: Influence of Crisis to Activity Indexes in Chosen Industrial Companies of the Country, *TEM Journal*, Vol. 7, No. 4, pp. 744-749, 2018. doi:10.18421/TEM74-07

[16] FOGLIATTO, F.S., da SILVEIRA G.J.C.: *Mass Customization. Engineering and Managing Global Operations,* Springer, 2011.

[17] PILLER, F.: *Mass Customization,* Deutscher Universitatsverlag, 2006.

[18] CHANDRA, Ch., KAMRANI, K.A.: *Mass Customization, A Supply Chain Approach,* Springer, 2004.

Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 7 2020 Issue: 3 Pages: 201-207 ISSN 1339-5629

doi:10.22306/al.v7i3.178 Received: 03 July 2020; Revised: 20 Sep. 2020; Accepted: 25 Sep. 2020

INVETORY VALUATION METHODS AND THEIR IMPACT ON THE COMPANY´S PROFIT GENERATION

Katarína Teplická
Technical University Košice, FBERG, Letná 9, 042 01 Košice, Slovakia, EÚ,
katarina.teplicka@tuke.sk (corresponding author)
Andrea Seňová
Technical University Košice, FBERG, Letná 9, 042 01 Košice, Slovakia, EÚ,
andrea.senova@tuke.sk

Keywords: inventories, assets, profit, valuation methods, efficiency
Abstract: Inventories are the assets of a company and creates her value. In this paper, we will deal with the most commonly used methods of inventory valuation (FIFO, LIFO, AC) and we will point out their impact on the company's profit generation. Confirmed hypotheses presents state that Slovak production companies use the FIFO method for valuing inventories and they have the most common type of inventories: finished products. Based on the results of inventory valuation using FIFO, LIFO, AC methods, we can state that the best results are shown by the FIFO inventory valuation method, because it realistically shows the price of inventories, which inventories are valued when consumed for consumption and corresponds to the price of inventories when acquiring € 8175. In the area of inventory value, it would be appropriate to introduce a simulation tool in the inventory management in companies, which would model the results of inventory valuation by individual methods.

1 Introduction

The decision on the method of valuing inventories should be based on economic efficiency, which is linked to profit generation. The main goal of this paper, we will deal with the most commonly used methods of inventory valuation and we will point out their impact on the company's profit generation.

Inventories are a type of current assets that significantly affect the company's financial results and profit generation [1]. In practice, inventory valuation is linked to the Accounting Act Law 431/2002. In many cases, companies do not address inventory valuation of individual types of inventories but follow the valuation method that suits them best or is set out in the company within the framework of the Internal inventory valuation directive. Inventories represent the assets of an enterprise which, given the purpose for which they were acquired, are not of a long-term nature [2]. Their optimal size ensures the success of production and business activities. When deciding how much and what supplies are needed for the efficient course of business activity, the decisive factors are e.g. the size of the company, the type and scope of its activities, technological processes of production, the situation on the market of raw materials and other factors [3]. Inventories create raw material inventories - material, raw materials, components – WIP – work in progress, spare parts, fuels, MRO goods - service etc., inventories of own production - work in progress, semi-finished products of own production, finished products, animals, supplier inventories – goods [4]. All these forms of inventory must be valued in the company at their consumption. Businesses decide which method of valuing inventories they choose.

2 Literature review

Li, YC, Liu, ZK. (2014) commented that selecting the inventory valuation method plays an important role in accounting in the firm. Different inventory valuation methods will impact profit and inventory, according to accounting standards there are several inventory valuation methods. The firm must be able to consider the actual situation, choose the most suitable method of inventory valuation [5]. Inventory processes are very difficult in the companies and exist some inventory problems in the companies, that are is needed to solve. Utami et al. (2018) have solved the problems exist in the leasing of photocopy machines which are recording incoming goods data, the data of goods being leased, and data about the quality of goods in storage. The system of evidence of goods has not been managed properly and the absence of an integrated system slows data sharing process the loss data, or data redundancy. The method of inventory recording of goods used is FIFO. Design of new system of evidence is able to improve the implementation of performance to be more effective, faster, good, safe and meet the needs of the company [6]. Behunova et al. (2020) presented that the inventory valuation is a part of production costs that are important to optimize, because their influence is on the selling price of product. In order to achieve a competitive price of the product, it is necessary to know not only the market but mainly the production costs that influence profit generation. Production costs form the largest part of the sales price of the product, it is important for the manufacturing company to monitor costs so that the price of the product is competitive in the domestic or foreign market [7]. Cost of production create costs of consumption of inventory and using of relevant method of inventory

valuation (FIFO, LIFO...) and new inventory evidence is important [8]. Regularly control of the costs have to use a suitably chosen implementation management logistics, which is currently a progressive tool of business development and competitiveness instrument in all companies and mostly in SMEs [9]. Le, HE. et al (2019) are describing using of inventory value methods is very important in various areas of industry. In chemical industry treatment methods and types differ depending on their physicochemical properties. In the paint manufacturing plant, storage, weighing, and mixing processes should be used emission model method to estimate. Those methods are connected with the inventory valuation methods and they influence profit generation [10]. Lara (2018) in her chapter of the book describe inventory valuation methods and their significance in area of income tax. Inventory create a part of asset in the firm and inventory value are very important for taxes payment. The most using methods of inventory valuation is method FIFO and AC. In the area of decreasing base of taxes, the firms are using method LIFO. By this method, the firms presented not relevant information about state of assets. Method LIFO is not punctual for inventory valuation [11]. Very important for evidence of inventory is reporting system that can be part of accounting system or management business system [12,13]. The value of inventory affects the price of the product to the customer and the price of the product on the market. This reason is base for inventory management in companies [14,15].

3 Methodology

Valuation of inventories at consumption is based on methods (Figure 1) such as FIFO (first in - first out), LIFO (last in - first out), AC (average cost; average cost; weighted arithmetic average). In addition to these basic methods of valuing inventories, we also know other methods that are less common in practice, e.g. HIFO method - (Highest In - First Out) (the highest price is used to assess the decrease in inventories, the value of the most expensive inventories), LOFO method - (Lowest In - First Out) (the lowest price is used to assess the decrease in inventories, the value of the cheapest inventories), NIFO - (Next In - First Out) method.

Each of the methods of valuing inventories has its advantages and disadvantages and companies have the right to choose a specific method, which affects the company's costs in valuing inventories and opportunities for customers [16]. Costs significantly contribute to the creation of the company's profit. From this point of view, it is important to optimize the level of inventory costs. Inventory optimization is possible with a large number of different types of inventory in the company and with different inventory prices. The most frequently used valuation methods of inventories within the operational management of inventories are the FIFO, LIFO, AC methods. FIFO method is an valuation method in which assets produced or acquired first are sold, used, or disposed of first. For tax purposes, FIFO assumes that assets with the oldest costs are included in the income statement's cost of goods sold (COGS) [17].

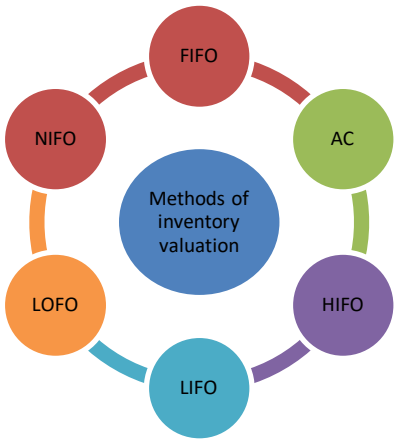


Figure 1 Methods of inventory valuation

The FIFO method follows the logic that to avoid obsolescence, a company would sell the oldest inventory items first and maintain the newest items in inventory. Although the actual inventory valuation method does not need to follow the actual flow of inventory an entity must be able to support why it selected the use of a particular inventory valuation method [18]. The inventory valuation method opposite to FIFO is LIFO, where the last item purchased or acquired is the first item out. In inflationary economies, this results in deflated net income costs and lower ending balances in inventory when compared to FIFO [2]. Method - (AC) The average cost inventory method assigns the same cost to each item. The average cost method is calculated by dividing the cost of goods in inventory by the total number of items available for sale. This results in net income and ending inventory balances between FIFO and LIFO. This method is base for using stochastic optimalization models in praxis and decrease inventory that inventory bind money in companies [19].

4 Results of research

As part of the project of inventory optimization in companies, we implemented a research questionnaire. The sample for the elaboration of the questionnaire consisted of 1560 companies from the field of industry with a focus on industry: mining, engineering, automotive, metallurgy, construction, energy in Slovakia. From the implemented questionnaire, we used two questions that we need for the area of inventory valuation in companies and the selection of a suitable method of inventory valuation and its impact on the company's profit generation. We established two basic hypotheses that we needed to verify through questionnaire questions.

H1: The most commonly used method for valuing inventories is the FIFO method.

H2: The most frequently valued type of inventories is finished goods.

The results of a research questionnaire with a sample of 1560 companies from the various industries pointed to the most frequently used method of valuing inventories in companies.

Hypothesis H1 was confirmed. H1: The most commonly used method for valuing inventories is the FIFO method (Figure 2). 660 companies are using method FIFO of inventory valuation that means 42% of selected companies. Method FIFO is very easy, effective and is accepted by Accounting Law 431/2002 in Slovakia.

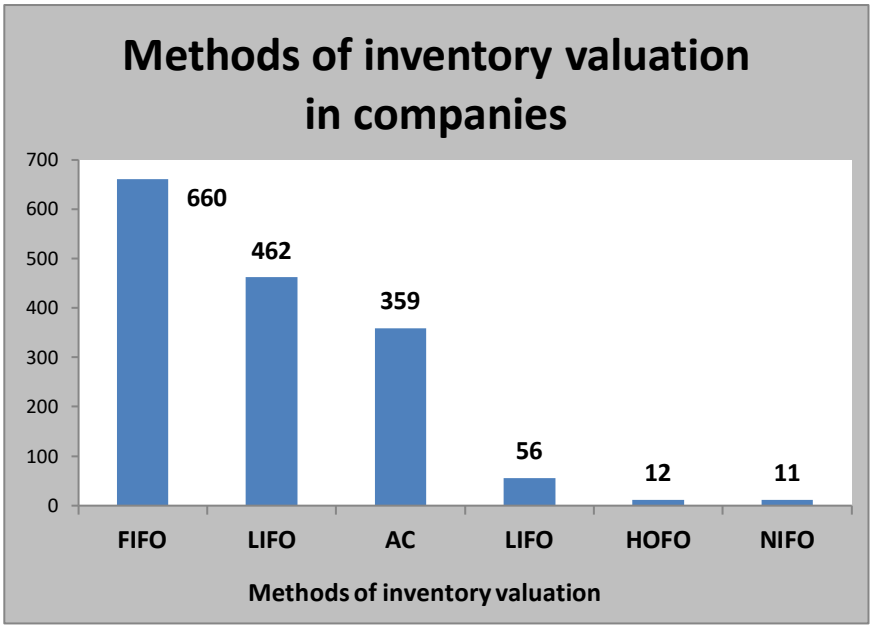


Figure 2 Using of methods of inventory valuation in companies

The results of a research questionnaire with a sample of 1560 companies from the various industries pointed to the most frequently valued type of inventory is finished goods.

Hypothesis H2 was confirmed. H2: The most commonly valued type of inventory was finished goods. The most frequently type of inventory was finished goods for 621 companies that mean 40% of selected companies (Figure 3). This conclusion points to direct using of finished goods for business and sale.

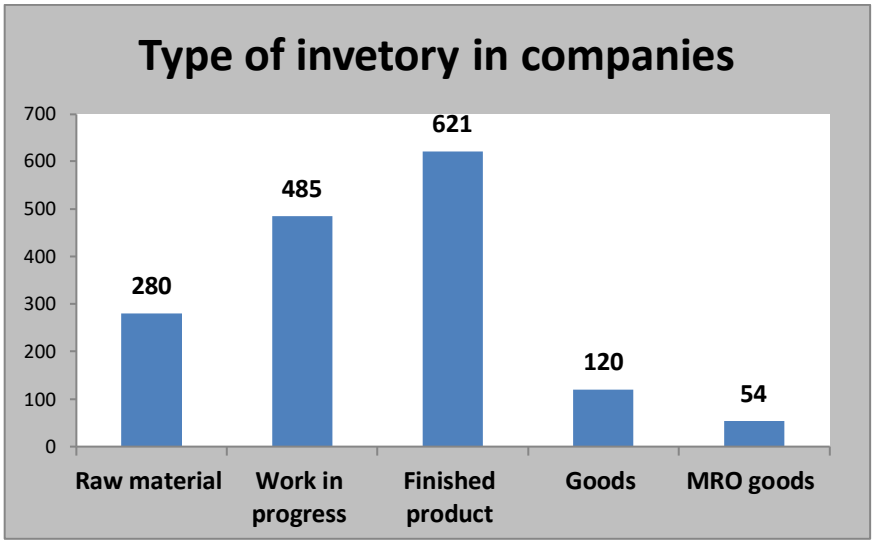


Figure 3 Most often type of inventory in companies

On the base of two hypothesis we can confirm that: 42% of selected companies use method FIFO of inventory valuation that is very easy, effective and is accepted by Accounting Law 431/2002 in Slovakia, and the most frequently type of inventory were finished goods [20]. 40% of selected companies are using this type of inventory for business and sale and create profit in the companies. Conclusions of the questionnaire survey we will value inventories using the FIFO method for the finished product. We will also point out the use of the LIFO and AC methods and significance of those methods for profit generation in the companies. As part of the decision-making process on the form of valuing inventories in companies, it is important to monitor the impact of the method used on the amount of the company's profit. We calculated the value of inventory costs according to selected methods - FIFO, LIFO and AC. The sales plan assumes 750 pieces of finished products, so we determined the amount of costs for a given number of finished products by individual methods.

FIFO method is an accounting method. FIFO assumes that the remaining inventory consists of items purchased last. An alternative to FIFO is LIFO method. LIFO is an accounting method in which assets purchased or acquired last are disposed of first. The calculation of the price of finished goods by method FIFO in the amount of 750 pieces is in table 1.

Table 1 Valuation of inventory by method FIFO [11]

FIFO	Increase			Decrease			Balance		
	ks	€/ks	€	ks	€/ks	€	ks	€/ks	€
Initial state							200	10	2000
Increase (300)	300	11	3300				200	10	2000
							300	11	3300
Decrease (400)				200	10	2000			
				200	11	2200	100	11	1100
Increase (400)	400	11,5	4600				100	11	1100
							400	11,5	4600
Decrease (350)				100	11	1100			
				250	11,5	2875	150	11,5	1725
Final balance				**750**		**8175**	**150**		**1725**

LIFO method is an accounting method. This method used to account for inventory that records the most recently produced items as sold first. The cost of the most recent products purchased (or produced) are the first to be expensed as cost of goods sold (COGS)—which means the lower cost of older products will be reported in items costs. The calculation of the price of finished goods by method LIFO in the amount of 750 pieces is in table 2.

Table 2 Valuation of inventory by method LIFO [11]

LIFO	Increase			Decrease			Balance		
	ks	€/ks	€	ks	€/ks	€	ks	€/ks	€
Initial state							200	10	2000
Increase (300)	300	11	3300				300	11	3300
							200	10	2000
Decrease (400)				300	11	3300			
				100	10	1000	100	10	1000
Increase (400)	400	11,5	4600				400	11,5	4600
							100	10	1000
Decrease (350)				350	11,5	4025	50	11,5	575
							100	10	1000
Final balance				**750**		**8325**	**150**		**1575**

Average cost method (AVCO) calculates the cost of ending inventory and cost of goods sold for a period based on weighted average cost per unit of inventory. AVCO is applied differently in periodic inventory system and perpetual inventory system. In periodic inventory system, weighted average cost per unit is calculated for the entire class of inventory. It is then multiplied with number of units sold and number of units in ending inventory to arrive

at cost of goods sold and value of ending inventory, respectively in perpetual inventory system, we have to calculate the weighted average cost per unit before each sale transaction. The calculation of the price of finished goods by method AC in the amount of 750 pieces is in table 3.

Table 3 Valuation of inventory by method AC [11]

	Increase			Decrease			Balance		
	ks	€/ks	€	ks	€/ks	€	ks	€/ks	€
Initial state							200	10	2000
Increase (300)	300	11	3300				500	10,6	5300
Decrease (400)				400	10,6	4240	100	10,6	1060
Increase (400)	400	11,5	4600				500	11,32	5660
Decrease (350)				350	11,32	3962	150	11,32	1698
Final balance				**750**		**8202**	**150**		**1698**

Based on the valuation methods used, we can state that for the same amount of issued inventories, the valuation in the item of costs is different (Figure 4). The lowest value of inventories is in the FIFO method; on the contrary, the highest value of costs is reflected in the LIFO method. For the values of the final balances of finished products, the cost value is highest for the FIFO method and lowest for the LIFO method. The LIFO method increases the cost item, which may be reflected in the reduction of the tax base, which is prohibited for business in Slovakia. Businesses can use the FIFO and AC method, which realistically measures inventories in consumption. The highest value of inventories that remain in the warehouse is presented by the FIFO method, which is important for the company because inventories are the property of the company that the company owns.

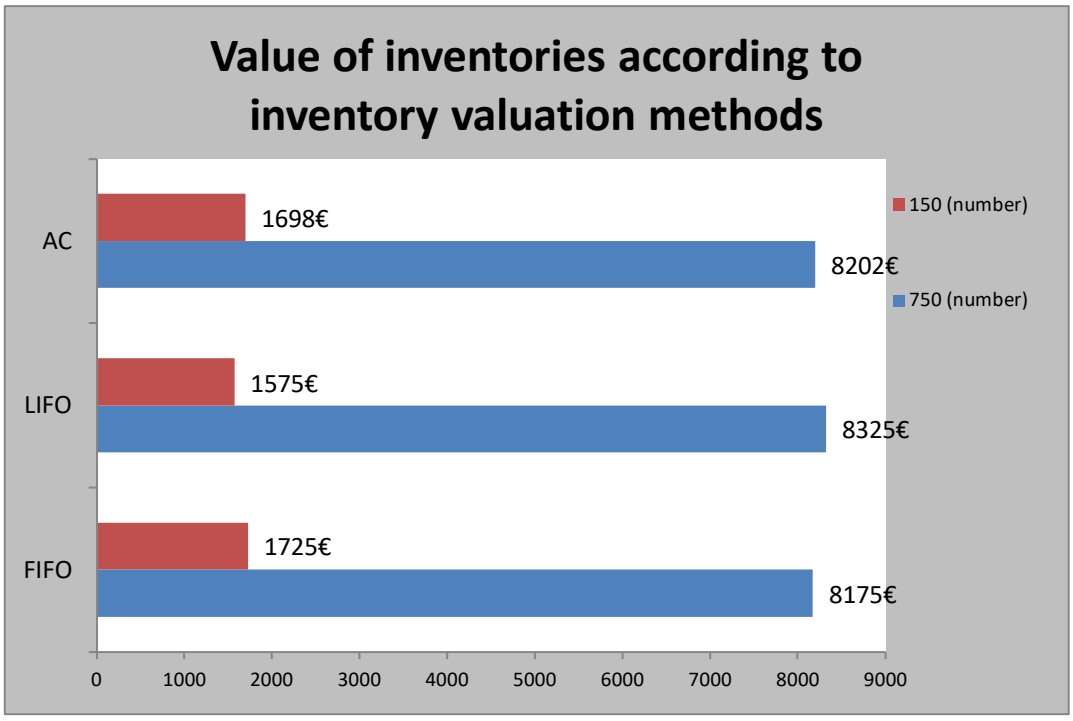


Figure 4 Results of valuation of finished goods

5 Discussion

All of authors in this article described to significance of inventory value methods. Their opinions were confirmed with the results of research. Li, YC, Liu, ZK, (2014) commented that selecting the inventory valuation method plays an important role in the firm [5]. Different inventory valuation methods will impact profit. This fact is presented in table 4. Utami et al. have solved the problems exist in the leasing of photocopy machines the method of inventory recording of goods used is FIFO, where the goods enter the first then the goods are issued first [6]. This method was used in research. Behunova et al. presented that the inventory valuation is a part of production costs that are important to optimize, because their influence is on the

selling price of product. In order to achieve a competitive price of the product, it is necessary to know not only the market but mainly the production costs of the company that influence profit generation [7]. This fact is presented in table 4 and in figure 4. Le, HE. et al. are describing using of inventory value methods is very important in various areas of industry in industrial chemicals differ in their treatment methods and types, depending on their physicochemical properties [10]. We can use this method FIFO in various industries. Lara in her chapter of the book describes inventory valuation methods and their significance in area of income tax. When the firm create high costs than have lower profit and pay lower taxes [11].

We investigated the impact of inventory valuation on the company's financial results (table 4) in determining the consumption of inventories at 750 pieces, the selling price of which was set at € 15. Revenues for all methods were the same, only the item of inventory costs changed, which we determined on the basis of three methods for valuing inventories (FIFO, LIFO, AC). We determined the operating costs fixed for all three methods. We found that when valued using the FIFO method, the company achieves the highest economic result in the form of a profit of € 875. With this simplified calculation of profit, we can see that the choice of the method of valuing inventories can ultimately affect the amount of the company's profit. When setting the valuation method, companies must take into account changes in the prices when acquiring inventories, which will reflect the changes in valuation more significantly and the more significant impact it will have when using individual methods.

Table 4 Generation of profit in company

Indicator/Method	FIFO	LIFO	AC
Revenue (750 ks finished goods x price 15€)	11 250	11 250	11 250
Costs / Decrease of inventory (750 ks finished goods)	8175	8325	8202
Operating costs – fixed	2200	2200	2200
PROFIT	**875**	725	848

6 Conclusions

Inventories create the assets of all companies and therefore their value is important. Based on the confirmed hypotheses, we can state that Slovak companies use the FIFO method for valuing inventories and at the same time have the most common type of inventories of finished products that are realizable on the market by selling and obtaining financial resources to purchase new inventories. The result of the calculation of the inventory price showed the highest value of stocks in the warehouse using the FIFO method in the amount of € 1,725. Based on the results of inventory valuation using FIFO, LIFO, AC methods, we can state that the best results are shown by the FIFO inventory valuation method, because it realistically shows the price of inventories, which inventories are valued when consumed and corresponds to the price of inventories when acquiring € 8175. The choice of the appropriate method of inventory valuation is the responsibility of each company and therefore it would be appropriate to introduce a simulation tool in the inventory management in companies, which would model the results of inventory valuation by individual methods and the highest profit share would be a criterion for choosing the appropriate method. In conclusion, we can confirm that the FIFO method is a method that in Slovakia realistically expresses the consumption of stocks and the final state of stocks in the warehouse as assets of the company. Using of this method FIFO is possible in various types of industries; it is method for profit influence that is important for business.

Acknowledgement

This article was supported by the state grant agency VEGA 1/0651/2018 „Research of institutional environment influence to the corporate social responsibility, consumers satisfaction, and performance of the company".

References

[1] TEPLICKÁ, K.: *Using new trends in praxis and economic gain for the firms,* Ostrava: VŠB-TU, 2014.

[2] TEPLICKÁ, K.: Inventory costing and their position in financial reporting, *Modern management,* Vol. 41, No. 7, pp. 52-53, 2006.

[3] AKHTARI, S., SOWLATI, T., SILLER-BENITEZ, D.G., ROESER, D.: Impact of inventory management on demand fulfilment, cost and emission of forest-based biomass supply chains using simulation modelling, *Biosystems Engineering*, Vol. 178, No. February, pp. 184-199, 2019. doi:10.1016/j.biosystemseng.2018.11.015

[4] SALVO, J.J., MACKENZIE, P.D., BENNETT, J.S., RELYEA, H.A., MORELLI, T.A. II.: *Inventory management system and method,* U.S. Patent No. 6341271, 2002.

[5] LI, YC., LIU, ZK.: *On the choice of inventory valuation methods*, 2nd Asian conference on the social science, pp. 190-193, 2014.

[6] UTAMI, M.K., SABARKHAH, D.R., FETRINA, E., HUDA, M.Q., et.al.: *The use of FIFO method for analysing and designing the inventory information system,* 6th International Conference on Cyber and IT Service Management, (CITSM) Indonesia, pp. 227-230, 2018.

[7] BEHÚNOVÁ, M., KNAPČÍKOVÁ, L., BEHÚN, M.: Logistics of controlling implementation in conditions of manufacturing enterprise, *Acta Logistica,* Vol. 7, No. 1, pp. 23-29, 2020.

[8] TURRINI, L., MEISSNER, J.: Spare parts inventory management: New evidence from distribution fitting, *European Journal of Operational Research*, Vol. 273, No. 1, pp. 118-130, 2019. doi:10.1016/j.ejor.2017.09.039

[9] CEVALLOS-TORRES, L., BOTTO-TOBAR, M.: *Case study: Probabilistic estimates in the application of inventory models for perishable products in SMEs,* In: Problem-Based Learning: A Didactic Strategy in the Teaching of System Simulation, Springer, Cham, 2019. p. 123-132.

[10] LEE, H.E., HUH, E.H.,YOON, Y., YOON, S.J., HUH, D.A., MOON, K.W.: Valuation of estimation toxic chemical release inventory method focusing on pain manufacturing process, *International Journal of Environmental Research and Public Health,* Vol. 16, No. 18, pp. 1-14, 2019.

[11] LARA, CFA.: *Tax based inventory valuation of assets for the determination of income tax and complementary taxes,* Estudios criticos de jurisprudencia tributaria y aduanera, pp. 63-80, 2018.

[12] ADELBERG, B.S., GOWER SMITH, W.D., HATTON, J.H., VISWANATHAN, S., LUSARDI, S.C.: *Vending store inventory management and reporting system,* U.S. Patent No 10,319,173, 2019.

[13] QIU, Y., QIAO, J., PARDALOS, P.M.: Optimal production, replenishment, delivery, routing and inventory management policies for products with perishable inventory, *Omega*, Vol. 82, No. January, pp. 193-204, 2019.

[14] COLLIARD, J.E., FOUCAULT, T., HOFFMANN, P.: Inventory Management, Dealers' Connections, and Prices in OTC Markets, *HEC Paris Research Paper No. FIN-2018-1286,* 2020. doi:10.2139/ssrn.3211285

[15] MULLER, M.: *Essentials of inventory management,* HarperCollins Leadership, 2019.

[16] SIMMONS, M.S.: *Vehicle inventory and customer relation management system and method*. U.S. Patent No. 10387826, 2019.

[17] SCHUSTER, Bobbi Denise, et al. *System and method for integrated, automated inventory management and advertisement delivery,* U.S. Patent No. 10229438, 2019.

[18] RAJENDRAN, S., RAVINDRAN, A.R.: Inventory management of platelets along blood supply chain to minimize wastage and shortage, *Computers & Industrial Engineering*, Vol. 130, No. April, pp. 714-730, 2019.

[19] AZADI, Z., EKSIOGLU, S.D., EKSIOGLU, B., PALAK, G.: Stochastic optimization models for joint pricing and inventory replenishment of perishable products, *Computers & Industrial Engineering*, Vol. 127, No. January, pp. 625-642, 2019.

[20] TEPLICKÁ, K.: Economic efficiency of inventory value in the firm, *Logistiký monitor,* Vol. 5, pp. 1-4, 2015. (Original in Slovak)

Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 7 2020 Issue: 3 Pages: 209-215 ISSN 1339-5629

SELECTED LOGISTICS PROCESSES IN THE FLOW OF PERISHABLE PRODUCTS
Maciej Koszorek; Katarzyna Huk

doi:10.22306/al.v7i3.181 *Received: 17 July 2020; Revised: 20 Sep. 2020; Accepted: 26 Sep. 2020*

SELECTED LOGISTICS PROCESSES IN THE FLOW OF PERISHABLE PRODUCTS

Maciej Koszorek
University of Zielona Góra, Institute of Management and Quality Sciences, Department of Logistics and Information Systems, ul. Podgórna 50, 65-246 Zielona Góra, Poland, koszorek.maciej@gmail.com
Katarzyna Huk
University of Zielona Góra, Institute of Management and Quality Sciences, Department of Logistics and Information Systems, ul. Podgórna 50, 65-246 Zielona Góra, Poland,
k.huk@wez.uz.zgora.pl (corresponding author)

Keywords: logistics, processes of logistics, perishable products
Abstract: Logistics processes and supply chains are widely viewed. The dependencies and conditions of their functioning depend primarily on the products that are in the circulation of these activities. Product flows in supply chains can be grouped according to certain types of products and their specificity of transport and storage. It will also determine the differences in the processes that will be used and their specificity. The article deals with three types of products: milk, fruit and human blood. Contrary to appearances, these products are very similar to each other, and the specificity of logistics activities is the same for this group. This is a group that has been called perishable products. Their specificity lies in the need to quickly deliver them to the final consumer so that they do not lose their properties. Most of this is possible thanks to the use of cold stores and efficient supply chains. The article compares the logistic processes used in the movement of human blood along supply chains. The aim of the article is therefore to analyse and compare the logistics processes used in the supply chains of blood and perishable products. The article is literary and empirical in nature and is based on a literature analysis, case study, participant observation and reports. The study presents the supply chain for perishable products, indicates the specificity of individual logistics processes and presents common features for this group of products. The Regional Centre for Blood Donation and Blood Treatment (RCKiK in Poland) in Zielona Góra was used as a case study. It is the organization that primarily manages the blood flow from donors to hospitals and other organizations right down to the ultimate consumer-patient.

1 Introduction

Shaping a good quality product that meets the expectations and needs of customers requires many related activities. These activities relate not only to the processing of raw materials, materials or semi-finished products, but also to many additional activities, such as proper transport, storage and information management. Logistics activities are determined by the specific characteristics of the products and the conditions that must be met so that they do not lose them. Many product groups do not require special treatment - they are resistant to weather conditions and other potentially harmful factors, however, one can distinguish those for which inadequate protection may affect the loss of quality or performance. The logistics task is to provide this protection at every stage of the flow. Requirements that often have to be met are unique to specific products, but to formulate general principles and notice similarities between flows that can later be used as reference points in the planning process, they are classified. An example of the classification of products according to the special challenges posed by logistics are perishable products that are sensitive not only to environmental conditions, but also to the passage of time. The article presents the flow of human blood in the supply chain. It has been compared to perishable products like milk and fruit. Their specificity lies in the fast flow and minimization of the loss of value of these products. This article uses a case study of blood flow based on an organization that manages these activities from blood donors to patients. It is the Regional Centre for Blood Donation and Blood Treatment (RCKiK in Poland) in Zielona Góra.

The aim of the article is therefore to analyse and compare the logistics processes used in the supply chains of blood and perishable products. The article is literary and empirical in nature and is based on a literature analysis, case study, participant observation and reports. The Regional Centre for Blood Donation and Blood Treatment (RCKiK) in Zielona Góra was used as a case study.

2 Logistics processes in business management

The company's activity is based on repetitive, successive activities that are to bring a specific result. They make up the process, i.e. "a logical sequence of consecutive or parallel activities, the implementation of which leads to meeting the client's expectations - both internal and external - by providing him with a product, service, documentation in accordance with his requirements" [1]. Before the product reaches the recipient, it must go through a series of processes that can shape it directly or indirectly.

Due to the multitude of processes, many researchers tried to systematize them based on various criteria. M. Porter proposed a simple division into basic and auxiliary processes. Basic processes are associated with the preparation of production and delivery of appropriate materials, product production, sales and distribution, marketing and after-sales services. Ancillary processes are management of the entire unit, its resources, as well as improvement activities [2]. Another classification was presented by J.G. Miller and T.E. Vollman, who distinguished the following groups of processes [3]:

- logistics - consisting in initiating, conducting and coordinating material flows,
- balancing - activities adapting the funds involved to real demand, such as purchases, material requirements planning, task delegation,
- quality - related to process control, compliance with technical requirements,
- information - related activities aimed at ongoing updating of data in the organization's system.

Table 1 Logistic processes and activities

Process	Actions
Transport	• choice of transport type and level of transport services, • establishing the transport network, • developing a vehicle traffic schedule, • selection of specific transport equipment, • handling complaints, • control of transport rates,
Shaping the level and structure of inventories	• formulation of a policy on the stock of raw materials, materials and finished products, • development of short-term sales forecasts, • definition of the inventory structure at storage points, • determining the number, size and location of storage points,
Logistic customer service	• agreeing on the scope of customer needs and requirements for the customer service system, • anticipating customer responses to an agreed service system, • determining the final quality of customer service level,
Storage	• determining the demand for storage space, • inventory distribution design, • receiving, completing and loading materials to and from the warehouse,
Packaging management	• choice of packaging to facilitate: o for loading, unloading and reloading operations, o about storage processes, o for protection against damage.

Source: [4].

Logistics processes on which this study focuses are carried out from the moment of obtaining raw materials to delivering the final product to the consumer. They rely not only on the physical movement of materials, but also on proper storage, protection and management of information. Many activities performed in the organization would be impossible without proper logistic service because it in some sense binds all the activities of the company. S. Twaróg identified five logistic processes and activities performed within them, which are presented in Table 1.

These processes as a whole come down to the optimal flow of raw materials, materials and finished products and related information at the lowest possible cost, appropriate quantity, quality, time and place of delivery [5]. Despite one clearly defined goal, there is no universal way of performing individual processes. Many of the conditions set depend on the properties of a given raw material, material or finished product. Efficient execution of logistics processes is particularly important in the case of products sensitive to external factors. Time is important here and ensuring appropriate conditions at each stage of the flow, as well as the information message accompanying physical flows. This type of logistics must be applied to perishable products.

3 Characteristics of the logistics of perishable products

The classification of products to the group of perishable products is not clear-cut and does not depend on a specific industry or product type. Some researchers attribute to it only products that spoil and, as a result, deteriorate over time, which starts from the moment they are produced. Additionally, they can be divided into those that have a predetermined shelf life, such as milk, blood components, yoghurts, and those of various shelf life, such as fresh fruit and vegetables [6]. In addition to the time criterion, they require appropriate conditions during processing, storage and transport. In other literature, demand conditions were also taken into account and the group of perishable products additionally classified clothing subject to temporary fashion and products replaced with the rapid development of technology (mainly electronics) [7]. In both cases, transportation must be fast and efficient to deliver the flow items at the right time and to the right

place, but products that lose their value due to deterioration require additional protection and the right temperature. The situation is similar in the case of storage and inventory management - the element that differentiates both types is the need to provide protection and optimal conditions for products that lose their properties, and the approach to inventory is the same - they should be shaped in such a way as to meet the demand, but at the same time avoid wastage resulting from the destruction of products or changes in consumer preferences, which boils down to minimizing inventories. Another important issue that perishable product logistics must deal with waste management. Due to the fact that some of the products may become worthless very quickly, there is no way to completely avoid losses, therefore actions aimed at neutralizing waste are necessary. A particular challenge is that some of the perishable products can become hazardous waste, such as medicines or electronics. The last highlighted element is information management, which is crucial in the event of unstable demand typical for this type of product. By monitoring the needs and changing preferences of consumers, the volume of flows can be adjusted to avoid losses. Moreover, the information message accompanying the physical flows can improve them and avoid errors. In order to further characterize some logistic processes of perishable products, three exemplary product groups were selected - milk, blood and soft fruit.

4 Identification of logistic processes in the flow of perishable products on the example of milk, blood and soft fruit

4.1 Selected logistic processes in the flow of milk in supply chains

The key role of logistics begins with the flow of the main raw material of dairy products - milk, which before processing is particularly exposed to time, external factors and very rapid loss of value. Once harvested, the milk is cooled and then collected from farms and transported to the dairy plant in two ways [8]:

- directly - from the producer to the dairy plant with the use of tank trucks,
- indirectly - from the producer, through a collection point, to a dairy plant, most often by means of cisterns, tanks or containers.

Due to the high sensitivity of the product to external factors, both transport and previous storage must meet the requirements for temperature and proper hygiene. Pursuant to the requirements of REGULATION (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin, raw milk must be chilled to a temperature not exceeding 8 °C immediately after collection, if it is to be picked up within one day and 6 °C if it is not picked up every day. During transport, proper hygiene should be maintained (especially with regard to maintaining cleanliness of equipment and containers, which should be washed and disinfected at least once a day), as well as such conditions that when reaching the plant of destination, the temperature of the raw material does not exceed 10 °C [9]. Once at the processing plant, the raw material is typically processed within 24 hours. As with any product that loses its value, time is crucial here to avoid potential damage or loss of quality. Before processing, the milk is temporarily stored in storage tanks or silos equipped with thermal insulation, liquid level indicator, temperature indicator and a stirrer. The temperature during the storage process should be around 4 °C [10]. After the above-mentioned logistic processes are correctly carried out, good quality raw material can be used for further production. After processing, milk does not lose value as quickly as raw milk, but dairy products still have a limited shelf life and need to be stored under appropriate conditions - on average at a temperature of 2 to 6 °C, with the exception of UHT milk and milk drinks in cartons, which retain their properties at temperatures up to 25 °C.

In addition to the physical flows, an important element is the communication of information and demand planning, which is difficult due to seasonal fluctuations in the demand and supply of milk. The supply is increased in spring and summer, and the demand is increased in the winter months [10]. Effective information management regarding winter demand allows stocks of already processed products to be shaped in such a way as to meet customer expectations by taking advantage of the surplus in the spring and summer period.

4.2 Selected logistic processes in the flow of blood and its preparations in supply chains

Another product that is sensitive to the passage of time and external conditions is blood, which is used in blood therapy after proper preparation and processing. Before it reaches its destination, it must go through a series of activities supported by logistic processes. Once collected from a donor, blood must be stored in single-use plastic containers that contain an anti-clotting solution. Transport to the Regional Blood Donation and Blood Treatment Centre (RCKiK in Poland) takes place at a temperature not exceeding 10 [11], and must also take place in a key time of less than 8 hours, during which blood should be processed in order to preserve the values of individual components [12]. After reaching the RCKiK, the blood goes to special centrifuges as soon as possible, where it is separated into three components: concentrate of red blood cells, plasma and buffy coat, which is used to obtain a concentrate of platelets. The shelf life and storage temperature requirements for the selected preparations are as follows [11]:

- red blood cell concentrates (RBC) - must be stored in a refrigerator at 2 to 6 °C, maximum 35 days in CPDA preservative fluid or 42 days in adenine-free citrate-phosphate-glucose fluid (CPD);

- fresh frozen plasma - must be frozen within a maximum of 6 hours from collection and stored at -18 °C or lower. In case of ensuring the temperature of -30, the shelf life of the preparation is 2 years, and if it is higher - one year;
- platelet cell concentrates - the storage temperature is 20 to 24 °C, and the maximum storage time - 72 hours or 5 days in breathable polyolefin containers;
- granulocytic concentrate - the shelf life of the preparation if stored at 20 to 24 °C is 24 hours.

Unlike the raw material, not all preparations require refrigeration, but this translates into a significant reduction in their shelf life.

Stock formation in the case of blood and blood preparations is difficult due to the unpredictable nature of supply and demand, which cannot be estimated by market research as is the case with many other products. Shaping the supply can take place through blood donation campaigns and other similar events, but the demand cannot be directly influenced [13]. The RCKiK experience in Zielona Góra shows that the demand for blood was often greater than the supply, but there were also situations when it was necessary to cancel the departure action due to too much supply of some blood components, which in a given period was not reflected in the demand and could be wasted. The uncertainty related to the blood demand cannot be reduced, but its seasonality can be used for estimation purposes. In summer, the supply of blood is reduced due to the fact that many blood donors decide not to donate it during holidays or vacation, and at the same time the demand increases, which is caused by the increase in the number of accidents [14]. It is precisely in the statistics on the number of car accidents that one can see periods when the demand for blood is increased and requires appropriate logistic preparation, i.e. winter breaks and holidays.

4.3 Selected logistic processes in the flow of soft fruit in supply chains

Another distinguished product from the perishable group are soft fruits, such as blueberries, currants, strawberries and blueberries. After picking them up from the production farm, transport can take place in two ways:

- directly to the processing plant;
- indirectly through a collection point to the processing plant.

An important issue in this flow is to keep the product as short as possible in non-refrigerated conditions [15]. The recommended temperatures and duration of transport processes, based on the example of raspberries and wild strawberries, are from -1 to 3 °C for transport not longer than 24 hours [16]. After reaching the processing plant, the fruit must be processed as soon as possible in order to maintain its high quality. The maximum storage period is not specified with one hundred percent accuracy, because, as it was noted earlier, fruits are perishable products in various periods of time, however, according to the soft fruit, they are most often suitable for a maximum of several days' storage at a temperature of about 0 °C (without a controlled atmosphere) [17]. After processing, most fruit preserves, such as jams or pasteurized juices, can be stored for several months without the need to provide them with special conditions, but there are exceptions, such as frozen fruit, which lose their value very quickly without ensuring the appropriate temperature. The optimal storage temperature for frozen soft fruit is -20 °C [18]. As in the case of other products distinguished in this chapter, stocking is based on seasonality, as fresh soft fruit is harvested in Poland during the summer period and preserves are accumulated during this time.

5 Comparative analysis of the logistics processes of the distinguished perishable products- results of research

In the above-mentioned examples of processes, many similarities can be identified, which result from the specific conditions that must be met by logistics in order to maintain the highest quality and avoid loss of value of the products. The comparison of selected aspects of the flow of milk, blood and soft fruit is presented in Table 2.

Table 2. Comparison of logistic processes in the flow of milk, blood and soft fruit

Logistics process	Milk	Blood and its components	Soft fruit
Transport before raw material processing	• While maintaining the cold chain, • At a temperature of not more than 10 °C, • Up to 48 hours.	• While maintaining the cold chain, • At a temperature of not more than 10 °C, • Less than 8 hours.	• While maintaining the cold chain, • At a temperature of -1 to 3 °C, • Up to 24 hours.
Storage before raw material processing	• In storage tanks or tank silos, • At a temperature of approx. 4 °C, • About 24 hours.	• No pre-storage, processing as soon as possible, • If necessary, at a temperature of not more than 10 °C.	• In storage or cold stores, • At a temperature of -1 to 2 °C, • A maximum of several days.
Storage after processing raw materials	• In storage rooms or cold stores (depending on the processing), • At room temperature or 2 to 6 °C, • Shelf life varied, from approx.	• In cold rooms, freezers, mixers or on storage racks, • At the temperature of 2-6 °C, below -18 °C or 20-24 °C, • Shelf life varied, from 24 hours	• In cold rooms or storage rooms, • At room temperature, approx. 5 °C (fresh juice) or 20 °C (frozen fruit), • Shelf life varied, from about 3

Logistics process	Milk	Blood and its components	Soft fruit
	2 weeks (cottage cheese) up to 6 months in the case of hard cheese.	(platelet cell concentrate) to 3 years (freshly frozen plasma).	days (fresh juices) to about a year (jams).
Logistic customer service	• Optimization of delivery time, • Ensuring freshness and reliability of supplies.	• Optimization of delivery time, • Striving for reliability of deliveries "to the rescue".	• Optimization of delivery time, • Ensuring freshness and reliability of supplies.
Shaping the level and structure of stocks	• Based on seasonality, • Purchased at collection points or directly at dairy plants.	• Very difficult, partly based on seasonality, • Obtained as part of voluntary donations, collected in the RCKiK stationary or by way of away actions.	• Based on seasonality, • Purchased at collection points or directly at processing plants.
Packaging management	• Transport packaging - cisterns, tanks or containers.	• Transport packaging - plastic packaging containing an anti-clotting solution.	• Transport packaging - transport boxes for soft fruit.

Source: own study based on: [9-11,15,16,19-21].

Although three different product groups have been selected, it can be seen that they all require a specific logistic approach. This is primarily determined by the critical time from the acquisition of the distinguished raw materials to their processing, in which they are particularly prone to loss of value, and the need to provide them with cooling conditions during transport and storage.

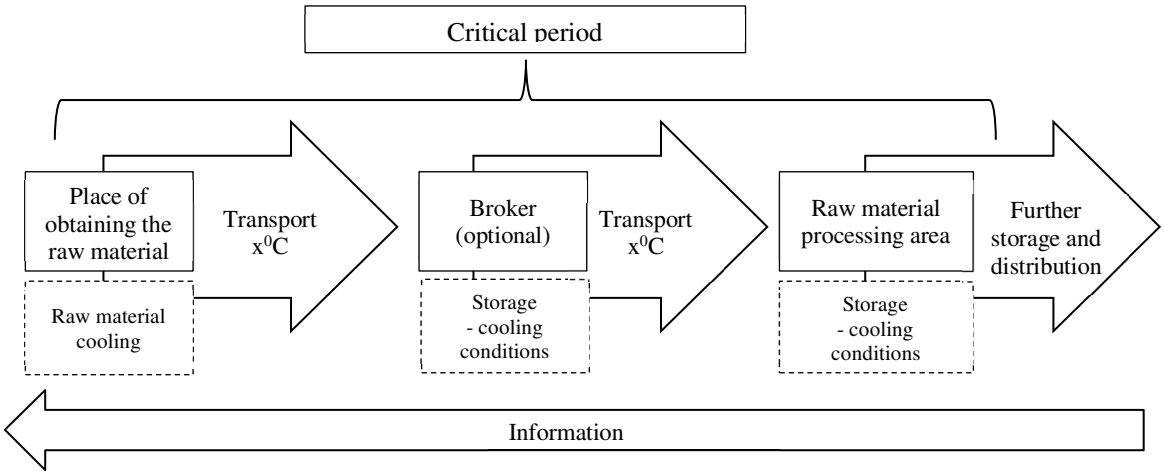


Figure 2 Diagram of logistic processes of perishable products in the supply chain

This is important because improper performance of logistic processes in this period may result in a reduction in the quality of the raw material and the finished product, and in the worst case - wasting it. After processing, the products are not so exposed to time and require various conditions (not necessarily refrigeration), so the greatest similarity should be seen at the stage of raw materials. Inventory management of all product groups is difficult due to their tendency to impairment and the need to rely on seasonality. Thanks to the conducted analysis, a general scheme of logistic processes from the moment of obtaining the raw material to its processing was formulated, which is shown in Figure 2.

The diagram shown above can be used as a reference for the flow of perishable products that are particularly sensitive to external influences and the time to processing, such as those presented in this paper.

In the case of perishable products, regardless of their type, it is important to:

- keeping products in an optimal place and cooling them,
- the shortest possible transport time,
- appropriate transport and storage conditions tailored to the specificity of the product,
- identifying individual products in supply chains,
- systems for identifying and checking the condition of products on the way in supply chains,
- the flow of relevant information at each stage of the chain,
- shortening the time of transport and storage until the products are processed,
- ensuring appropriate measures to protect the freshness of products and their packaging,
- optimal inventory control cycle.

However, it should be noted that all logistic processes in the supply chains regarding perishable products should be adjusted individually to given groups of goods. Their specificity and rapid depreciation of value implies the need to individually adjust logistics activities to product groups.

6 Conclusion

Providing the best quality is the overriding goal of every manufacturer, but to achieve it, it is not enough just to improve production and other processes that shape the product in a direct way. Efficiently carried out logistic processes condition the quality of the product at every stage of the flow, starting with obtaining the raw material, ending with creating inventories and delivering the finished product to the customer.

Classifying a product to the perishable group requires high efficiency and shortening the duration of logistics processes. Due to the large variety of products classified as perishable, different requirements are imposed in terms of ensuring the conditions or the use of appropriate packaging, but the main task of logistics remains the same - as the fastest possible flow in such a way as to minimize loss of quality.

The set research goal was achieved, the logistic processes of perishable products were identified and analysed. Thanks to the comparative analysis of the logistics processes of selected products, the common features were noticed and a general scheme was proposed showing them from the moment of obtaining the raw material to the storage and distribution of already processed products. In addition, in all analysed processes, a critical period was observed until the products were processed, and it was indicated as a time particularly important for logistics and shaping the final quality, which should be taken into account at the planning stage.

References

[1] SKRZYPEK, E.: *Jakość i efektywność*, Wydawnictwo UMCS, Lublin, 2002. (Original in Polish)
[2] PORTER, M.: *Competitive Advantage*, Free Press, Nowy Jork, 1985.
[3] MILLER J.G., VOLLMAN T.E., *The Hidden Factory*, Harvard Business Review No. 5, 1985.
[4] TWARÓG, S.: *System logistyczny, in,* Kauf S. (red.), *Vademecum logistyki*, Wydawnictwo Difin, Warszawa, 2016. (Original in Polish)
[5] KAWA, A., SOLECKI, B., ŚLIWKA, R.: Projekty usprawniające procesy logistyczne, *Logistyka*, Vol. 2009, No. 1, pp. 26-30, 2009. (Original in Polish)
[6] AMORIM, P., GUNTHER, H., ALMADA- LOBO, B.: *Tackling Freshness in Supply Chain Planning of Perishable Products*, VII ALIO/EURO, Workshop on Applied Combinatorial Optimization, Porto, 2011.
[7] NAGURNEY, A., YU, M., MASOUMI, A., NAGURNEY, L.: *Networks Against Time: Supply Chain Analytics for Perishable Products,* Springer Science & Business Media, Nowy Jork, 2013.
[8] RUDZIŃSKI, R., *Organizacja logistyki w zakładach przetwórstwa mleka,* [w:] Zeszyty Naukowe Uniwersytetu Przyrodniczo-Humanistycznego No. 87, Seria Administracja i Zarządzanie (14) 2010, Wydawnictwo UP-H, Siedlce, pp. 161-163, 2010. (Original in Polish)
[9] Parlament Europejski, Rada Unii Europejskiej, ROZPORZĄDZENIE (WE) NR 853/2004 Parlamentu Europejskiego i Rady z dnia 29 kwietnia 2004 r. *ustanawiające szczególne przepisy dotyczące higieny w odniesieniu do żywności pochodzenia zwierzęcego,* [Online], Available: https://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2004R0853:20110311:PL:PDF, [17 Feb 2020], 2004. (Original in Polish)
[10] NOWAKOWSKA – GRUNT, J., KOT, S.: *System logistyczny w przedsiębiorstwach przemysłu mleczarskiego* [w:] Nowicka-Skowron M. (red.), *Prognozowanie i modelowanie systemów logistycznych w przemyśle mleczarskim*, Wydawnictwa Politechniki Częstochowskiej, Częstochowa, pp. 106-115, 2004. (Original in Polish)
[11] NIECHWIADOWICZ – CZAPKA, T., KLIMCZYK, A.: *Leczenie krwią*, Wydawnictwo PZWL, Warszawa, 2011. (Original in Polish)
[12] KALWASIŃSKA, W.: Droga krwi [Online], Available: https://www.gov.pl/web/nck/droga-krwi, [21 Feb 2020], 2019. (Original in Polish)
[13] SZOŁTYSEK, J., TWARÓG, S.: Gospodarowanie zasobami krwi jako nowy obszar stosowania logistyki, *Gospodarka Materiałowa i Logistyka,* Vol. 2009, No. 7, pp. 12-17, 2009. (Original in Polish)
[14] Krwiodawcy, W wakacje zawsze brakuje krwi [Online], Available: https://krwiodawcy.org/wakacje-zawsze-brakuje-krwi, [23 Feb 2020], 2016. (Original in Polish)
[15] DOMARADZKI, A.: Wsparcie logistyczne w obszarach produkcji i przetwórstwa owoców miękkich, *Logistyka*, Vol. 2012, No. 4, pp. 899-900, 2012. (Original in Polish)
[16] Poradnik spedytora, *Drogowy transport owoców* [Online], Available: http://poradnikspedytora.pl/2013/drogowy-transport-owocow/, [23 Feb 2020], 2013. (Original in Polish)
[17] ZAGÓRSKA, K., *Jak przechowywać owoce borówki, aby wydłużyć okres ich podaży na rynku?* [Online], Available: http://www.sadyogrody.pl/logistyka_i_opakowania/107/jak_przechowywac_owoce_borowki_aby_wydluzyc_okres_ich_podazy_na_rynku,4281.html, [24 Feb 2020], 2016. (Original in Polish)
[18] GRABOWSKA, B.: Mrożenia owoców miękkich Part. 1. Normy i Przepisy [Online], Available: https://www.chlodnictwoiklimatyzacja.pl/artykuly/230-wydanie-06-2014/3196-mrozenia-owocow-

miekkich-cz-1-normy-i-przepisy.html, [24 Feb 2020], 2014. (Original in Polish)
[19] SZOŁTYSEK, J., TWARÓG, S., Korzyści ze stosowania logistyki w zarządzaniu systemem cywilnego krwiodawstwa w Polsce, *Logistyka*, Vol. 2010, No. 6, pp. 14-17, 2010. (Original in Polish)
[20] Ministerstwo Zdrowia, DZ. U. Min. Zdr. 2017.63 [Online], Available: http://dziennikmz.mz.gov.pl/api/DUM_MZ/2017/63/journal/3870, [17 Apr 2020], 2017. (Original in Polish)
[21] Dziennik Ustaw Dz.U. 2015 poz. 667 [Online], Available: http://prawo.sejm.gov.pl/isap.nsf/download.xsp/WDU20150000667/O/D20150667.pdf, [17 Apr 2020], 2020. (Original in Polish)

Review process
Single-blind peer review process.

JOURNAL STATEMENT

Journal name:	**Acta logistica**
Abbreviated key title:	Acta logist
Journal title initials:	AL
Journal doi:	10.22306/al
ISSN:	1339-5629
Start year:	2014
The first publishing:	March 2014
Issue publishing:	Quarterly
Publishing form:	On-line electronic publishing
Availability of articles:	Open Access Journal
Journal license:	CC BY-NC
Publication ethics:	COPE, ELSEVIER Publishing Ethics
Plagiarism check:	Worldwide originality control system
Peer review process:	Single-blind review at least two reviewers
Language:	English
Journal e-mail:	**info@actalogistica.eu**

The journal focuses mainly for the original and new, interesting, high-quality, theoretical, practical and application-oriented contributions to the field of science and research as well as to pedagogy and education in the field of logistics and transport.

Publisher:	**4S go, s.r.o.**
Address:	Semsa 24, 044 21 Semsa, Slovak Republic, EU
Phone:	+421 948 366 110
Publisher e-mail:	**info@4sgo.eu**

Responsibility for the content of a manuscript rests upon the authors and not upon the editors or the publisher.