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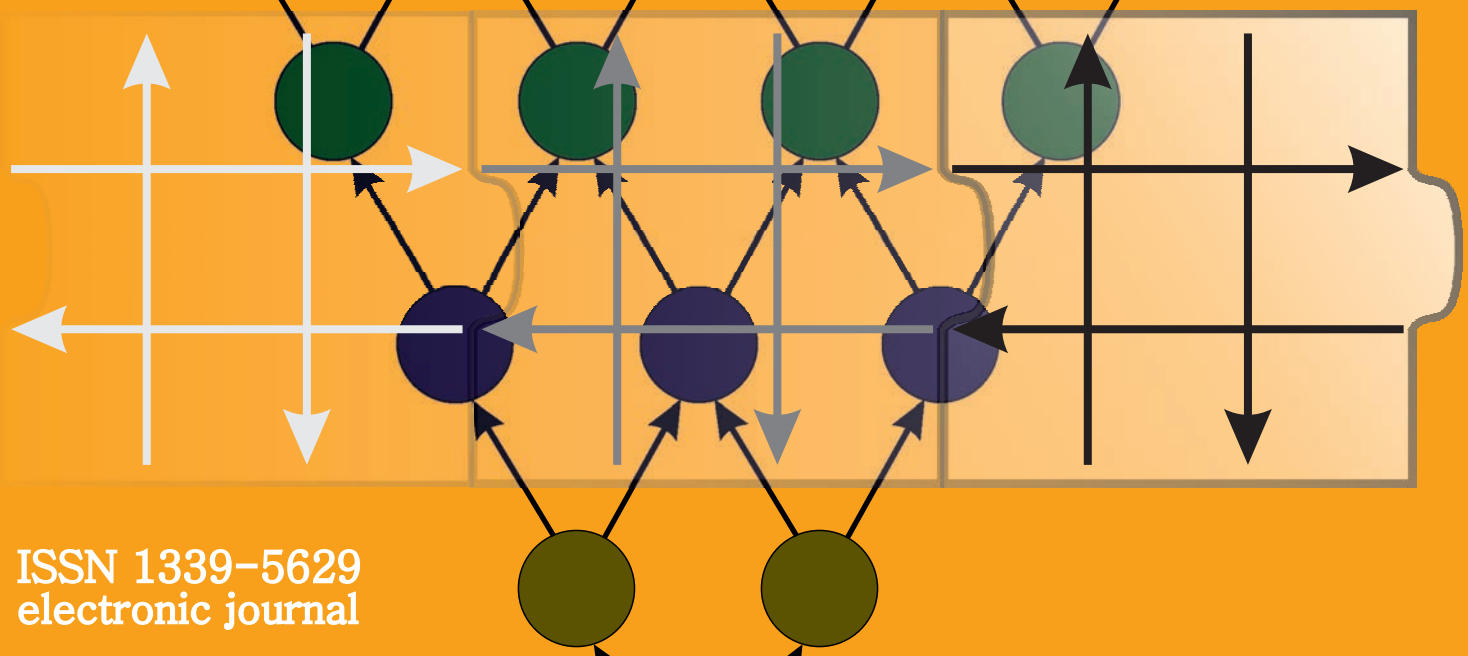
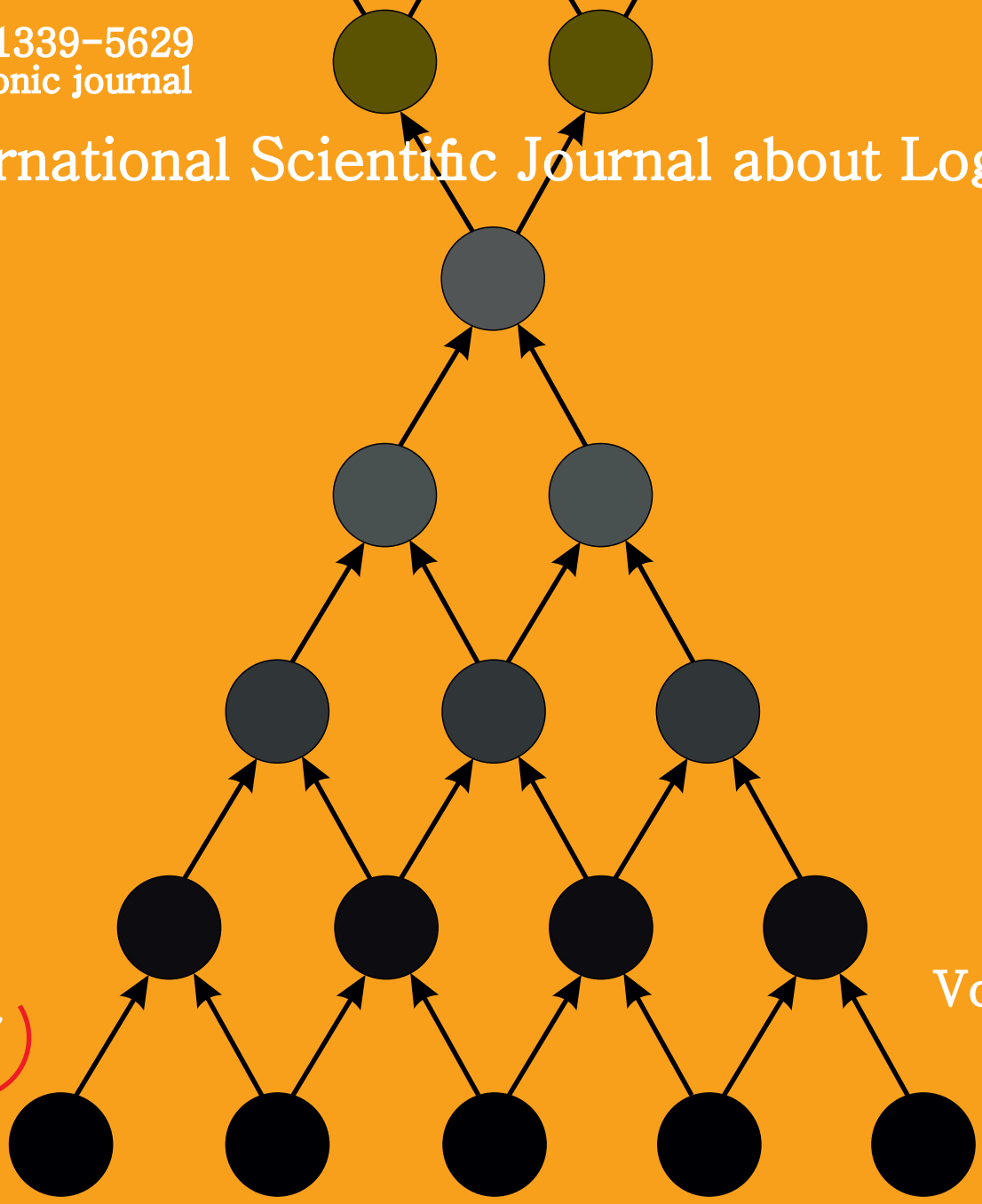


ISSN 1339-5629
electronic journal

International Scientific Journal about Logistics



Volume 9
Issue 4
2022

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(DECEMBER 2022)

Acta Logistica -International Scientific Journal
Volume: 9 2022 Issue: 4 ISSN 1339-5629

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Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 361-368 ISSN 1339-5629

doi:10.22306/al.v9i4.326 *Received: 12 July 2022; Revised: 12 Sep. 2022; Accepted: 07 Dec. 2022*

METHODOLOGY FOR CALCULATING THE COST PRICE OF THE BENDING PROCESS FOR THE NEEDS OF MANUFACTURING LOGISTICS

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Keywords: press brake, logistic process, bending, bid calculation, cost price.
Abstract: The research of this paper aims to characterize and describe the methodological sequence of operations necessary for the correct calculation of the cost price when performing a bid calculation in the bending process step on a bending machine. The research focuses on determining the methodology and its application exclusively to sheet metal parts in the engineering industry in the processing of steel and stainless-steel sheets. To research this issue, we used empirical and quantitative research in a real work environment. The methodology for calculating the cost price of bending sheet metal parts yields the relationships between component inputs, the result of which is a time parameter that is expressed by the actual production costs. The results can be used in the real working environment of manufacturing companies for comparison with already established practices and a verification of their outputs. At the same time, it is possible to use the determined methodological procedure as a basis for implementation in the Aurendi web application.

1 Introduction

Market trends are leading to the digitization, the use of technology and the transformation of businesses in the era called Industry 4.0. The most important aspect of any company's success is a satisfied customer. The business environment is changing year by year and marketing and business practices are witnessing an ever-increasing tendency to focus on the customer and their needs [1,2]. Global competition makes it necessary for industrial companies to accurately monitor production costs throughout the design process. However, it is difficult for a company to determine the best technology to ensure its profitability [3,4].

Cost management is a major section of business management in the manufacturing industry. The level of implementation of the cost management is a comprehensive index for measuring the level of enterprise management [5]. The ability to predict the cost of manufacturing parts is therefore considered a key factor for the commercial success of products [6]. Since tenders for inquiries usually take place with very limited availability of information and within short time frames, estimates of the costs on which these tenders are based are highly inaccurate and pose a significant risk to suppliers. In particular, the actual consumption of production capacity cannot be predicted with sufficient accuracy [7]. For a product to succeed in the manufacturer's competitive business, there should be an accurate estimate of its design, development, and manufacturing costs [8]. In this respect, calculations of the production costs of finished products need to be made quickly and reliably [9]. There are two concepts for calculating the price of a product, namely absorption calculations and direct calculations [10]. Absorption calculations are also called full calculations, meaning a calculation concept in which all production costs are absorbed into a product. Direct calculations, meanwhile, are commonly known as marginal calculations or variable calculations, and involve only assigning variable production costs to products [11]. The paper uses the full calculation methodology.

The methodology described herein for a specific bending process step is one of many inputs on a comprehensive scale to determine the target price. We understand the target price here as the cost of the product without compromising its quality [12].

The bending process is herein defined for the processing and production of sheet metal parts in the engineering industry, whereas individual processors must map their own given industry in detail, as they would any other industry. Manufacturers of sheet metal parts must take different measures to compete on the market to differentiate themselves from their competitors. Offering customized products of the highest quality at the lowest possible price is the ultimate goal for the long-term operation of any company. For the price to be as competitive as possible, the costs must be known. Once the product manufacturing process is complete, detailed information can be collected and used to determine the cost of the final product using additional costing. Regardless, an estimate of production costs is often required before the actual production of a given part. Therefore, the costs must be estimated within the specified accuracy range, even if not all the necessary details are known yet. To overcome these missing technical details, cost estimation techniques are used to approximate costs within a certain range of accuracy [13,14]. However, the basis of the calculation is the automation of the calculation based on structural and technological parameterization. This enables automatic transfer of initial design and technology data to the costing module [15].

The paper's research is based on the need to specify the individual process steps within the methodology of the Aurendi online web application. In this specific case, it is the issue of bending. The Aurendi web application is a calculation tool for the automated calculation of the offer price of sheet metal parts and welded structures in the engineering industry. The application mainly focuses on performing bid calculations by the calculation of cost prices and sales margin. The primary function of this tool is to achieve an accurate calculation of the bid price while increasing the efficiency of the bid creation process. At the same time, the application simplifies the manufacturing companies' contact with suppliers in the engineering industry through a regularly updated database system. The principle on which the system functions is its ability to extract data from the input production documentation in .dxf and .step file formats. Files in the aforementioned formats can be opened in the application environment and the system automatically loads all the key information for the calculation. By combining the ability to obtain the required data from the tender documentation, a unique methodological approach to the calculation of tender bids and a database system, the calculation of tender bids can be performed in a fraction of the time compared to the conventional method of calculation. The accuracy of the calculation of bid prices is also significantly better. The application is built on a cloud solution and can be used from anywhere, requiring only an Internet connection.

The paper describes a methodical approach to cost price calculations of a specific technical issue, focusing on the technology of bending sheet metal parts on press brakes. This is a key step in bid calculations, which has a significant share in the final price of the product and is also complicated for a qualified estimate. The paper's results can be used as a basis for the implementation of this methodology in the Aurendi web application. This implementation makes it possible to monitor the process and evaluate the outputs of individual calculations, and retrospectively verify the correctness of the determined methodology.

2 Methodology

The methodology is divided into three main branches that must be projected – preparation time, bending time and the resulting conversion to the price for the preceding sections. In the case of time per bend, it is necessary to state the time calculation for the setting of one bend, while the resulting time will be this calculation multiplied by the number of bends on a specific job. In the price calculations, it will then be necessary to take into account the possible need for the participation of auxiliary workers, whose time must be taken into account in the cost price.

The methodology is limited to the use of press brakes up to a maximum bend length of 5 meters. These relationships can also be used in setting up the methodology for larger press brakes, however, it would be necessary to make your own plans and adjust the relationships for the given machinery. Therefore, the following descriptions will only use a maximum bend length in the range of 5 meters. Longer bends are relatively more demanding in terms of the expected higher weight of the parts, in which it is necessary to take into account the additional costs associated with the use of transport equipment.

The method of statement of monitored outputs is described in two ways:

- General values,
- Precise values.

General values are stated in the research wherever a given value is subject to individual setting by each manufacturing company depending on the company's internal settings and pricing policy. Tables containing exact values are created using in-process surveys and are recommended for use in your own calculations.

2.1 Procedure for determining preparation time

Determining the amount of preparation time is generally considered to be the most important and at the same time the most complex quantity in the calculation of time parameters within the calculation of cost prices for bid calculations. This parameter is the most important mainly due to the very high costs associated with the operation of

the machinery, whose acquisition value is on the order of millions of crowns. It is the most complicated due to the need to estimate when using the conventional method of calculation, and where the responsibility lies with the budgeter, who must be familiar with the production process. The hourly rate is calculated from the acquisition cost of the machine and the overhead costs associated with the operation of the machine, which must be reflected in the machine preparation time. Preparation time is understood here as a non-production cost of the machine, when certain operations must be performed within the machine settings and preparation of the machine workplace. This is unproductive time, but it must be taken into account in the calculation of the cost price of the product. It can therefore be stated that costs are already incurred in the pre-production phase of the processing process. The stated costs are calculated in the bid calculation and distributed proportionally to the quantities of the required parts. Here, a quantity discount based not on the business strategy but on the pre-production phase of the production cycle is evident. In the case of high series production on the order of hundreds of pieces, the preparation time is practically negligible, however, when dealing with small series production, this parameter is key and significantly affects the cost price.

As part of the calculation, all parameters must be considered and defined. The definition of input parameters is shown in Table 1. Also included is the information regarding selected inputs, especially information about the nature of the value, its source and the possibility of a user setting of the quantity. The latter information is required for Aurendi users. The value of the quantities is left in the general form.

Table 1 Chart of input parameters in the preparation process

Composition of overall preparation time	Nature of value	Source of value	User setting of quantity	Quantity value	Unit
Bend programming	Constant	Database	YES	a	minutes / bend
Number of bends	Variable	STEP	NO	b	pieces
Workplace preparation	Constant	Database	YES	c	minutes
Adjusting the press brake bars	Variable	Database	YES	d	minutes

2.1.1 Bend programming

This is a fundamental parameter for working on a press brake. The parameter has the nature of a constant, which we understand will be set only once within the work with respect to the measurements in the work process. The first value of the parameter describes the time required for programming individual bends on the machine.

2.1.2 Number of bends

This parameter must be read from the drawing documentation. When using the Aurendi application, this parameter is automatically loaded by the application from the input documentation in the .STEP file format. This is a variable depending on the specific production assignment.

2.1.3 Preparation of workplace

A constant whose value is adjustable by each manufacturing company depending on its own determinations and the layout of the working environment of the press brake. For the purposes of presenting the article, the plans were made in a specific manufacturing company. When using the Aurendi application, this parameter can be set by the user.

2.1.4 Setting up the press brake dies

This parameter is characterized by the relationship between the time requirements for the installation of dies in the machine when processing different lengths of bends. This is a variable depending on the input documentation. The specified relationship corresponds to the time it takes for the production worker to install the dies on the press brake. The specific type of die is selected based on the strength of the sheet, which is given by the input documentation. However, the sheet metal force parameter is irrelevant for this calculation. The production worker chooses the appropriate set of bending dies according to the individual properties of the machine. Since it is very probable that the bends will be of different lengths on different parts depending on their dimensions, to set the preparation time correctly it is necessary to work only with the longest detected bend on the part. The reason is the manual laborious installation of the dies in the press brake, and if we take into account the longest bend, there will be no risk of additional installation of dies being necessary, because there will no longer be a need to increase the length. In the case of choosing one of the shorter bends, or the shortest, there would be additional costs associated with the additional installation of dies in the machine. The given relationship is shown in table no. 2.

Table 2 Dependence of the length of bends on the time of setting the dies

	Minimum length of bend [mm]	Maximum length of bend [mm]	Time required for die setting (d) [min]
Span of bend lengths	1	1000	2
	1001	2000	4
	2001	3000	6
	3001	4000	8
	4001	5000	10
	5001	6000	20
	6001	7000	30
	7001	8000	40

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2.1.5 Defining relationships of inputs to the preparation process

The actual calculation of the preparation time t_p is a simple task when we know all the input parameters and their values (1). The parameters correspond to the description in table no.1. The units of preparation time t_p are expressed as minutes [min].

$$t_p = \{(a * b) + c + d\} \quad (1)$$

2.2 Procedure for setting the bend time

To determine the time required in what is already the production phase of bending, the time for one bend was taken and subsequently multiplied by the number of bends detected on the part. This process step can be determined in this way, because the decisive parameter that could cause differences between bending times of different lengths is the thickness of the sheet, which, however, is constant with respect to the input of one part. Therefore, we always work with the part that is being bent and which is separated from a single sheet of metal of the same thickness in the previous step. 2 To solve the time per bend, we must proceed analogous to the determination of the preparation time. When using the Aurendi calculation application, setting the time for bending must be approached in such a way that the calculation methodology will be applied to each detected bend separately and then the bending times will be summed depending on the detected bends. If the conventional method of calculation is used, the process will be the same, with the difference that the detection of bends is up to the budgeter.

The approach of calculating the time for each bend has, compared to the preparation time, a certain specificity associated with the checking of the machine settings, which must be taken into account in the calculation. By checking, we mean by measuring every first different bend performed on the machine. 3 This is an inspection of the first piece, where we consider the constant time determined for inspection measurements of each bend during the initial setup of the machine.

An important criterion for calculating the bending time is understanding the bending process on the press brake. For a correct calculation, it is necessary to detect all the bends on the specified part. However, it is also necessary to consider the fact that if several bends are detected on a part that are in the same axis, they are considered to be a single bend. The reason is to adjust the press brake so that both bends are bent at the same time. With this type of bending, it is possible to prepare bending on the machine at what are called multiple workstations within the working space of the machine. At a given machine setting, bends are performed simultaneously. Figure 1 shows a typical example of several such bends (marked in green) on a part shown spread out, which are on a single axis.

All parameters required for the calculation of the bending time are shown in Table 3. This table provides information on all necessary inputs for the calculation. As in the previous table, it describes the nature of the value, its source and information on user settings with respect to functionality within the application. The values are again left on a general level.

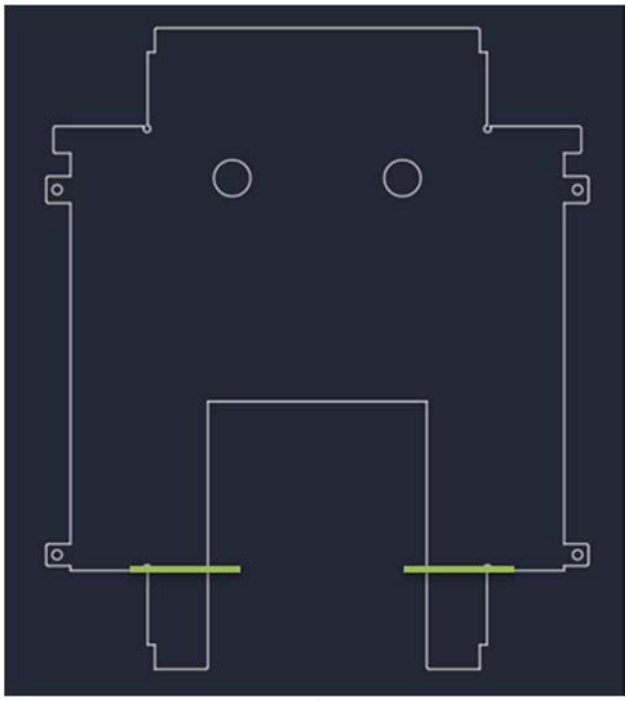

Figure 1 Expanded shape of the bent part, own drawing

Table 3 List of input parameters for the bend time calculation

Composition of total rate per bend	Nature of value	Source of value	User setting of quantity	Quantity value	Unit
Number of bends	Variable	STEP	NO	e	Pieces
Thickness of sheet metal	Variable	STEP	NO	f	mm
Insertion of part in press brake	Constant	Database	YES	g	Seconds
Unloading of part from press brake	Constant	Database	YES	h	Seconds
Net time for one bend on press brake	Variable	Database	YES	i	Seconds
Checking of executed bend	Variable	Database	YES	j	Seconds

2.2.1 Number of bends

The given parameter is a variable, which is the basic input of the tender documentation. In the conventional methodology of determining the cost price, this parameter is read by the budgeter directly from the tender drawing documentation. In the event of the use of an automated calculation process via the Aurendi web application, the parameter is loaded automatically.

2.2.2 Sheet metal thickness

As with the previous parameter, the sheet metal thickness is a parameter derived from the production documentation. When using the Aurendi application, this parameter is loaded automatically; in the case of a non-automated method, it must be read from the production documentation. The parameter enters the process in relation to the time required for bending on the press brake. Table 4 illustrates this dependence, but it should be noted that the dependence varies with the specific type of machinery. The limitation of this table is the technical assumptions of the press brake, which can handle bends up to a maximum sheet thickness of 6 mm.

Table 4 Sheet metal thickness dependency on bend time

Net time for 1 bend on press			
Sheet metal thickness [mm]	Bending time [s]	Sheet metal thickness [mm]	Bending time [s]
0.5	2	2.5	6
1	2	3	7
1.3	3	4	9
1.5	3.5	5	11
2	5	6	15

2.2.3 Insertion of part into press brake

This parameter is based on component surveys that should be performed by each company in order to specify the output cost price. This is the exclusive part of the process, which maps only the time needed for the operator to lift the part from position A, which is reserved for the part entering this process step and its insertion into the press brake. The process step ends by precisely placing the part on the preset stops of the machine.

2.2.4 Unloading of part from the press brake

The parameter for unloading a part from the machine is defined similarly to the previous, insertion, parameter. Here, part of the process maps the time required to unload the already finished part to location B, which is reserved for the already finished parts, and thus is based on the bending step in the process. The beginning of the step is the release of the press brake and shifting of the part by the operator to a predetermined place.

2.2.5 Net time for 1 bend on the press

This is based on the relationship given in Table 4. Based on the detected sheet metal thickness, an appropriate time parameter is assigned, the value of which corresponds to the technical parameters of the press brake. This is a process step that begins with the insertion of the part into the working space of the press brake. Immediately afterwards, the bending process itself takes place at the operator's signal. The signal is made by depressing the foot pedal. This step ends when the bend has been performed and the jaws are returned to the initial position.

2.2.6 Checking of the bend

This involves checking every first different bend that has been performed on a given part. The step maps the time required to check all bends. The inspection is usually performed with a protractor and a measure, or with a caliper – all measuring implements should be calibrated and certified. The result of the performed measurement is a possible correction on the machine, if required by the measurement result. The value itself is also the subject of a decision by the quality control department in each company. This value was left as general in the methodology.

2.2.7 Definition of relationships of inputs to the bending process

The calculation is performed including the parameter for checking the performed bending. First, the calculation for one bend (2) is determined, and then the calculation for all bends on the part (3). We check the performed bend j only for each different first bend. For a calculation in a series, this parameter is taken into account only for the first piece. Units of both equations are expressed as a seconds [s].

$$y = g + h + i + j \tag{2}$$

$$z = (g + h + i + j) * e \tag{3}$$

2.3 Determination of the cost per task depending on the preparation time and time per bend

The preceding sections map the process steps to ensure the time needed to fulfill them. In this section, all these times will need to be evaluated in terms of setting the cost prices for these procedural steps. To reliably meet this goal, it is necessary to define additional input parameters that are part of the given calculation. This mainly concerns company rates – specifically the hourly rate of the press brake and the hourly rate of the auxiliary worker.

Table 5 shows the inputs for calculating the cost price. It is not necessary to set specific values of rates within the methodology; general values will be used for the correctness of the calculation procedure.

Table 5 Hourly rates

Description of input	Nature of value	Source of value	User setting of quantity	Quantity value	Unit
Hourly machine rate	Constant	Database	NO	k	EUR / hour
Hourly rate for auxiliary worker	Constant	Database	NO	l	EUR / hour
Number of auxiliary workers	Variable	Database	NO	m	worker

2.3.1 Hourly machine rate

This varies depending on the purchase price of the machine and operating costs. The hourly rate must be set by the company so that it is competitive on the market with respect to the required profitability of the machine.

2.3.2 Hourly rate for auxiliary worker

The setting of the hourly rate of the auxiliary worker is fully under the control of each manufacturing company, again with regard to competitiveness.

2.3.3 Number of auxiliary workers

In calculating the cost price, the determination of the number of auxiliary workers with respect to the assignment must also be taken into account. Tables 6 and 7 show the criteria for determining the number of auxiliary workers. The priority criterion is the evaluation in Table No. 6, when it is necessary to first assess the part by weight. The secondary criterion is the distinction according to the dimensions of the part.

Table 6 Dependence of number of auxiliary workers on part weight

Number of auxiliary workers depending on the weight of the part		
Minimum weight [kg]	Maximum weight [kg]	Number of workers
0	20	1
21	40	2
41	60	3

Table 7 Dependence of number of auxiliary workers on part dimensions

Number of auxiliary workers depending on part dimensions				
Minimum length of side A [mm]	Maximum length of side A [mm]	Minimum width of side B [mm]	Maximum width of side B [mm]	Number of workers
0	1500	0	1500	1
1501	2500	1501	2500	2
2501	5000	2501	5000	3

2.3.4 Calculation of price for preparation time

The following calculation consists of two parameters – the net time spent preparing the machine and the working environment (4) and the proportional calculation of the price for the auxiliary worker (5), which is based on the specified preparation time. The relationship is defined between the preparation time t_p and the hourly rate of the machine k. Units of the equations (4), (5) and (6) are expressed in actual cost [EUR].

$$X_1 = \left(\frac{t_p}{60}\right) * k \tag{4}$$

When working on different parts, an auxiliary worker will not always be needed, but it is crucial to state the calculation, including the element of additional labor, and if no auxiliary worker is needed for the component assignment, the parameter m will be zero. The definition of the calculation of the price per auxiliary worker is defined by the relationship between the preparation time t_p, the hourly rate of the auxiliary worker l and the number of auxiliary workers m.

$$X_2 = \left\{\left(\frac{l}{60}\right) * t_p\right\} * m \tag{5}$$

The calculation of the complete price for the preparation time is expressed by the sum of the calculations of the price for the preparation time X_1 and the relative rate for the auxiliary worker X_2.

$$X = X_1 + X_2 \tag{6}$$

2.3.5 Calculation of price for bending

The calculation is performed first by determining the price for one bend (7) and then the calculation for all bends on the part (8). Both calculations are shown including the incorporation of the auxiliary worker parameter. Units of both equations are expressed in cost [EUR].

$$Y = \left(\frac{k}{360}\right) * y + \left\{\left(\frac{l}{360}\right) * m\right\} * y \tag{7}$$

$$Z = \left(\frac{k}{360}\right) * z + \left\{\left(\frac{l}{360}\right) * m\right\} * z \tag{8}$$

With the final sum of partial outputs when calculating the prices for the final preparation time X and calculating the price for all detected bends on the part Z, we achieve the determination of the price for the whole workshop bending operation on the press brake.

3 Result and discussion

The paper provides a definition of all component parts of the production process of bending sheet metal parts in the engineering industry on bending machines. The developed methodology describes the complete logistical sequence of all tasks within this operation to determine the time intensity of the process. Time data that can be effectively calculated through formulas and the connections of individual inputs are key elements in calculating the cost price for this technological operation.

The three main branches that make up the methodology describe the relationships between the individual inputs. When calculating the time required for bending, the factors of technical complexity when performing the bending operation were taken into account. The key parameter here is to define the relationship between the sheet metal

thickness and the time required for the bending itself. This relationship was determined by measurements made directly in the work process. It should be noted that this relationship, although properly measured, can vary depending on the machine and the manufacturer. At the same time, it can be argued that the dependency will need to be updated over time due to the development of increasingly powerful machines. However, dependency is a legitimate and solid part of the methodology.

A similar result can be stated even when determining the preparation time for programming the bending parameters. Here, it can also be stated that the given time will depend on each machine and will need to be monitored and updated, depending on the development of the given technology on the market.

The final part of the methodological procedure then only determines the relationship between individual time determinations and the hourly rates of machines and the manufacturing companies themselves. Here, it is appropriate to conduct further research focused on this issue and to subject the input parameters under consideration to a more comprehensive analysis.

4 Conclusions

The presented methodology has two levels of practical use. The first is the application to a functional work process to accurately calculate rates in a specific area by each manufacturing company individually. In this phase, the methodology is fully usable without the necessary prerequisites in terms of system equipment of companies. If it is necessary to streamline the actual process of calculating bids at the same time as calculating cost prices, it is appropriate to use the given procedure. Though component values of individual inputs may differ, this fact does not have a negative impact on the specified process.

The methodology has a major impact when implemented in the already functional model of the Aurendi web application. Implementation of the process into the application results in a fully automated model for calculating the bending step in the process of calculating cost prices for sheet metal parts and welded structures. By using the model in the application, a further increase in the efficiency and accuracy of automated calculations will be achieved. Here, too, however, further research is recommended, which will monitor the corrective setting of all technical and economic inputs in the process of calculating the time and price. As part of more comprehensive research, with the participation of various engineering companies, it is recommended to regularly collect and evaluate feedback from already specific bid calculations and to compare the results with real production time. The methodological procedure research performed can serve as a basis for further research focused on the calculation of the deviation between the predicted calculation and the actual costs of production of sheet metal parts and welded structures.

Acknowledgement

The work was supported by the specific university research of Ministry of Education, Youth and Sports of the Czech Republic at VSB - Technical University of Ostrava, projects no. SP2021/43 and no. SP2022/78.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 369-378 ISSN 1339-5629

OPERATIONAL CONCEPT OF AN INNOVATIVE PACKAGING MANAGEMENT SYSTEM
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doi:10.22306/al.v9i4.327 Received: 13 July 2022; Revised: 25 Oct. 2022; Accepted: 15 Nov. 2022

OPERATIONAL CONCEPT OF AN INNOVATIVE PACKAGING MANAGEMENT SYSTEM

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Keywords: packaging management, simulation study, decision method, industry 4.0.
Abstract: Nowadays choosing the right packaging system is becoming increasingly challenging, mainly due to the pressure to meet dynamically changing customer needs. In order to remain competitive, the types of unit loads handled by companies are changing more and more frequently, which means that the choice of the ideal packaging system is also becoming increasingly important. The packaging of products influences the efficiency of logistics operations and the cost of running the system, whose role is becoming increasingly important. As a result of the detailed literature analysis presented here, it is concluded that no framework has been developed to date that provides an adequate answer to the choice of the optimal packaging system in different circumstances. The methods used in practice focus on a few narrow areas and ignore many relevant aspects. In this paper, we present the testing options for the packaging management system we have developed, the building blocks of the system and their role in the testing process. In addition, the basic process of one type of testing, namely the selection of the optimal packaging system for a new product type, is described.

1 Introduction

In industrial practice, the selection of appropriate packaging and the improvement of existing packaging systems are becoming increasingly challenging, mainly due to the significant expansion of product structures, the rise of e-commerce and the variety of seasonal packaging [1,2]. A detailed literature review was carried out using the systematic literature search method, the main aim of which was to determine the current state of the field and to identify the scientific gaps.

This literature analysis was carried out using the SLR (Systematic Literature Review) method. In practice, the usefulness of a research is mainly determined by its dissemination rather than its publication. The SLR includes documentation of all methods performed [3,4].

Traditionally, literature reviews present research findings in descriptive or narrative form. A good narrative presentation provides the reader with an overview of the different views of a discipline, including its key methodologies and theoretical traditions. Reports on systematic reviews should include a section on the methodology used and a precise description of the process of the study. This is mainly necessary, in their view, to ensure that all decisions are taken in a transparent manner [3,5].

The literature analysis (Figure 1) was carried out on 3 databases in order to capture the widest possible range of research. The first part of keyword search was performed for a broader domain. These were the following keywords:

- artificial intelligence,
- digital twin,
- digital twin technology.

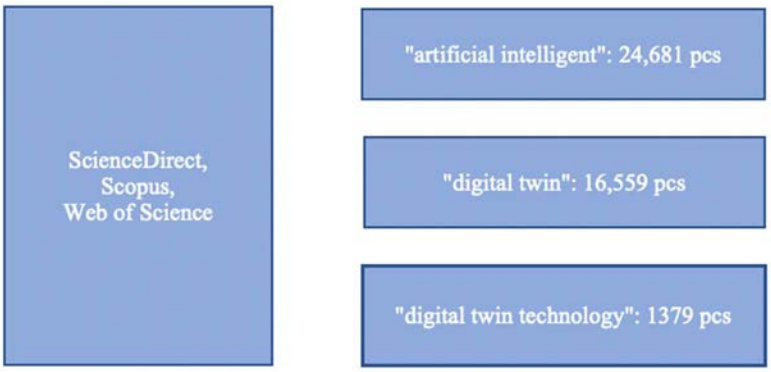

Figure 1 Previous literature reviews (own editing)

Specific keywords within these areas were then identified and also searched on Scopus, Web of Science and ScienceDirect. The research was also made in 3 databases Scopus, Web of Science and ScienceDirect. The used keywords were the same in all three databases.

Keywords:

- Packaging management AND logistics;
- Digital technology AND packaging system;
- Digital technology AND packaging planning AND logistics.

The timeline of publications is illustrated in Figure 2, which shows an increasing trend year by year in the ScienceDirect database. The search results for all keywords are summarised in Figure 2 for all fields.

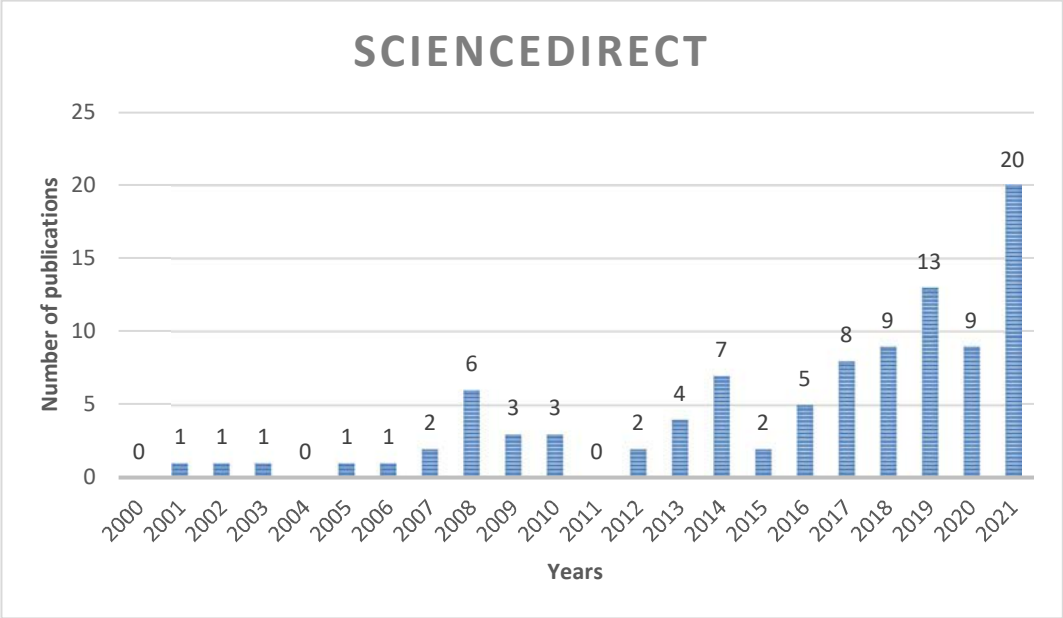

Figure 2 ScienceDirect database's publications result (own editing)

Publications in the Scopus database are illustrated in Figure 3, which also shows the summarised keyword search results for all fields.

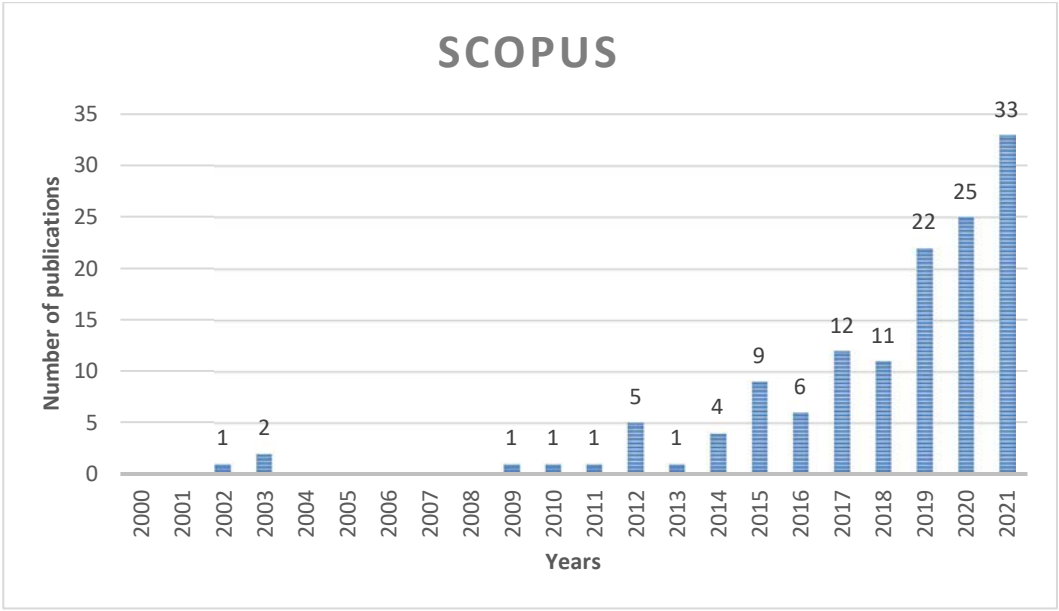

Figure 3 Scopus database's publications result (own editing)

It is clear from both figures that the number of publications on the subject has increased over the years. In the Web of Science database, the used keywords resulted only two publications, published in 2015 and 2020.

The number of publications shows an increasing trend, and after reviewing the abstracts of some publications, the articles can be grouped into 2 major categories. The first group is sustainability and the second group is digital technology and industry 4.0. It can be seen that there are significantly more publications related to sustainability in the databases. The publication [6] describes the principles of green packaging and the investments in its development. Study [7] aims to identify the main environmental sustainability initiatives of some logistics service providers and to identify future projects. The article mentions that the interviewed companies have implemented several initiatives such as energy efficiency, CO2 emission reduction. The publication [8,9] deals with the generation of packaging waste and the growth of e-commerce. This study considers several types of packaging materials, including disposable primary packaging, disposable protective packaging and returnable packaging. Sustainability and the circular economy are also addressed in [10,11]. A critical issue for circular economy industries is the development of reverse logistics for packaging and transport of semi-finished products. The journal [12] deals with the use of packaging in the automotive industry, where comparisons of different sustainable packaging systems are presented, but does not deal with digital technologies and the benefits of their application. The article [13], published in 2021, after the coronavirus pandemic, deals with soaps, hand sanitizers and their packaging. It has become essential to manage and recycle soap packaging waste to reduce its environmental impact. The study [14] also deals with the circular economy and presents a structured literature review. The strict environmental regulations related to the transport of environmentally hazardous materials offer a high cost saving potential for an optimized transport and packaging concept. This publication [15] is a case-oriented journal dealing with product-specific transportation of engine components, but digital technologies are not mentioned in the paper. The second category includes publications related to digital technologies and industry 4.0. Publication [16] deals with e-commerce logistics business models, Big Data analysis. It develops a hybrid content analysis model for in-depth analysis of the fundamental knowledge of e-commerce logistics. Publication [17] addresses the operations management problems of returnable shipping items. Publication [18] has already addressed the new opportunities of the digital age, but has not investigated packaging. This paper presents views that may be representative for the context of future bus services and the design of bus services. Research in [19] deals with artificial intelligence and the development of information technology. It proposes an approach to design business models for supply chain applications of artificial intelligence. Journal [20] deals with the application of the digital twin concept for proactive diagnosis of technology packaging systems. An important issue in the manufacturing of process equipment, especially packaging equipment, is the modernization of manufacturing automation systems. It deals with the elimination of failures in packaging equipment, applying Big Data analysis methods, artificial intelligence principles and digital technologies to solve these problems. The article Packaging 4.0 2022 examines the applicability of Industry 4.0 in packaging science, including the lack of research in this area. It discusses the potential benefits of Industry 4.0 packaging in different sectors, including logistics [21]. The paper [22] provides a solution to the shortcomings of material handling systems in cloud-based manufacturing, presenting a new material handling paradigm. The identification and analysis of recyclable packaging in the automotive industry is addressed in [23]. Currently, if a product meets the requirements, it is labelled and then placed on steel pallets. Products are also secured with adapters to prevent movement within the pallet.

Based on the literature analysis, it can be concluded that no packaging management system has been developed so far, which ensures the optimal choice of packaging materials for the products under investigation by applying mathematical methods and Industry 4.0 technologies. In the rest of the paper, the operational concept of this system is presented.

2 Operational concept of the packaging management system

The presented packaging management system is basically concerned with the optimal choice of collection and transport packaging systems, that is does not cover the choice of consumer packaging. The operational concept of the packaging management system is presented, including the structure of the system, the tasks to be performed, the cases to be examined and the operational process.

2.1 Structure of the packaging management system

Figure 4 shows the initial conceptual design of the packaging management framework. To build the system, it is necessary to clearly define the actors, the main tools, the databases and the relationships between them. As shown in Figure 4, the framework can be divided into three parts: the study participants, the main tools used in its operation and the databases to be used.

Study participants: In order to define and continuously improve the development of the system and to ensure the quality of the inspections, the following participants need to be involved:

- ***Management:*** Management defines the development guidelines. They takes strategic and tactical decisions,

negotiates with new companies on the basis of expert advice and concludes contracts.

- ***Experts:*** The experts are completelty knows the packaging management system and doing the necessary tests. They have a complete knowledge of three main areas: selecting the right packaging for a new product (collective and/or transport packaging), selecting the right packaging for an existing product, and testing packaging because of quality reasons. They will also be responsible for data collection, data processing and evaluation tasks according to the type of test selected. The use of software and simulation programs supporting the packaging management system is also part of the scope of the duties.
- ***R & D team***: The research and development team develops the methods and procedures approved by management and required for testing
- ***Information providers*****:** The information providers are those who provide the additional information needed to carry out the investigation. In particular, they provide data and parameters of possible packaging systems for a product, according to the needs of the experts.

Used major tools during process: In many cases, the tasks to be carried out by the packaging management system require environmental data and digital inspection facilities, the tools for which are:

- ***Simulation software:*** Solving manufacturing logistics problems in each area requires the use of computer simulation tools, mathematical statistics, modelling, and algorithms. The aim of logistics solutions is to properly influence and manage material flows. The application of mathematical modelling is almost impossible, as it requires the combined planning of material, information, and financial flows. Therefore, computer simulation is a perfect tool to solve these problems [24]. A discrete event driven simulation framework is used to examine the events associated with the proposed packaging system. This allows the virtual model of the plant to be coupled with the real plant control for the actual simulation [25]. Thus, the entire operation can be tested and optimized. With the discrete event driven simulation system, it is possible to improve and simulate logistic processes, optimize material handling, machine utilization and labor demand with statistical analysis capability. By using tools with object-oriented and 3D modeling capabilities, manufacturing accuracy, efficiency, throughput, and system performance can be increased [26]. Simulation processing starts with a preliminary analysis to identify problems, and then simulation plans, checks and validations are created to generate them. After collecting and examining the packaging data, the software processes it to identify the problem and generate simulation plans [27]. The simulation solution has several advantages over the real system, as it is cheaper, faster and allows to test many more possible cases, as well as to analyse designed systems that do not yet exist [28].
- ***Sensors, cameras****:* Other major tools include sensors and cameras. In some cases, it is necessary to collect and manage the data of the real system, and on the basis of these data we can propose a better, more efficient system, as well as to detect and manage quality defects during the inspection of packaging.

Required databases for system operation:

- ***Packaging system database:*** Database of packaging schemes that can be used in the optimization
- ***Logistics system database:*** A database containing the logistical data of the process under study, which are determined based on the data provided by the study company and/or a simulation study.
- ***Database for decision and optimization algorithm:*** Database of decision/optimization methods (conditions, objective functions) for selecting the right packaging.

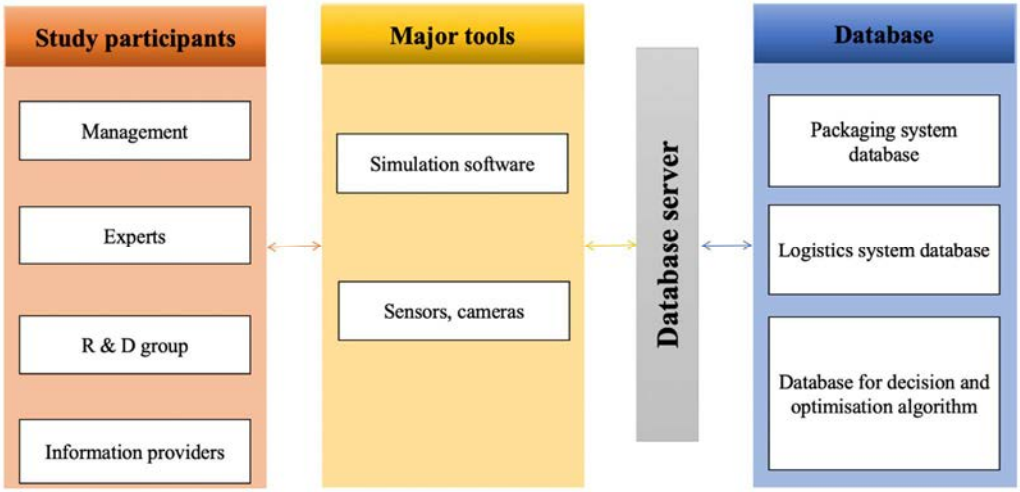

Figure 4. Packaging management system concept (own editing)

2.2 *Tasks to be performed by the packaging management system*

In this paper, the conceptual design of a packaging management system is presented, which, in terms of its function, helps to select and improve the appropriate packaging system and to ensure the quality of the packaging system used in relation to the designated logistics process. The developed packaging management system performs 3 main tasks, which are presented in Figure 5.

These are the followings:

- ***Selection of the appropriate packaging for the new product: model „A”***, which requires the use of a digital model.
- ***Improvement of the appropriate packaging for the existing product: model „B”***, which requires the use of a digital shadow.
- ***Testing the packaging to eliminate quality defects: model „C”***, which requires the use of digital twins.

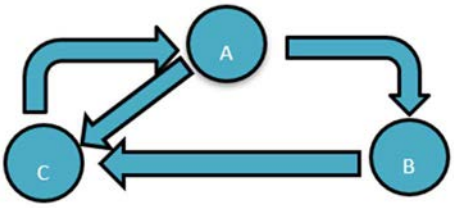

Figure 5 Packaging management system operational process (own editing)

In practice, these tasks are becoming frequent as a result of the drive to meet specific customer needs and increasingly effective product innovation, and all three types of tasks can occur within a short timeframe for a single product.

2.3 *Define the examine cases*

The designated logistics process can be extensive from supplier to customer. Once the system has been defined, the cases and their complex cases from supplier to buyer can be formed. We distinguish 6 elementary types and the complex cases that can be formed from them.

In order to understand the system to be analysed and defined, the 6 types are first presented. The packaging system for these types may change (full circle) or remain the same (empty circle).

The types defined for the purpose of the study are:

Type 1 (Figure 6): The type of packaging does not change during the test process. For example, if it is removed from the same packaging during production and then returned to the same packaging after processing.

Figure 6 Type 1 (own editing)

Type 2 (Figure 7): Unit load device changes in a process without branching. In this case, machining takes place after delivery to the production area, so the packaging system will change, as shown by the full circle.

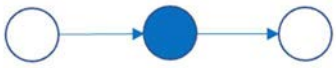

Figure 7 Type 2 (own editing)

Type 3 (Figure 8): The unit load device will not change when several processes come together. For example, picking or assembly.

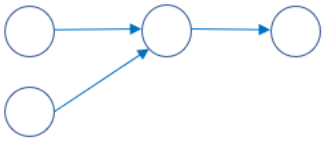

Figure 8 Type 3 (own editing)

Type 4 (Figure 9): The unit load device will change when several processes meet, e.g. picking or assembly.

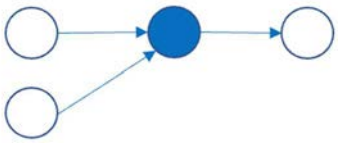

Figure 9 Type 4 (own editing)

Type 5 (Figure 10): The unit load device will not change for multiple forks of a process. In this type, product arrives at the production area from one supplier.

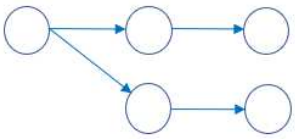

Figure 10 Type 5 (own editing)

Type 6 (Figure 11). The unit load device will change when several processes meet. In this type, product arrives at the production area from one supplier. For this type, a disassembly process takes place, where the packaging system will also change.

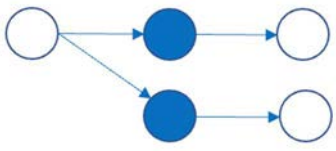

Figure 11 Type 6 (own editing)

These types can be combined to form chains.

2.4 Operational process of a packaging management system when choosing a packaging system for a new product type

Due to the complexity of the operational concept, only the operational process for model „A" of the three task types is presented in this publication.

Steps in the process under examination (Figure 12):

1. **Delimitation of the examined system:** The selection of the logistic subsystem to be developed should be done in this step [29].

2. **Define the purpose of the study:** This initial step in the process involves defining exactly what we want to achieve as a result of the study, including the decision criteria for the choice of packaging, their weight and the requirements for the packaging systems. The main decision criteria identified in the literature are as follows [29]:

- Transit time*:* The average time elapsed between two points in the delimited system. The duration of logistical operations can vary considerably depending on the type of packaging system and can be shortened by choosing the right packaging system. Shorter lead times, faster response to customer needs and lower losses increase the competitiveness of the company [30]
- Total operating cost: The choice of packaging system is a major determinant of the design of material flow systems and their operating costs, as well as the cost of purchasing and maintaining the packaging system. It is in the company's clear interest to choose a packaging system that minimizes the overall operating costs.
- Quality of the packaging system: the quality of the packaging system can be an important criterion for the choice of the packaging system. Only packaging systems that meet the essential requirements should be included in the test. This factor is a component defined by the company, with a value ranging from 1 to 10 (1 being the worst to 10 being the best). Examples of factors considered in relation to this factor are the availability of the packaging system, its recyclability, its modernity, its integration into the current system [31].
- Usability within the process under test: this indicator is used to measure the expected number of times the packaging system under test can be reused in the designated logistics process. The packaging system can be divided into two main parts. One is plastic and the other is wood based. Plastic devices have a lifetime of about 100 cycles in the supply chain, while wood devices have a maximum of 15-20 cycles [32].
- Environmental impact of the logistics process: environmental protection is becoming increasingly important today. Sustainability, particularly about regulatory and public concerns about single-use packaging waste, is driving a major change in consumer packaging. Regulators are moving forward, and companies and retailers are proactively committing to improve the sustainability of their packaging and fundamentally rethinking their packaging systems. For packaging processors with the right focus and innovation capabilities, the new environment could offer significant growth and new partnership opportunities in packaging review [33]. The environmental impact of the logistics process is determined subjectively by the experts conducting the study, on a scale of 1 to 10, where 1 is the worst and 10 is the best rating.

Weighting method: there are several methods in the literature for determining the weighting of decision criteria according to the interests of the company. The weighting process can be either a serial scale or an interval scale. When solving multicriteria decision tasks, one of the essential elements is to determine as precisely as possible the order of importance of the evaluation criteria, or in other words, the weighting of the order of importance. In addition to the best decision alternative, a ranking of possible choices can also be developed, and it is therefore important to perform weighting steps. The interval scale also provides information on the degree of preference. In this respect, the Guilford method is recommended as it is the most widely used and accepted in terms of reliability, accuracy and applicability. The method requires the use of an analytical team with a minimum number of staff. In the design of the present system, this procedure is carried out by the expert group, with a minimum of 5 persons being suggested. The procedure requires a comparison work in pairs of factors to be compared, weights are already automatically added [34]. The Guilford weighting pairwise comparison method is used to determine the order of the evaluation factors, transforming them to an interval scale. From a set of evaluation factors, any 2 can be selected to determine which is more preferred over the other, i.e., which characteristic or attribute is more important than the other. Each decision maker in each pair assigns a score of 0 or 1 to express which evaluation factor is preferred [35].

Setting requirements for the packaging system: criteria can be set for specific aspects of the possible packaging systems for the product types under consideration, which will influence the outcome of the selection process (e.g. the operating cost of the system under consideration must not exceed a certain value).

3. **Define the objects relevant for the choice of packaging system(s):** the operations and objects relevant for the choice of packaging system(s) shall be identified for the logistics system defined. For example, the formation, dismantling, quality control of the packaging system(s), i.e. the points where the formation and/or dismantling of the packaging system(s) can take place. Based on these objects and the material flow relationships between them, a material

flow graph can be constructed from combinations of the cases from Figure 6 to Figure 11.

4. **Material flow graph:** Based on the relevant objects and the material flow relationships between them, a material flow graph can be constructed using the cases from Figure 6 to Figure 11 to illustrate the optimization task.

5. **Uploading packaging scheme database with datas:** The packaging scheme database contains several data tables, which are:
- Ranks of packaging systems under study: a data table containing the main information of the packaging systems, with data on size, load capacity, capacity, purchase cost, maintenance cost, quality, usability, book load data for the packaging systems. It is the responsibility of the information providers to fill in the data table.
- Conformity data for packaging systems tested: This data table shows which packaging systems can be used for which material flow object according to the requirements defined by the company. The experts are responsible for completing the data table.

6. **Uploading the logistics system database with datas:** the database containing the main data of the logistics system under study contains the following data tables:
- Time factors for the packaging systems tested: this data table shows the unit load formation and/or dismantling and/or handling times of the packaging systems tested for the material flow objects. The data in this table are filled in by the experts.
- Material handling equipment data: a data table containing data on speed, size, operating cost, maintenance cost, capacity of the material handling equipment in the process under investigation. The experts are responsible for completing the table.
- Technological operations data: a data table containing the time factors and capacity data of the technological operations in the material flow system under study, to be completed by the experts.

7. **Making possible test variants:** in this step, the variants of the packaging systems that can be assigned to the objects defined in step 3 are trained, so that all possible packaging system chains to be tested by the simulation test model are obtained. A packaging scheme chain shows which packaging scheme is applied to which object with respect to the defined scheme.

8. **Determining the test conditions, the objective function:** the test criteria defined in step 2 are converted into normalised objective function components and weighted using the Guilford weighting method. By determining the weighted sum of the normalised objective function components, an objective function can be formed for which the highest value packaging system chain variant gives the optimal value. If necessary, it is possible to select conditions for the attributes (e.g. lead time, operating cost, etc.). In case an attribute of a packaging chain does not satisfy the condition(s), it cannot be selected.

9. **Designing a simulation test model:** the basic principle of simulation is based on a simplified representation of a real system [36]. To build a real simulation model, it is necessary to know the simulation technique and other areas of the company, such as the logistics of production and service processes [28]. Simulation tests have been designed by building a custom application or by using predefined simulation frameworks (e.g. Plant Simulation, Arena, Simul8, etc.). Development time can be significantly reduced by using these frameworks, as predefined objects can be used and parameterized, while at the same time the specific behaviour of the model can be managed by methods if necessary. The design of the simulation model should be done taking into account the defined system and the test objectives. The material flow model and the information flow model shall be developed and the method of operation shall be defined in order to produce the objective function defined in the previous section.

10. **Simulation model implementation:** the simulation test model designed in step 9 is integrated into the simulation framework in this step.

11. **Upload simulation test model data:** in order to run the simulation model, the simulation model data tables must be populated with the data defined in the previous steps.

12. **Testing and validation of the simulation model:** after the simulation model has been created, the model is tested to eliminate possible data errors, program errors and conceptual errors. For an existing system, the validation of the simulation model is done by comparing the model with reality, while for a future system, it is done by checking the data and processes.

13. **Running the simulation model, evaluating the results:** running the tested and validated simulation model results in the value of the objective function for each packaging system chain variant, so that the most favourable variant can be selected. The number of variants tested depends to a large extent on the number of packaging system variants that can be tested for the objects, as well as on the number of objects.

14. **Checking the appropriateness of the results:** in this phase, the validity of the results obtained is checked,

and if it is feasible for the company, the test is completed and the company moves on to implementation, otherwise further tests are carried out by modifying the test model.

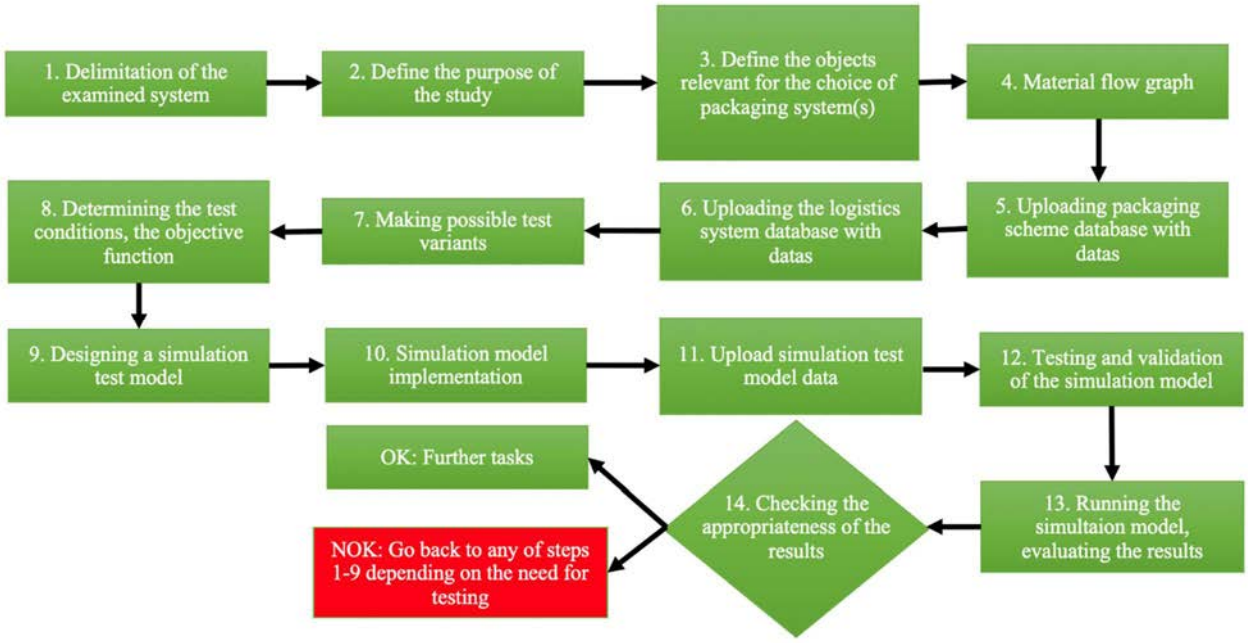

Figure 12 Steps in the process under examintaion (own editing)

3 Conclusion

The publication focused on the area of packaging system choice which area are continuously growing. Following a detailed literature review, a major gap in the competitiveness of companies in this area was identified. Companies are increasingly confronted with the issue of choosing the right packaging system due to the variability of customer needs, but the available methods only address a subset of these issues and overlook a number of important aspects. The paper presented the basic operational concept of an innovative packaging management system in which advanced digitalisation technologies (e.g. digital twin, digital shadow, etc.) played an important role. It is considered that by creating a packaging management system based on scientific modelling and optimisation methods, the packaging system selection process can be made more efficient than before (considering multiple variants and aspects), reducing several losses (e.g.: transport loss, loading loss, maintenance loss, etc.). The concept presented the testing options, the building blocks of the framework and their role in the testing process. The main steps in the application of the framework were described through the choice of packaging system for new products. In the following, we plan the detailed development, implementation, testing and application of the presented framework in a corporate environment.

Acknowledgement

The described article was carried out as part of the NTP-SZKOLL-22-0023 National Talent Program of the Ministry of Human Capacities.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 379-386 ISSN 1339-5629

doi:10.22306/al.v9i4.328 Received: 17 July 2022; Revised: 28 Oct. 2022; Accepted: 16 Nov. 2022

THE CURRENT STATUS OF EAST SLOVAKIAN TRANSHIPMENT POINTS AND THE POSSIBILITIES OF THEIR FURTHER DEVELOPMENT

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Keywords: railway transport, transhipment point, gauge.
Abstract: The article discusses the possibilities of East Slovakian transhipment facilities, which, despite their relatively strategic location and the possibilities they provide, are far from being used as much as their capacities allow. Growing requirements for green transport and reducing the carbon footprint create space for increasing rail transport as the most ecological option; on the other hand, the long-standing problems experienced by East Slovakian transhipment points put them in a competitive disadvantageous position compared to other countries. The opening of the Silk Road provides opportunities that East Slovakian transhipment points do not use or use very little. Therefore, the article points out the weaknesses of East Slovak transhipment centres and looks for ways to improve the current situation, it also draws attention to the possibilities of East Slovakian transhipment centres, especially Čierna nad Tisou, and makes suggestions for rationalization. The findings of the article point to the fact that Eastern Slovakian transhipment facilities have a potential that needs to be further developed, which, however, will probably not be possible without state aid.

1 Introduction

International trade is currently growing significantly, and the volumes of goods being transported are increasing. The European Union has created an appropriate legal framework for the transport sector to facilitate the free movement of people and goods within the Union [1]. Any country has a strategic document establishing a model of actions with the view to achieve a global developmental goal. To be competitive, a country must have a viable economy [2]. But the volume of goods between Europe and Asia is an important element of international trade within the EU, as one of the most important Asian partners is the People's Democratic Republic of China. The main mode of transport is sea container transport. However, in recent years, part of the flow of goods has been diverted from maritime to rail. Several measures have been taken to support rail transport in this area, such as the creation of a joint CIM / SMGS consignment note. The higher application of common consignment note CIM/SMGS in rail transit cross Slovak republic is good way how to make railway transport more efficient [3].

Improving and supporting rail transport within the Europe - Asia freight flows brings an opportunity for the development of the largest Slovak transhipment point in Čierna nad Tisou. The makespan of operations at container terminals is crucial for the lead time of cargo and consequently the reduction of transportation costs. Therefore, an efficient transhipment and short storage of containers are demanded [4]. The transhipment point thus becomes one of the most important points of the two international direct transport regimes (CIM / SMGS) in rail freight transport.

Reducing costs and increasing efficiency are very important objectives for all service providers, which is made possible by a thorough survey of demand in this area. The excessive increase in transport intensity is one of the negative impacts on the economy [5]. In the end, what will decide which mode of transport will be chosen it depends on:

- cost of transport,
- ability to create networks,
- railway safety,
- environment protection [6].

Transport of goods in intermodal transport in Slovak republic (Table 1) is inreasing. During last 20 years transport is more than 10 times higher what shows huge potential for intermodal transport.

Table 1 Transport of goods in intermodal transport of Slovakia - transport of intermodal transport units (containers) by railway

Year	2000	2005	2010	2015	2020
Transport of goods total (gross tonnes)	564 228	1 256 000	2 779 126	4 791 633	5 890 000
National	15 892	28 000	163 024	482 370	439 000
Export	116 909	388 000	1 129 479	1 980 692	3 213 000
Import	92 924	445 000	1 162 635	2 068 072	2 147 000
Transit	338 503	395 000	323 988	260 499	91 000

Source: statistics data of Ministry of Transport and Construction of the Slovak republic [7]

It is obvious that this significantly increasing transport of goods also requires an increase and a focus on automation. The big problem is related to railway transit, where problem is in the transferring many information, e.g. waybill, technical condition of the wagon, etc. [8].

2 Historical development of East Slovakian transhipments

After the end of World War II, the Slovak Railways were among the most damaged European railways and their restoration lasted until April 1946. In May of the same year, the construction of the railway transhipment yard in Čierna nad Tisou began. Thanks to the large area, in which there are wide and normal gauge tracks, Čierna nad Tisou is said to be the largest land port. On April 15, 1947, the wide gauge line built in Slovakia merged with the wide gauge line on Soviet territory. As early as the week of April 22, 1947, the first train from the USSR arrived in Čierna na Tisou after a wide gauge, and transhipment to normal gauge wagons began. In addition to tracks and equipment, facilities for the maintenance of locomotives, wagons and mechanisms were built in Čierna nad Tisou. In the first stage, 4 tracks of normal gauge were built, to which 4 and 3 tracks of wide gauge for transport and 1 track for transhipment were later added. The transhipment consisted of 1 wide track and 1 normal gauge track, which were next to each other. At one end was a wooden ramp 50 meters long. At the same time, a definitive transhipment ramp was being built, which they called the "covered ramp". The scope and technical level of transport and transhipment facilities were low. In 1947, an average of 3,500 tons of goods was transhipped here. In the first years of operation of the transhipment facility, it was assumed that raw materials for the heavy and textile industries would flow from the eastern side of the border. However, the most intensive was goods with grain. The composition of transported and transhipped commodities was later influenced by the construction of Východoslovenské železiarne (East Slovak Ironworks) in Košice, as the transport of iron ore increased. The launch of the "Družba" pipeline in 1963 was also significant, as millions of tons of oil a year were stopped translating in Čierna nad Tisou. [9]

The requirements for transhipment increased and so it was necessary to build additional tracks and transhipment ramps.

Already e.g. in 1947, 700,000 tons of grain were transhipped there. Gradually, ore defrosting plants, pumping stations for oil products and other ancillary facilities were built here. The construction of the wide gauge line started from Maťovce to Haniska near Košice, it is 106 km long in the Slovak Republic. At present, there are approximately 160 km of tracks and 500 switches on an area of 10 km2 at the transhipment point in Čierna nad Tisou.

3 Characteristics of East Slovakian transhipments

The East Slovak transhipments include:
- transhipment complexes in Čierna nad Tisou,
- wagons from wide gauge (1 520 mm) to normal gauge (1 435 mm) and
- modern Combined Transport Terminal in Dobra.

East Slovak transhipment points are of strategic importance on a European scale, especially in east-west transport, as they are the gateway to Central Europe.

The Čierna nad Tisou transhipment yard provides the following services:

- transhipment, loading and unloading of goods,
- pumping of liquid substances,
- wagon strapping,
- determination of the weight of consignments,
- palletising, packaging and strapping of goods,
- detection of damage to wagon consignments,
- distribution of unloaded consignments,
- issue of a transit declaration,
- representation of the declarant on delivery of the customs declaration,
- delivery of transport documents,
- sending consignment notes and other documents to the carrier. [10]

Table 2 Types of transhipped goods in East Slovakian transhipments

Naming of good	Types of transhipped goods
Wood	soft hardwood, raw wood
Iron ore	agglomerated, non-agglomerated, iron ore pellets and concentrate
Iron, steel products	angles iron, bars, rods, rolled products
Minerals	stone, gravel, salt, sand, kaolin
Coal	black and brown coal
Coke	anthracite and pitch coke
Chemical products	methanol, ethyl alcohol, benzene, various oils

Various types of transhipment machines and equipment are used for loading, because (as show Table 2) various types of transhipped goods are transhipment and unloading in East Slovakian transhipment points. Machines and equipment can be as follows:
- lifting devices,
- hydraulic excavators,
- universal front loaders,
- technological translation equipment,
- pumping complexes,
- tippers [10].

Tippers are used in modern transhipment facilities for transhipment of bulk substrates. They have more power than other transhipment facilities, unloading the wagon is automated.

Tipper types:

- side tippers - the load is dumped through the side wall, the wagon can be rotated by 150 ° - 175 ° around the axis, which is parallel to the track axis;
- front tippers - the load is dumped over the folded front wall of the wagon, tilting the wagon by 45 ° + 65 ° around an axis that is perpendicular to the track axis;
- rotary tippers - the load is dumped through the side wall of the wagon, the wagon can be rotated by 150 ° - 175 ° around an axis that is parallel to the track axis;
- combined tippers - in the longitudinal and transverse direction they tilt the closed wagon with the emptying of the load by the wagon door [11].

3.1 Workplaces in East Slovakian transhipment facilities in Čierna nad Tisou

The transhipment section is used to perform transhipment activities and manage transhipment according to customer requirements. It is important that customer service is performed in a quality and timely manner, adhering to all technological and safety procedures. The transhipment section consists of the following circuits:

- ore;
- heavy machinery;
- light mechanization;
- overdrafts.

The above-mentioned districts provide transhipment, unloading and loading of goods such as wood, coils of steel sheets, loose lumber, rails, coke, anthracite and other goods. There is also a transfer from wide gauge to normal gauge and from normal gauge to wide. Transhipment ramps, on which bridge and gantry cranes are located, are used to fulfil and perform the required services and works. The employee is responsible for the activities of individual districts and work on transhipment ramps is organized by warehouse masters and warehouse supervisors. Transhipment ramps allow you to work in continuous operation.

Within these districts, there are individual workplaces where transhipment activities are carried out. The first district is the **Ore District**, which is divided into the following individual ramps:

- general ramp,
- high ramp I. - III.,
- sub-high ramps I. - IV.,
- Eastern South / North Ramp,
- II. ore ramp.

General ramp – use for transhipment of bulk substrates such as agglomerated iron ore, non-agglomerated iron ore, pellets and other bulk substrates. Transhipment is performed using hydraulic crawler excavators, which are equipped with a hydraulic grab. The maximum capacity of this ramp is 6,500 tons in 24 hours.

High ramp I. - III. - is intended for storage of bulk substrates for unloading pellets and iron ore. There is a rotating tipper on the high ramp III..

Sub-high ramps I. - IV. - perform iron ore loading and freight adjustment in NR (normal gauge) wagons when weighing them on a rail scale.

Eastern ramp - southern is used for transhipment of logs and stem-wood. Transhipment is performed using 2 hydraulic belts of excavators type DH 411 and Liebherr 934. The maximum capacity on this ramp is 1800 tons in 24 hours.

Eastern Ramp - north is used for transhipment of ferrous metals, iron ore and other ores. Transhipment is carried out using 2 hydraulic excavators type DH 411 and Liebherr R 932. The maximum capacity on the north east ramp is 4,300 tons in 24 hours.

II. ore ramp - used for transhipment of pellets, ferroalloys, titanium ore, coal, coke and other granular goods. Transhipment is performed using 2 pieces of hydraulic belts of type DH 28.1. Maximum capacity for II. ore ramp is 4,300 tons in 24 hours.

The second circuit is the **Heavy Mechanization Circuit**, which is divided into the following ramps:

- new meat ramp,
- I. ore ramp,
- old container ramp,
- portal ramps,
- container ramp.

New meat ramp - use for transhipment of pellets and coke. Transhipment is performed using 3 gantry cranes. The maximum capacity on the New Meat Ramp is 2,000 tons in 24 hours.

The ore ramp is used for transhipment of steel scrap, ferrous metals, ilmenite, pellets, logs and wood. Transhipment is carried out using 4 bridge cranes with a capacity of 12.5 tons. The maximum capacity on the I. Ore Ramp is 2,400 tons in 24 hours.

Old container ramp - use for transhipment of bulk substrates and loading of iron ore on heaps. Transhipment is performed using one hydraulic excavator.

Portal ramps - are used for transhipment of metallurgical products, machinery, ferrous metals, iron scrap, bar steel, pig iron, sheet steel, transformers, crates, marble, logs, etc. The portal ramps form 2 crane tracks. Transhipment is carried out using bridge cranes with a load capacity of 80,000 / 12,500 kg and 25,000 / 8,000 kg. The maximum capacity is 2,000 tons in 24 hours.

Container ramp - is used for reloading, loading and unloading of sheet steel, bar steel, big-bag bags. It is used for loading goods on road vehicles from the storage area or from the railway wagon. There is also a customs warehouse, which has a 600m2 storage area. The

maximum capacity of the Container Ramp is 900 tons in 24 hours.

Technological equipment of the **Heavy Mechanization Circuit**:
- new meat ramp - 3 gantry cranes, 2,000 tons / 24 hours,
- I. ore ramp - 4 bridge cranes, carrying capacity 12.5 t, 2,400 t / 24 hours,
- portal ramps - 6 bridge cranes, carrying capacity 25 and 80 t, 2,000 t / 24 hours,
- container ramp / portal ramps, KPS cranes, load capacity 36 t, 900 t / 24 hours.

The third circuit is the **Light Mechanization Circuit**, which is divided into the following ramps:
- loading platform Nr. I and II.,
- customs ramp,
- transporter ramps,
- loading platform Nr. III.

Loading platforms I. and II. - loading platforms is used for transhipment of aluminium, zinc, non-ferrous metals, nickel sheets, cellulose boxes, cotton, rubber, fibbers, chemicals in barrels, raw hides, rolls of paper and loose substrates such as ferroalloys and magnetite. Forklifts and front loaders are used for transhipment. The maximum capacity of the Loading platforms is 1,400 tons / 24 hours.

Customs ramp - on this ramp there are 2 customs warehouses, which are used for storage of goods. The customs warehouse consists of 2 steel halls, which are prefabricated and have dimensions of 20 m + 7.85 m. The capacity of customs ramps depends on the area in the halls. The maximum capacity of the Customs Ramp is 250 tons / 24 hours.

Transporter ramps - NT-6 is used for transhipment of bulk feed, salt and cereals in covered wagons with wide gauge to normal gauge wagons. Belt transporters and mechanical shovels are used for transhipment. The maximum capacity of the Transporter Ramp is 750 tons / 24 hours.

Loading platform Nr. III. - is used for the transhipment of bulk substrate such as salt. A mechanical shovel, winders, conveyors (screw, belt, bucket) are used for reloading. Maximum capacity of the Loading platform Nr. III. is 750 tons / 24 hours.

The fourth circuit is the **Pumping Circuit**, which is divided into the following:
- old complex 6/8,
- new complex 8/8, x
- complex 12/12 and
- EDC pumping complex.

The old complex 6/8 is used for pumping kerosene, petrol, diesel, gas oil, fuel and heating oil. HUNA 611 DF centrifugal pumps are used for pumping. The maximum capacity of this complex is 360 tons in 24 hours.

The new 8/8 complex is used for pumping technical oils, alcohol derivatives, fuels, various liquids and acetates. In the complex, the units are divided as follows: pumping points, pumping station, operating building and dispatching. The new complex consists of normal and wide gauge tracks, between which there is technology that is used in the pumping station. It allows pumping 8 wagons, and the total output is 3,600 tons in 24 hours. Management and control of the pumping system is from the dispatching building. Control and management are performed using a control system; part of this process is the weighing of rail tanks at the entrance and exit to the complex.

Complex 12/12 is used for pumping fuel, kerosene, gas oil from wide gauge wagons to normal gauge wagons and vice versa, "bottom through drain valves or top using RPP 150 gear pump."

The EDC pumping complex is used for pumping hazardous substances of crude benzene and oil into normal gauge wagons from wide gauge wagons and vice versa by means of discharge valves. The maximum capacity of this complex is 1,100 tons in 24 hours.

3.2 Three subsidiaries of ZSSK CARGO and their missions

The railway company Cargo Slovakia, a.s. was established as one of the two newly established successor companies on January 1, 2005 by the division of the former passenger and freight transport operator - Železničná spoločnosť, a.s. Its activities follow the 180-year history of railways in Slovakia. The owner, founder and 100% shareholder of the Railway Company Cargo Slovakia, a.s. is the Slovak Republic. The Ministry of Transport and Construction of the Slovak Republic acts on behalf of the government. From a business point of view, the main product of the Railway Company Cargo Slovakia, a.s. (hereinafter ZSSK CARGO) is the performance of commercial and transport activities on the railways and the focus on the implementation of transport and transportation services in freight transport. The second main product is services related to the rental of rolling stock and their repairs and maintenance. The decisive activity for the company is the transport of goods such as iron ore, coal, wood, etc. The company's product portfolio includes the following services:
- carriage of wagon consignments,
- automotive,
- intermodal transport,
- services in East Slovakian transhipment,
- support services.

3.2.1 Bulk Transhipment Slovakia, a.s. (BTS)

The company is the operator of the fully automated technology of the transhipment complex in Čierna nad Tisou. The unique technology of transhipment of bulk substrates - rotary tipper - supports, in addition to direct transhipment, also indirect transhipment with the possibility of storage under a high ramp along its entire length. The complex has a defrosting hall. The transfer of

bulk substrates from wide gauge wagons to normal gauge wagons is ensured by two fully automated workplaces:

- West transhipment complex
- East transhipment complex.

The annual transhipment performance in continuous operation is 4.8 mil. tons [12].

The complexes provide transhipment of pellets, iron ore, concentrate, coal and coke. The main technological elements of both workplaces are rotary tippers. Unloading of goods with a rotary dump truck significantly reduces damage to the SR of wagons and speeds up the transhipment process (as show Fig.1). During loading, the normal gauge wagon is placed on a static rail scale ensuring official weighing of the wagon tare, the net weight of the substrate and the final gross weight of the wagon. In cooperation with the mobile conveyor, it also ensures an even distribution of the goods in the wagon. The direct transhipment system is an automated process controlled from the operations centre - control room, by two operators.

The complex is equipped with water curtain technology and air conditioning for the greening of the operation. Another advantage of transhipment is the possibility of technological wetting of substrates to temporarily limit the freezing of the substrate in the winter, whereby the end customer significantly shortens the thawing in its defrosting halls and the stay of wagons at unloading. The West transhipment complex also has a customs warehouse on an area of 5,418 m^2. It allows the storage of bulk substrates under customs supervision in quantities of up to 50,000 tons.

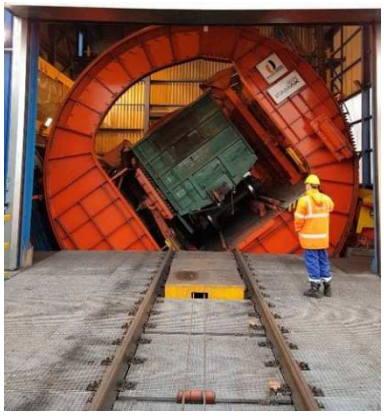

Figure 1 Rotary tipper [11]

The transhipment yard is used for bulk substrates with the main focus on ore, intended for steel production. Even today, some types of goods are unloaded using excavators, but the transhipment facility handles it much faster. Thanks to the tippers, this process takes about 5 minutes, which means that one wide-gauge wagon is transferred to normal-gauge wagons in 5 minutes. In 2.5 to 3 hours, a complete set of normal gauge is loaded or unloaded.

The whole transhipment process begins with the arrival of the wide-gauge set up the ramp to the dump truck building. In it, the loaded wagon is disconnected from the towing equipment set and moved to the rotary tipper.

The wagon is fixed and rotated 175 degrees, so it is turned up by the wheels. It takes 120 seconds and 69-70 tons of goods are unloaded into stock bins.

Handling of piece goods is carried out at the workplace: East ramp - Portal.

The gantry double-girder crane creates conditions for direct transhipment from wide gauge wagons to normal gauge wagons and vice versa, as well as indirect transhipment with restocking, or transhipment from / to road motor vehicles. The telescopic traverse with four electromagnets enables the transfer of ingots up to 35 tons, coils and also sheet metal sheeting. If necessary, it is possible to use one of the four types of grabs for reloading wood or bulk substrates.

The gantry crane offers an expansion of the company's commodity offer of transhipment services with the possibility of reloading goods in a customs regime. The crane handles the goods on a 600m long track. The load capacity on the main lift is 50t and the auxiliary lift has a load capacity of 12.5t. From the south side, it has a side unloading of 8 m, which allows unloading of goods on a new paved panel area with an area of 5,000 m^2. Another usable area for reloading goods is the ramp area with an area of 7,200 m^2.

By establishing and operating a customs warehouse, the company is able to ensure the storage of goods under customs supervision without being subject to customs duties and other charges payable on the importation of goods into the territory of the European Union.

3.2.2 Cargo Wagon, a.s.

The main activity of the company is the management of the freight wagon fleet. The company provides rental of wagons to ZSSK CARGO and to the external environment.

3.2.3 ZSSK Cargo Intermodal, a.s.

Back in 2015, there was an effort for a qualified investor to join the subsidiary ZSSK CARGO Intermodal, a.s., focused on the implementation of intermodal transport. Although four companies took part in the tender, only one complete tender and three notices of decision not to submit a tender were finally received by the deadline. However, the only offer submitted by the investor EP Cargo did not meet the expectations of ZSSK CARGO. Three companies - the Russian company TransContainer, the Chinese company Bondex Logistics and the Slovak company Railtrans International - took part in the competition, but did not submit a bid. Therefore, in the end, the selection of a qualified investor was not made and the company's management was advised to consider further options for the development of intermodal transport and system solutions through support activities within the parent company.

4 Possibilities of East Slovakian transhipment points

As of March 1, 2022, the selected transhipment activity and part of the transport service were separated from the East Slovak transhipment sections. They will be provided through a subsidiary of BTS. The trial operation of the new model of transhipment organization was introduced in Čierna nad Tisou on 1 December 2021. This means that on the first of December, there were changes in the East Slovakian transhipment section concerning transhipment activities not only in work organization, but also in the personnel area [13].

The changes, which had been prepared for a long time, were mainly due to a reduction in transported volumes and more efficient transhipment. The historically high volumes, which in Čierna nad Tisou decades ago reached the limit of 12 million tons, are now halved. In recent years, shipments have been at the level of 6-7 million tons per year. The transhipment facility in Čierna nad Tisou provides transhipment services for several types of commodities, but the highest share, almost 90 percent of the total volume belongs to iron ore and the remaining percent is divided between coal, metals, building materials, chemistry, wood and intermodal transport in 2021 belonged only 0.32 percent. Since the start of operation of both rotary dumpers, approximately 70% of the goods have been transferred using modern technology, and only a small part has been handled at ZSSK CARGO, which meant high fixed costs.

In the area of transhipment of bulk materials, the main goal is to maximize the use of modern automated transhipment complexes, which can carry out this activity with lower operating costs compared to transhipment by excavators. Transhipment on automated dump trucks is at a high quality level and without damaging the wagons. New technologies thus replace the work of excavators and excavators as much as possible.

4.1 Proposals for the rationalization of the Čierna nad Tisou transhipment point

The use of individual ramps varies, but none is used to 100% of its capacity. For a long time, the most used are the Municipal ramp, where mainly iron ore and ferrous metals are transferred, then II. Ore ramp where ferrous metals and iron ore are also handled. The used ramps also include the Eastern ramp, the I. Ore ramp and the Meat ramp. Of course, the most used ones also include Rotary tipper and Pumping complexes. It is important to realize that 100% use of the Rotary tipper is not possible, as downtime may occur during the transhipment of goods due to the technical capabilities of the tipper as well as the arrival of wagons by the transhipment operator.

The use of rail transport can also be increased by introducing a combined transport system. The development of combined transport has created space for the construction of intermodal transport terminals in the Slovak Republic, while currently there are 9 of them. TKD Dobrá is located in close proximity to the Čierna nad Tisou transhipment station, so when it started its operation, an agreement was made that there would be no transhipment facilities in the Čierna nad Tisou stacked intermodal transport units. This means that the Container ramp, which was designed for the transhipment of intermodal transport units in Čierná nad Tisou, remained unused. At the same time, this ramp it has one gantry-bridge crane of high capacity. Therefore, the transhipment capacity of this ramp is used for transhipment of metals. It is not only impractical, but also dangerous to handle long sections of metal semi-finished products with one crane. When loading longer and heavier steel ingots, the technology of synchronous transhipment with two gantry cranes on gantry ramps is used, which cannot be done with one crane. Therefore, only shorter steel ingots can be transhipped at the Container ramp, which significantly disadvantages the competitiveness of this transhipment area.

4.2 Advantages and disadvantages of East Slovakian transhipment points

East Slovakian transhipment points have several advantages:

- experienced and professional workers,
- the transhipment point is the gateway to Central Europe,
- transhipment of goods is in one place,
- the largest transhipment center that offers a wide range of services between the Slovak Republic and the Republic of Poland,
- a popular and recognized transport company on the railway transport market.

Among disadvantages are:

- military-political situation in Ukraine,
- high rate of wear and tear of the machine park,
- insufficient and uneven use of transhipment capacity,
- unbuilt border crossings,
- indebtedness of the company.

These disadvantages give possibilities for the development of the transhipment point. The main areas suitable for development are:

- modernization of information technologies,
- modernization of transhipment technology,
- development of business and operational activities,
- reducing negative impacts on the environment.

5 Result and discussion

The border crossing station Čierna nad Tisou, which is located on a large area, has several workplaces. At the same time, it has a lot of mechanization equipment. It has a new pumping complex in operation, which is intended for

pumping liquid commodities and also a rotary wagon tipper, which is intended for transhipment of ore.

The East Slovak transhipment points are not only characterized by a change in gauge, but also by a change in the transport mode, thanks to which the East Slovakian transhipment points are also equipped to perform and provide transport and procurement services. Different legislation regarding transport documentation acts as a limiting factor. Increasing performance also requires fast processing of trains, which is possible thanks to a suitable information system. However, it must be fully compatible with the advanced information systems of neighbouring countries.

Another challenge facing Eastern Slovakian transhipment points is the fact that today around 12,000 trains are transported from the Far East and back via Belarus and Poland, but only a few dozen go through the Slovak terminal in Dobra. Neighbouring states support this segment mainly through subsidies per container in various modes of division.

6 Conclusions

The Slovak Republic is interested in achieving growth in rail transport. This is also the goal of the transport policy of the European Commission. Within the EU, the transition of a significant part of goods flows, especially over longer distances, from road to rail. Especially in the interest of the sustainability of freight transport and ecology. However, this will not be possible without the respective measures of individual member states. Several European countries are already taking steps leading to, for example, the support of intermodal transport, the support of the system of individual wagon shipments, and others.

The largest railway transhipment station in the Slovak Republic is located at the Slovak-Ukrainian border near the town of Čierna nad Tisou. Its biggest advantage is that it extends at the meeting of two gauges, namely the wide so-called Russian and normal so-called European gauge. Its advantageous position lies in its allocation and the fact that it is located at the mouth of the Carpathians, on the Schengen border and at the same time in the center of Europe on the fifth transport corridor.

The favourable geographical location together with the possibility of possible expansion of the terminal gives the transhipment a significant competitive advantage. On the other hand, there is outdated infrastructure, which in some cases has not been modernized for decades, and there are no funds available for development. East Slovak transhipment stations are not using their capacities. They also offer only limited services to their customers and overall promotion is low.

Increasing the quality and reliability of rail transport as well as developing transport infrastructure and strengthening international cooperation is also an opportunity for East Slovak transhipment points. However, this goes hand in hand with the demand to improve the position of eastern Slovakia, especially from the point of view of insufficient and undeveloped infrastructure.

East Slovakian transhipment points face the challenge brought by the future in the form of rising input prices, increasing competition and, above all, a lack of support from the state, which does not realize that it is necessary to invest in state transport infrastructure and support logistics in the field of international transport of goods.

Acknowledgement

This publication was supported by the Operational Program Integrated Infrastructure within the project: Enhancements to support the efficient exploitation of outputs from H2020 projects solved at TUKE (code ITMS: 313011W554), co-financed by the European Regional Development Fund and VEGA 1/0268/22 granted by the Ministry of Education, Science, Research and Sport of the Slovak Republic.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 387-395 ISSN 1339-5629

THE LAST MILE DELIVERY PROBLEM: A KENYAN RETAIL PERSPECTIVE
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doi:10.22306/al.v9i4.329 *Received: 20 July 2022; Revised: 27 Oct. 2022; Accepted: 14 Nov. 2022*

THE LAST MILE DELIVERY PROBLEM: A KENYAN RETAIL PERSPECTIVE

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Keywords: delivery challenge, online retail, e-commerce.
Abstract: The article aims to determine the last mile delivery challenges faced by online retailers in Kenya. This is based on the online retailing sub-sector's contribution to the country's economy. Despite its significant contribution to the country's economy, little is known about the challenges facing online retailers during last mile delivery. In other countries such as China and South Africa, that are doing better in online retailing, extensive research has been done to determine unique challenges facing their online retailers during last mile delivery. It is important for the online retailers and relevant government agencies in Kenya to understand the last mile delivery factors that hinder the growth e-commerce. A qualitative research design using face-to-face interviews was used to collect data from seven online retail managers in Nairobi. The findings revealed there are a variety of last mile delivery challenges facing online retailers. These include the lack of a good national addressing system, traffic concerns, security concerns, high cost of delivery, postal service unreliability, and unconducive county government by-laws. The lack of a good national addressing system was found to be the most common last mile delivery challenge facing online retailers in Nairobi. It is recommended that retailers request their customers to share location details via online map applications such as Google Maps to overcome this challenge. The use of other delivery options, such as customer pick-up points of convenience can also be considered.

1 Introduction

Electronic commerce (e-commerce) has grown at an unprecedent level in recent years. The global e-commerce sales are projected to rise from $4.248 trillion in 2020 to $7.391 trillion in 2025 [1]. This is an increase of 74% within a period of five years. In 2022, 50.2% of total global e-commerce sales, which account for more than half, are expected from China. The incredible growth of e-commerce in China, making it a world leader, is attributed to the establishment of a delivery infrastructure that supports express last mile delivery service, among other factors [2]. Despite the strong government support for e-commerce infrastructure in China [3], it is acknowledged that online retailers face some delivery challenges, such as high delivery failure rates due to 'not at home problem.' This means customers are not available at home to receive their ordered goods. Moreover, frequent time window changes due to unpredictable delivery routes have complicated the timely delivery of goods to shared delivery facilities in China [3].

In Kenya, online retailing continues to contribute to the growth of the country's economy. According to the Government of Kenya [4], the retail sector is listed among the six priority sectors aimed at making the country a middle-income country by the year 2030. In addition, Kenya's e-commerce revenue is projected to reach $3 608.00 million in 2022, compared to China's projected e-commerce sales of $2 784.74 billion [1,5]. Furthermore, South Africa's e-commerce revenue is projected to reach $8.74 billion [6]. These figures indicate that even though the online retail subsector contributes significantly to Kenya's economy, the revenue is still quite low by regional and global standards. As in China, Weber and Badenhorst-Weiss [7] acknowledge that online retailers in South Africa face logistical challenges, such as incomplete orders, cold-chain distribution complexities and high cost of distribution. The last mile delivery challenges facing online retailers in these two countries, considered as regional and global e-commerce leaders, are dissimilar.

Despite the significant contribution of the online retail subsector to Kenya's economy, little is known about the last mile delivery challenges facing online retailers. A Statista report [8] on the structure of e-commerce in Kenya found little to describe on delivery characteristics. This means that the Statista report [8] did not find useful results to report on Kenya's e-commerce, including last mile delivery challenges. However, in Google Scholar there were some studies done in Kenya which addressed the service quality issues affecting online shopping [9,10]; factors affecting the adoption of e-commerce [11,12]; and the general or legal challenges facing online retailers in Kenya [13-16]. The studies listed in Google Scholar failed

to examine the last mile delivery challenges facing online retailers in Nairobi. Moreover, Kenya's e-commerce lacks a reliable, low-cost delivery service [17-19]. But there lacks clarity on which components of the delivery service to which this referred. Therefore, there is a need for this study to further investigate the problem, and more specifically to determine the last mile delivery challenges faced by online retailers in Kenya.

A search for journal articles was restricted to peer reviewed journals between 2014 and 2022 using two groups of keywords: delivery challenge/factors and online retail/e-commerce. The keywords were linked by the Boolean OR operator to create a search string for each group. The group search strings were linked by the Boolean AND operator to have combined search strings. Articles that were published in languages other than English were excluded from the search.

Online retailers have been facing numerous challenges while delivering goods to customers. Globally, recent studies suggest that last mile delivery is one of the most expensive and inefficient part of the supply chain [7,20-24]. The high cost of delivery is attributed to complicated and costly handling of returns [7,24]. Moreover, the high cost of returns is a result of making numerous product returns due to the use of cash-on-delivery where customers refuse to pay [21]. In some cases, the high number of returns is caused by dissatisfaction with what is purchased online upon delivery [25].

Apart from costly handling of returns, last mile delivery is associated with high shipping charges [20,22,23]. The high shipping costs result from delivering goods in small quantities, which makes it more expensive to transport [22]. The use of different supply points, such as distribution centres or existing stores to deliver goods to customers also has implications on the cost of last mile delivery [23]. Furthermore, Archetti and Bertazzi [26] argue that the high cost of delivery is associated with explicit requests made by customers for same-day or even next-day deliveries, which end up demanding more transportation resources. This implies that the high cost of delivery is caused by different factors.

Other online retailers suggest that delivery delay is a challenge to them during last mile delivery [3,21,27,28]. The delivery delays can be attributed to unpredictable delivery routes, which complicate delivery time to shared delivery facilities [3]. A study by Janjevic and Winkenbach [28] indicate that delivery delays are caused by traffic congestion and the poor quality of roads in urban areas. Lack of traffic discipline was also found to be a common occurrence in many cities in developing countries [29]. Furthermore, some places remain inaccessible for e-commerce companies due to the absence of good roads, affecting delivery time [25]. This shows that delivery delays can be caused by different factors.

Gopal and Miguel [22] argue that last mile delivery is known to be one of the most polluting aspects of the supply chain. This is attributed to the many delivery trips that are made which cause air and noise pollution [22]. In Germany, e-grocery retailers find it difficult to deliver because of local emissions from delivery vehicles [30]. To reduce local emissions related to distribution, Ehrler, Schoder and Seidel [30] found that some e-grocery retailers had started using electric vehicles. In Ukraine, light commercial vehicles and intermediate light commercial vehicles have also been recommended for use in reducing emissions on roads [31]. This means that there exists a variety of approaches used to reduce emissions from delivery vehicles. Therefore, retailers must balance customer satisfaction and the environmental impact of their actions since consumers are becoming more aware of global climate change.

The other complications during delivery can be attributed to the lack of a cold-chain delivery [7,23,28,30]. The authors noted that there were few providers of cold chains for perishable products, such as fresh food, especially in some urban areas and other far areas. In some urban areas, online retailers experienced complications during delivery because of security concerns and restrictive policies, such as low emission zones and restricted areas for a specific size of vehicles [28]. Security concerns in an area impact distribution service, particularly in emerging markets [28]. For example, an unattended home delivery method is rare in emerging markets due to the many security incidents that are reported, unlike in the United States of America (USA) and other mature markets, which have few incidents [28].

The lack of proper street addresses also makes it time consuming when doing delivery [21]. In India, Bhattacharya and Mishra [25] established that e-commerce operators find it difficult to deliver goods to their customers due to the unique postal addresses. They also noted that India's administrative divisions based on blocks and sub-blocks cover large geographical distances which cause complications during delivery.

In Kenya, it was noted that lack of a working national addressing system has made it difficult to deliver items to customers' homes [17,32,33]. This has made it more challenging for online retailers to deliver goods to the actual locations of customers. In addition, Kenya's e-commerce lacks a reliable, low-cost delivery service [17-19]. This can be attributed to the non-functioning postal system in Kenya [19,34]. This leaves online retailers to operate their own delivery motorbikes, which increases the cost of doing business [34]. Furthermore, Nielsen [35] reported that 70% of Kenyan online shoppers are not willing to shop online again due to extra delivery charges. In contrast, the European countries doing well in e-commerce have used their public postal corporations to improve delivery reliability and reduce the cost of delivery [19].

From the above literature review, online retailers are facing several last mile delivery challenges, including high cost of delivery; delivery delays; complex handling of returns; cold-chain delivery constraints; poor roads and

traffic concerns; unreliable postal delivery service; non-conducive urban policies; security concerns; and environmental concerns, such as pollution. This leads to the following proposition.

Proposition 1: There are multiple challenges that online retailers face in offering last mile delivery service.

2 Methodology

A qualitative research design was used to determine last mile delivery challenges faced by online retailers in Nairobi. According to Leedy, Ormrod and Johnson [36], a qualitative research design aims to collect textual data from an informative small sample, analyze data subjectively, and communicate findings using narratives. A qualitative approach was ideal to enable the collection of in-depth qualitative data from the small number of online retailers that are found in Nairobi County.

Given that there exists no official database of online retailers in Nairobi, a Google search was used and a total of 44 online retailers were found [37]. The 44 online retailers were used as the target population. Seven online retailers were sampled from the target population to allow for an in-depth data collection. This was based on the assertion that the minimum sample size for in-depth interviews is six for data saturation to occur [38,39]. The seven online retailers were purposively selected, to ensure that each of the five product categories mostly bought online in Kenya were represented in the final sample size [40]. The five product categories are: toys; furniture and appliances; food and personal care; electronics and media; and fashion.

A semi-structured interview guide was administered using the face-to-face technique to one customer relationship manager or the equivalent manager in charge of customer care for each of the sampled online retailers. The collected data was first transcribed into word processing files and crosschecked for accuracy before it was entered into ATLAS.ti software program to perform thematic analysis. Researchers have noted that thematic analysis helps them to integrate related data from different transcripts and identify key themes or patterns from the data set for further exploration [41].

Validity in qualitative research is concerned with 'credibility' and 'transferability'. 'Credibility' relates to ensuring that socially construed responses match with what respondents intended, while 'transferability' refers to the generalizability of findings [41]. 'Credibility' was ensured by recording the interviews using an audio device for reference on the exact quotes given by managers to authenticate the findings. In addition, the researcher was personally involved in asking questions and capturing the responses in a notebook. The managers were also informed that their participation in the interview was voluntary, and they can seek clarity to any question before responding. 'Transferability' was ensured by having a representative sample that considered the five product categories that are mostly bought in Kenya. 'Dependability' concerned with reliability in qualitative research [41], was achieved through cross-checking of the codes developed by the researcher. The interviewed managers were also assured of their confidentiality and anonymity to encourage them in giving unbiased information.

3 Results

The online retailers that participated in the study were assigned codes as R1, R2, R3, R4, R5, R6, and R7. This was meant to ensure anonymity and confidentiality of the collected information. The findings from the interviewed participants are presented using the following themes.

3.1 Lack of a good national addressing system

All online retailers reported that the lack of a good national addressing system made it difficult to offer last mile delivery service. This was because of either some buildings were not numbered, or some streets were not labelled which forced delivery personnel to make calls to verify the exact location of their customers. Some residential areas were congested with buildings which made it difficult to deliver goods to customers. R1 had this to say:

> *Honestly, I will say that lack of a proper addressing system is in Nairobi…and that is why you will notice riders will tend to call the customer to confirm exactly where they are…because you might be on this street but then the street has multiple buildings that they need to actually verify that where the customer is exactly*

R5 was of a similar view, describing that:

> *… tracing new customers is hectic especially in Eastlands where roads are not labelled well, and buildings congested without any numbers…our delivery crew have to call asking directions*

This implies that the lack of a good national addressing system made it difficult for online retailers in Nairobi to offer last mile delivery service.

3.2 Traffic concerns

Traffic concerns were also raised as another challenge experienced by online retailers in Nairobi while offering last mile delivery service. The causes of traffic congestion include ongoing road construction, rain and rush hours experienced in the afternoons. Traffic was found to cause delays in product delivery. R1 noted that:

> *…a good example is like currently Mombasa Road right now is under construction together with Waiyaki Way…. traffic is expected in these areas which goes hand in hand together with the level of delay that customers might face…while they want the product to be delivered within promised time…. we try and dispatch most of our goods by midmorning…since that is when the traffic has died down.*

R5 also noted that:

> *… traffic congestion in Nairobi is like hell…especially in the afternoons… and also when it rains…we use*

bodabodas to manoeuvre with traffic jam but still it is a big problem.

The findings on traffic concerns implies that online retailers in Nairobi were having late deliveries due to traffic concerns. The County Government of Nairobi, the Ministry of Interior and Coordination of National Government, and the Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works had failed to manage traffic flow in Nairobi.

3.3 Security concerns

The results also indicated security concerns as a challenge faced by online retailers in Nairobi during last mile delivery. Delivery personnel were reported to have been attacked while delivering goods in some informal areas. The attacks were linked to the cash they collected as they delivered goods to customers. It was also noted that some customers had tried to defraud delivery personnel by presenting fake messages as evidence of payment. R4 stated that:

…security concerns especially on our delivery team, as they make deliveries, they are collecting cash as well…there is always that risk of being attacked by people just to take away the cash…there has been experiences especially in informal areas like Mathare and Kibera…we have lost some cash in those areas.

R2 also noted that:

Nairobi, the biggest issue is conmen because we do payment on delivery….and we use m-pesa, airtel money, visa card…so try showing the rider or driver a payment made from m-pesa which is false or fake….so we have had several of those, but we have our own internal system of dealing with this plus insurance for goods in transit.

Based on the findings on security concerns, it implies that the option of cash on delivery in Nairobi had reported theft of cash, fraud cases involving presentation of fake payment messages, and personal attacks on delivery personnel. This shows that the Ministry of Interior and Coordination of National Government had failed to provide security service to businesses in Nairobi. Furthermore, the Ministry of Information, Communications and Telecommunication (ICT) had failed to protect online businesses in Nairobi from fraudsters.

3.4 High cost of delivery

High cost of delivery was also found to be a great challenge during last mile delivery. The high cost of delivery was because transport service providers were consuming more fuel, traffic jams, and the high vehicle maintenance costs caused by the poor state of roads in Nairobi. This forces transport service providers to charge more to stay in business. Moreover, it was reported that some delivery charges exceeded the price paid for the product. R4 noted that:

…delivery cost to the business now is quite high…the longer you stay in traffic the more fuel you consume, the longer you have to pay the delivery team…. there is also now the aspect of bad roads…the owners of the truck will now charge you much higher because now they have to incur high maintenance costs

R7 had a similar view and had this to say:

…actually there are some concerns…sometimes a client maybe wants an item that costs Ksh. 200 and when you check the delivery from your riders…the charge is like Ksh. 300…so, there is some concern

This implies the County Government of Nairobi, the Ministry of Interior and Coordination of National Government, and the Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works had contributed to the high cost of delivery due their inability to manage traffic congestion in Nairobi. Furthermore, the County Government of Nairobi and the Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works had contributed to the high cost of delivery by failing to improve the poor state of roads in Nairobi.

3.5 Unconducive County government by-laws

The unconducive county government by-laws were also reported among the last mile delivery challenges faced by online retailers in Nairobi. Online retailers reported that law enforcement officers from the County Government of Nairobi harass their delivery personnel even when they have the required parking and distribution licences. R4 noted that:

…there are a lot of issues with county by-laws especially on parking and the designated parking slots….not all customers have those designated loading zones,… so you are always at crossroads with county askaris despite paying for the licenses and parking fee, our team gets in trouble for parking at a wrong place or doing deliveries at non designated areas…I will give you an example like Parklands area, despite making payments to the county government for parking and distribution licenses, they really harass us that our trucks are not parked at the right spots or we do not have the official sticker of that bay.

R2 was of a similar view and noted that:

…of course, we have issues with city council askaris during pickups because most of our sellers are based in the CBD…so they really harass the motorbike riders even though they have licenses.

From the responses, it implies that the County Government of Nairobi had failed to protect genuine businesses in Nairobi. Delivery personnel were being harassed by law enforcement officers from the County.

3.6 Postal service unreliability

The results also revealed that postal service unreliability posed some challenges during last mile delivery. The postal service was found to be inefficient and not able to offer the same day delivery service. It was also reported that the postal service was slow when delivering goods to clients. R7 reported that: *"…they are slow…and some clients actually forgotten about postal service."* R1 was of a similar opinion and reported that:

> *…. actually, we have had some discussions around postal service…but then we found that it wasn't the right time to utilize postal service. The postal service in Kenya is also undergoing changes internally to ensure they have that efficiency within themselves as well…for example I can't utilize the postal service to deliver for me the same day…because what they have is the next day delivery.*

This implies that the Postal Corporation of Kenya (PCK) had failed to offer reliable and efficient postal service in Nairobi. Most online retailers prefer same day delivery service, which is not offered by PCK.

The results of last mile delivery challenges are summarised in Table 1. Proposition 1 is true as more than one last mile delivery challenge was identified.

Table 1 Last mile delivery challenges faced by online retailers in Kenya

Most common last mile delivery challenge	Lack of a good national addressing system
Other last mile delivery challenges	Traffic concerns; security concerns; high cost of delivery; unconducive county government by-laws; and postal service unreliability

4 Discussion

From the responses presented in the preceding section, the lack of a good national addressing system was reported as the most common last mile delivery challenge facing online retailers in Nairobi. The finding revealed that this challenge had made it difficult for online retailers to deliver goods to customers' location. The finding validates results from Communication Authority of Kenya (CAK) [17] and Alushula [32] that found the lack of a working national addressing system in Kenya made it difficult to deliver items to customer's homes. Online retailers reported that streets were not labelled, and buildings were not numbered, making it difficult to deliver goods to customers. In the United Arab Emirates, Ghandour [21] found that the lack of proper street addresses had made it time-consuming and costly for e-commerce firms when offering delivery service. As an alternative, Halldórsson and Wehner [42] found that the use of pick-up points in Sweden enabled delivery service providers to deliver many goods at the same time.

The results also showed that online retailers in Nairobi are having difficulties during last mile delivery because of the unreliable postal service. The postal service in Nairobi was reported to be unreliable and inefficient to the extent of being unable to offer same-day delivery service. In India, a study by Bhattacharya and Mishra [25] reported similar results where online retailers found it difficult to deliver goods to their customers due to huge complications in administrative divisions based on blocks and sub blocks that cover large geographical distance. However, in some countries postal service unreliability is not common especially in countries doing well in e-commerce. For example, Ekekwe [20] argues that Amazon.com and eBay are great e-commerce firms in the USA because they depend on the postal system to serve their customers.

The other last mile delivery challenges facing online retailers in Nairobi include traffic concerns; security concerns; high cost of delivery; and unconducive county government by-laws. It was established that traffic congestion is a great challenge to online retailers in Nairobi when offering last mile delivery services. The findings revealed that traffic congestion led to delivery delays in Nairobi. The causes of traffic congestion in Nairobi were reported as rush hours in the afternoons, rains, and the poor state of roads. The result concurs with CAK [17] that found delivery service in Kenya's e-commerce was unreliable. This is likely to hinder the growth of e-commerce in Kenya. A study by Janjevic and Winkenbach [28] identified traffic congestion as a last mile delivery challenge in urban environments of emerging markets. They suggested that traffic congestion can be resolved by either use of alternative modes of transport or use of different vehicles

The high cost of delivery was also reported as a last mile delivery challenge facing online retailers in Nairobi. The high cost of delivery was partially due to the poor state of roads that increased vehicle maintenance costs. Traffic congestion in Nairobi also led to a high cost of delivery because vehicles consume more fuel. This finding validates CAK [17] that found there was lack of a low-cost delivery service in Kenya's e-commerce subsector. Furthermore, Nielsen [35] reported that 70% of Kenyan online shoppers are not willing to shop online again due to extra charges. If not addressed, this challenge is likely hinder the growth of e-commerce in Kenya. In South Africa, Brink [23] found that high shipping charges are a significant challenge for online groceries in Gauteng. Globally, Ehrler, Schoder and Seidel [30] found that online grocery retailers in Germany face very high costs of delivery. Similarly, Mangano and Zenezini [27] posit that last mile delivery is probably one of the most expensive and complex global supply chain processes. This calls for use of other measures to manage the high cost of delivery. For instance, online retailers should carefully plan their deliveries by offering two slots per week to maximize drop density [30]. However, sometimes online retailers can incur extra cost to fulfil low customer orders [22].

Security concerns were also raised as a last mile delivery challenge facing online retailers in Nairobi. Delivery personnel reported attacks to their managers. The attacks were reported in some informal areas. The attacks were linked to the cash that the delivery personnel collected as they delivered goods to customers. It was also reported that some customers had tried to defraud delivery personnel by presenting fake messages as evidence of payment. This finding is supported by Janjevic and Winkenbach [28] who found the unattended home delivery method was rare in emerging markets, such as Kenya due to high security-related issues. Therefore, security concerns need to be addressed to promote the growth of e-commerce in Kenya. This is supported by a study by Janjevic and Winkenbach [28] which reported that mature online markets, such as the USA have fewer security-related issues that affect the delivery service.

Unconducive county government by-laws in Nairobi are a challenge to online retailers during last mile delivery. It was reported that delivery personnel were harassed by the County law enforcement officers. This is unacceptable and relevant government agencies need to address this to promote the growth of e-commerce in Kenya. A study by Janjevic and Winkenbach [28] identified urban freight policies as a last mile delivery challenge in urban environments of emerging markets. They were of the view that the urban freight policies are subject to restrictive policies applicable in a given e-commerce market, for instance, having low emission zones or restricting the size of vehicles allowed in a given area.

5 Conclusions

In conclusion, online retailers in Nairobi face numerous last mile delivery challenges. The main last mile delivery challenge is related to the lack of a good national addressing system. Online retailers mentioned that some buildings in Nairobi were not numbered, and some streets were not labelled, making it very difficult to trace customers' locations during delivery. It is recommended that the online retailers request their customers to share location details via online map applications such as Google Maps for delivery. The use of other delivery options, such as customer pick-up points of convenience, can be adopted by the retailers. The customer pick-up points of convenience engage the online customer in collecting goods from pick-up stations near them. The use of pick-up points in Sweden had enabled delivery service providers to deliver many goods at the same time [42]. Through the Retail Trade Association of Kenya (RETRAK), online retailers should lobby the County Government of Nairobi to ensure all streets are labelled and buildings are numbered. Evidence collected from online retailers also revealed that retailers face other last mile delivery challenges such as traffic concerns, security concerns, high cost of delivery, unconducive county government by-laws, and postal service unreliability. Traffic concerns caused by ongoing road construction in Nairobi, rain, and rush hours in the afternoons led to delays in product deliveries. It is recommended that online retailers should undertake better delivery planning, such as alternative routing and scheduling at different times to avoid delivery delays. Retailers should consider introducing incentives for off-peak deliveries to encourage customers get their deliveries when there is less traffic. Instead of using delivery trucks, retailers should consider using flexible modes of transport such as motorbikes '*bodabodas*' due to their excellent manoeuvrability when there are traffic jams during peak hours. Furthermore, through the RETRAK, online retailers should lobby the County Government of Nairobi, the Ministry of Interior and Coordination of National Government, and the Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works to properly manage vehicle traffic situation in Nairobi.

Based on the finding that security was a great concern for online retailers in Nairobi, the study concludes that delivery personnel are at risk of attacks, losing cash, and being subjected to fraud. It is recommended that online retailers adopt either the payment before delivery option or the cashless payment option to reduce fraud cases and losing cash. Retailers can also consider outsourcing security personnel to assist in the delivery of high-value goods. Through the RETRAK, online retailers should also lobby the Ministry of Interior and Coordination of National Government to provide security services during delivery. Retailers can put in place online security systems and measures to prevent cyber-attacks and fraudsters. This involves the use of escrow service, requesting customers to use strong passwords, and setting up system alerts for suspicious customer behaviours.

The study also found that online retailers in Nairobi are experiencing high costs of delivery attributed to high charges from transport service providers. The high transport charges are due to the traffic congestion and the poor state of roads in Nairobi. It is recommended that retailers should use other delivery options, such as customer pick-up points of convenience, to reduce delivery costs. Retailers can also continually optimize delivery routes by analysing historical route data to identify the most efficient routes. Through the RETRAK, online retailers should also lobby the County Government of Nairobi, the Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works to improve the state of roads in Nairobi and effectively manage traffic congestion. This will eventually lead to reduction in the operational expenses of transport service providers.

The finding on harassment from the County law enforcement officers implies that the County Government of Nairobi was not providing a conducive business environment for online retailers. It is recommended that online retailers should document and report all the law enforcement officers found to harass delivery personnel. Through the RETRAK, online retailers should also lobby the County Government of Nairobi to investigate and take

disciplinary measures against law enforcement officers harassing online retailers. Lastly, the finding that postal service unreliability is posing some challenge during last mile delivery, means that online retail managers cannot rely on postal services when doing delivery in Nairobi. It is recommended that online retailers consider using alternative courier service providers that can meet their delivery needs. Through the RETRAK, online retailers should also lobby the PCK to reengineer its delivery services to make them more efficient.

Overall, the findings offer practical implications to the managers and relevant government agencies on the last mile delivery challenges that should be addressed. The retailers can embrace the different managerial strategies recommended in the study to overcome last mile delivery challenges. Additionally, retailers can lobby via RETRAK for provision of essential services whose absence is contributing to the identified last mile delivery challenges. This should lead to the growth of the online retail subsector in Nairobi hence creating more employment opportunities and enhanced economic growth.

Owing to the limited research in last mile delivery service, these findings are a valuable addition to logistics-related research in Nairobi. However, this study was limited to online retailers in Nairobi County. Any generalisations of results to other retailers that are not purely online, to other counties, and other countries should be considered cautiously. A similar study should be conducted in other counties in Kenya to test whether the results are similar. Further research should focus on other countries in Africa which have adopted e-commerce to a great extent, such as South Africa and Nigeria, to provide an opportunity for a comparative study

Acknowledgement
The authors are very grateful to the Department of Transport and Supply Chain Management for the permission granted to undertake this study. This research did not receive funding from any agency.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 397-404 ISSN 1339-5629

doi:10.22306/al.v9i4.330 *Received: 24 July 2022; Revised: 14 Nov. 2022; Accepted: 30 Nov. 2022*

PROMOTING CORPORATE ENTREPRENEURSHIP THROUGH ELECTRONIC HUMAN RESOURCES MANAGEMENT PRACTICES: AN EMPIRICAL STUDY

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Keywords: corporate entrepreneurship, electronic human resources management practices.
Abstract: The current study aims to provide an overview of the role of electronic human resources management practices (E-HRM) in corporate entrepreneurship (CE) in telecommunication corporations in the Duhok governorate-Kurdistan region to progress their entrepreneurial capacities through implementing E-HRM systems. The study sample was made up of 5 telecom companies. The structured questionnaire designed by the researchers was used to collect primary data, totalling 32 respondents. Data analysis was performed by different statistical methods through SPSS program. The results of the study reveal that the correlation coefficient between the variables of the study is 0.775 (Total index). This shows a positive relationship between E-HRM and Corporate Entrepreneurship, supporting the validity of the first main hypothesis of the study. The results also indicate that E-HRM practices have a significant positive effect on Corporate Entrepreneurship due to the calculated F value (45.184) is higher than its tabular value (4.17). Accordingly, the second research hypothesis has been accepted.

1 Introduction

In today's business world, there has been a rising concern by organizations in depending on corporate entrepreneurship (CE) as a great source to boost the innovative capabilities of their workforces. Especially in this Century CE has progressively been determined as a legitimate way to upper levels of individual and organizational performance [1]. Corporate entrepreneurship according to [2] is the process of establishing new and innovative business inside established an organization to increase organizational profitability and improve corporation's competitive advantage. On the other hand, [3] axplains CE as a process of expansion of the corporation's area of competence and conforming opportunity set via internally created combinations of original resource [3]. Corporate entrepreneurship can be understood as the result of effective exploration for entrepreneurial opportunities generating from asymmetries of market or technological knowledge [4]. Corporate entrepreneurship according to [5] is based on Innovation of original product category, new technology, or innovative business model that leads to constant benefit for the firm. As [6] mentioned that CE states to a procedure that happens within an existing corporation, and leads novel business ventures, other original actions and alignments such as creation of innovative goods and services, technologies, strategies, and managerial systems.

Information technology totally impacts all managerial branches including human resources practices in today's global networking timeframe. Recently, using of new technology in implementing HRM practices has growing dramatically [7]. Electronic human resources management (E-HRM) is a means of executing human resources practices in corporations via a sensible and directe support and the complete usage of web-technology-based platforms [8]. The number of organizations who have been replacing human resource management practices with electronic HRM increasing continuously because of vast progress in information and communication technology (ICT) sector.

2 Literature review

2.1 Corporate entrepreneurship (CE)

In last decades, the research on CE field has been growing significantly, while, according to some researchers there are some aspects of corporate entrepreneurship still need to be researched [9]. Because of today's highly competitive business world and emergence of globalization phenomena make business environment to be more dynamic and challenging. Organizations need to be more entrepreneurial and attempt to recognize and exploit new opportunities arise and avoid riks from the

external environment so as to achieve competitive advantage. Firms that develop CE are mostly recognized as flexible and dynamic organizations ready to take benefit of different opportunities when they arise [1]. Corporate entrepreneurship essentially involves high levels of both risk and uncertainty [5]. The ideas behind CE can be traced back to the mid-1970s. The concept was introduced firstly by [10] as a leadership style and strategy implemented by large firms to handle with the growing level of market instability [11]. Corporate entrepreneurship is a set of organizations actions that focus on the finding and pursuit of business opportunities via innovation, creating new business, or creation of original business models. Successful corporate entrepreneurship involves simultaneous consideration to both innovation and exploitation [12]. Corporate entrepreneurship according to [13] is a multi-dimensional concept that contains of three man dimensions which are: innovation, strategic renewal, and new business venturing. He added more explanations to these dimensions and according to him Innovation is determined as a process contains transition of novel ideas to value added products and services, Strategic renewal is characterized as the major organizational change activities through restoration of the major impressions, and new business venturing is determined as the establishment of a new business entity or new business acquisition [14]. Close to this explanation, [15] classified CE to two main types of phenomena: the first one is the creation of new businesses within existing organization, such as inner innovation or venturing; and the second one is the transition of corporations via renewal of the basic ideas on which they are made. Corporate Entrepreneurship concept has numerous definitions due to the importance of the subject. Jennings and Lumpkin defined the CE as the scope to which innovative goods and services or original markets are established [16,17]. Corporate entrepreneurship defined by [13] and according to him it refers to practices meant at establishing new business in creating firms through product and process innovations and market developments. Corporate entrepreneurship is targeted on employees' readiness of large size firms to adopt entrepreneurial behavior and communicate with the bureaucratic corporation they are working for, in order to beat various obstacles to new products and services development. Moreover, CE involves the transformation processes, as the most complicated form, that are anticipated to accelerate organized changes of organizational culture and structure to inspire entrepreneurial behaviour of employees [7].

2.2 Electronic HRM practices

In the last few decades, the use of new technology in facilitating management functions in general and human resource management function in particular has increased significantly. There are almost all the human resources activities that new technology systems interrupted during implementation or changed the way of caring out these functions. Although the main purpose for the execution of new technology within the human resources practices was to enhance processes in implementating HR practices, other encouraging effects such as reducing cost, providing better quality of services, higher productivity also occurred [10]. Implementing HR practices electronicaly is expected to create value for both in and out-firms beneficiaries, especially at the time of rapid competition and evolutions that today's organizations are facing. Therefore, managers in human resource departemnt should use contemporary systems and create integration in HR practices to attain desired values [18]. The term electronic human resources management or E-HRM in short, has been emerged in the 1990s, with the idea of the beginning of electronic commerce concept [19]. Therefore, because of the reputation of e-commerce field, the prefix "e" was used in HRM field; consequently the E-HRM term has been emerged. Technological development has created a new generation of workforces as well as changed organizational structure in contemporary corporations. These kinds of changes are structured in a manner that organizations who do not depend on new technology in performing their daily tasks, thay may loss massive of their capital resources [20]. E-HRM is a comprehensive concept covering all potential integration mechanisms and contents between human resources management and IT so as to create value within and across firms for both employees and management [21]. Electronic human resource management is very crucial as it enables firms in performing HR functions for their staffs and managers. Manageres and workforces will be able to access easily and efficiently to information through the typical use of internet or web technology channels. This, in turn, leads to employees and managers empowerment with the purpose of growing their proficiency in accomplishing certain human resources functions. In a wider view, organizations that use web technologies in human resources functions can be more flexible, cost-effective, customer-oriented, and more strategic [22]. E-HRM concept is different than human resources information system or (HRIS) in short. HRIS concept indicates systematic processes for collecting, storing, updating and distributing data and information related to HR functions [23], where HRM department is the main user of this system [24]. On the other hand, E-HRM concept refers to the application of human resources practices with support or full dependence on web technology, and this system can be used by HRM department staffs, and other employees in the organization, potential employees, in addition to the organizational management. The main areas of application of the E-HRM systems are basic HR planning, Staffing, training and development, job analysis, performance appraisal, and rewards and compensation [25-26].

2.3 E-HRM and Corporate entrepreneurship

Corporate entrepreneurship according to [8] includes three main dimensions which are innovation, proactiveness, and risk taking. On the other hand, Zahra

(1996) proposed that CE is consisted of three dimensions which are innovation, strategic renewal and, corporate venturing. Some other authors identified more dimensions [9]. But all the classifications with different dimensions of CE, included (innovation) dimension. Innovation, as an element of corporate entrepreneurship, is an obligation of the organization to create original products or services, production methods, and organizational systems with concentration on technology development [8-13]. One of the key characteristics of CE that explain the entrepreneurial orientation of organization and continually appears in organizational and academic studies is the organization's ability to innovate [23]. The evidence of the study that has been conducted by [12] in Spain on the basis of a mixed sample of industrial organizations confirmed a relationship between some of the HRM practices (performance appraisal, internal career opportunities, and incentive based compensation) with innovation, venturing that it is the influence of the human resources management practices on employee involvement that offers opportunities for innovation. Another study by [27] illustrated that (training and development, compensations, and performance appraisal) as the focal human resource management activities have impact on different aspects of innovation. HRM practices are the essential components that contribute to empower organizations to be more innovative, proactive, and accept risk [28]. Many authors demonstrated that establishing EHRM systems can make organizational employees to be more openness to innovation and strategic learning [29]. E-HRM plays a substantial role in professional development, increased competence and capability and employees innovation abilities. Especially, after using information and communication technology (ICT) tools in HR functions. We can conclude that implementing electronic HRM systems by organization can provide innovation opportunities to organization as the main corporate entrepreneurship dimension, through preparing innovative employees especially staffs that are dealing with new technology in their jobs.

Regarding the second dimension of corporate entrepreneurship, which is risk taking behavior of employees as determined by [30]. Electronic human resources management systems enable enhancing employee's behavior in terms of risk acceptance through improving electronic communication continually among employees on one hand and between employees and managers on the other hand. Two issues determined by [4] that any examination of human resources management and corporate entrepreneurship correlation need to be addressed: the development of informal entrepreneurial behavior and employees risk acceptance. Human resources practices impact corporate entrepreneurship by establishing circumstances for the development of informal cooperative relationships. The theory of organizational learning would seem to be the suitable model for understanding how human resource practices can support corporate entrepreneurship. Organizational learning happens when employees are willing and able to create informal networks where they freely exchange information, implicit knowledge and generate shared perspectives. Especially these kinds of networks are more influential when organizations adopt e-HRM systems. Due to it can facilitate teamwork, continuance connection, and increase cooperation. Strategic renewal determined by some CE scholars as the third main dimension of corporate entrepreneurship. This area of CE is strongly linked to E-HRM. Especially, when [31] proposed three levels of electronic human resource management; operational, rational, and transformational E-HRM. Transformational level concerns human resource practices with a strategic aspects such as knowledge management, strategic competence management, and strategic reorientation. Through this it is possible to create a change-ready staff via tecnilogical systems that empowers the employees to develop in line with the organization's strategic choices [32].

3 Methodology

This study examines the role of (E-HRM) practices in corporate entrepreneurship (CE) in telecommunication corporations in Duhok governorate-Kurdistan region. E-HRM practices (recruitment, selection, training & development, rewards & compensations, performance appraisal) were considered as independent variables and corporate entrepreneurship was considered as dependent variable. A structured questionnaire was designed to collect the primary data. The population of this research includes in telecommunication corporations operating in Duhok governorate. The sampling method of this study is based on the probability sampling which are clustered to three groups, department managers, unit directors, and employees. The primary data that have been collected for ths study are analysis using SPSS program.

3.1 Research hypotheses

H1: There is a significant correlation between E-HRM practices (recruitment, selection, training & development, rewards & compensations, performance appraisal) and corporate entrepreneurship in Telecommunication industry in Duhok governorate (Figure 1).

H2: E-HRM pracices has a significant impact on Corporate Entrepreneurship in Telecommunication industry in Duhok governorate.

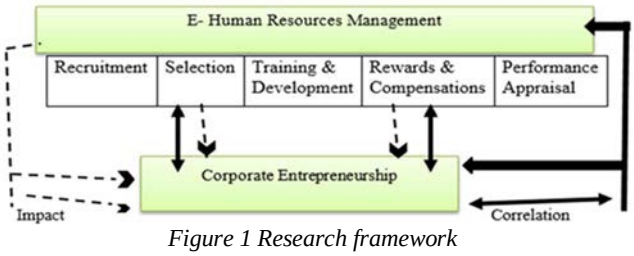

Figure 1 Research framework

3.2 Reliability analysis

Researchers used the Cronbach Alpha coefficient to ensure the research instrument's reliability (Table 1), the Cronbach Alpha should be equal to or greater than (0.06), but it is better to be closer to (1.0). The Alpha value for overall E-HRM functions was (0.872) in the current study, and for corporate entrepreneurship was (0.815). The Alpha value for training and development, as well as selection, was higher than (0.8), whereas the value for rewards and compensations was (0.731). While for both performance appraisal and recruitment is only (0.65). As a result, the Cronbach's Alpha value for all aspects was greater than the standard value, making this questionnaire reliable and appropriate for the study.

Table 1 Reliability analysis

Factors	No. of Items	Cronbach's Alpha
Overall E-HRM Functions	15	0.872
Recruitment	3	0.647
Selection	3	0.804
Training and development	3	0.810
Rewards and compensations	3	0.731
Performance Appraisal	3	0.656
Corporate Entrepreneurship	10	0.815

4 Results and discussion

As illustrated in table 2 more than two-thirds of the respondents were male; from the 32 respondents, 22 were male, and 10 were female. The results also found out that 46.9 %, of the respondents were between (30-40) years. Followed by those aged less than 30, which has reached 40.6%, and only four were over 41 years which represent only 12.5%. The results illustrated that nearly three-quarters were employees, 15.6% were head of departments, and the remained 12.5% were unit managers. Majority of the respondents have a bachelor's degree wich accounted for 68.8%, followed by diploma 21.9%. While master's and others degree were only 9.4%. This indicates that the telecommunications companies rely more on employees who have bachelor's degree in performing their jobs. The findings of the study showed that respondents who have more than five years of experience reached 40.6%. 25% and 21.9% for those have (3-5 and 1-3) years of experience respectively. And respondents have less than one year of work experience are only 12.5 %. According to the results, 100 % of the respondent companies have HR department.

Table 2 Descriptive Analysis for research sample

Descriptive		Freq.	%
Gender	Male	22	68.8
	Female	10	31.2
Age (Years)	less than 30	13	40.6
	30-40	15	46.9
	Above 41	4	12.5
Job Title	Employee	23	71.9
	Unit Manager	4	12.5
	Head of Dept.	5	15.6
Education Level	Diploma	7	21.9
	BSc	22	68.8
	MSc	2	6.3
	Others	1	3.1
Work experiance	Less than 1 year	4	12.5
	1-3 years	7	21.9
	3-5 years	8	25
	5 years and more	13	40.6
Have HR Dept.	Yes	32	100
	No	0	0

4.1 Descriptive analysis of study variables

The findings presented in table 3 indicate that most of the respondents agreed on recruitment function through its indicators (X1-X3), where the level of agreement reached (87.5%), followed by neutral (10.44%) and only (2.06%) were disagree, with an arithmetic mean (4.06) and a standard deviation (0.618). Regarding to the selection function, around 60% agreed through its indicators (X4-X6). Furthermore, over 80% agreed with training and development function, while only 8% disagreed. In terms of rewards and compensations function, the level of agreement is the lowest, which is only 46%. Finally, over 88% of the respondents agreed on performance appraisal function through its indicators (X13-X15).

Table 3 Descriptive analysis of the independent variable (E- HRM)

Variables		Evaluation Levels										Mean	Standard deviation
		Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree			
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%		
Recruitment	X1	8	25	22	68.8	2	6.3	0	0	0	0	4.19	0.535
	X2	4	12.5	21	65.6	6	18.8	1	3.1	0	0	3.88	0.660
	X3	8	25	21	65.6	2	6.3	1	3.1	0	0	4.13	0.660
Average		87.5%				10.44%		2.06%				4.06	0.618
Selection	X4	3	9.4	18	56.3	6	18.8	5	15.6	0	0	3.59	0.875

	X5	3	9.4	17	53.1	7	21.9	4	12.5	1	3.1	3.53	0.950
	X6	2	6.3	14	43.8	10	31.3	5	15.6	1	3.1	3.34	0.937
Average		59.4%				24%		16.6%				3.48	0.920
Training and development	X7	7	21.9	16	50	5	15.6	4	12.5	0	0	3.81	0.931
	X8	12	37.5	18	56.3	1	3.1	1	3.1	0	0	4.22	0.870
	X9	5	15.6	19	59.4	5	15.6	2	6.3	1	3.1	3.78	0.906
Average		80.23%				11.44%		8.33%				3.93	0.902
Rewards and compensations	X10	2	6.3	10	31.3	15	46.9	4	12.5	1	3.1	3.23	0.880
	X11	3	9.4	19	59.4	6	18.8	3	9.4	1	3.1	3.63	0.907
	X12	3	9.4	7	21.9	17	53.1	5	15.6	0	0	3.25	0.842
Average		45.9%				39.6%		14.5%				3.37	0.876
Performance Appraisal	X13	6	18.8	20	62.5	4	12.5	2	6.3	0	0	3.94	0.759
	X14	16	50	14	43.8	1	3.1	1	3.1	0	0	4.41	0.712
	X15	12	37.5	17	53.1	2	6.3	1	3.1	0	0	4.22	0.832
Average		88.5%				7.4%		4.1%				4.19	0.767
Total Average		72.4%				18.5%		9.1%				3.81	0.817

4.2 Descriptive analysis of dependent variable (Corporate Entrepreneurship)

As shown in the table 4, the mean value of Corporate Entrepreneurship as the dependent variable is 3.45. This refers that the level of Corporate Entrepreneurship among agencies managers higher than the average. More than 52% of the respondents were agree with Corporate Entrepreneurship indicators (X16-X25), 35% were neutral and 12% were disagree.

According to the calculations in table (3 and 4), the mean value for the variables (E-HRM and Corporate Entrepreneurship) is beyond average, and the over-all average for the research variables standard deviation reveals that the diffusion of indicators is not very far separately, indicating a positive relationship between the two variables.

Table 4 Descriptive analysis of dependent variable (Corporate Entrepreneurship)

Variables		Evaluation Levels										Mean	Standard deviation
		Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree			
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%		
Corporate Entrepreneurship	X16	1	3.1	20	62.5	9	28.1	1	3.1	1	3.1	3.59	0.756
	X17	1	3.1	18	56.3	10	31.3	1	3.1	2	6.3	3.47	0.879
	X18	1	3.1	2	6.3	20	62.5	9	28.1	0	0	2.84	0.677
	X19	1	3.1	13	40.6	14	43.8	4	12.5	0	0	3.34	0.745
	X20	1	3.1	8	25	20	62.5	3	9.4	0	0	3.22	0.659
	X21	8	25	22	68.8	1	3.1	1	3.1	0	0	4.16	0.628
	X22	0	0	24	75	6	18.8	2	6.3	0	0	3.69	0.592
	X23	2	6.3	15	46.9	11	34.4	4	12.5	0	0	3.47	0.803
	X24	1	3.1	8	25	16	50	7	21.9	0	0	3.09	0.777
	X25	4	12.5	19	59.4	5	15.6	2	6.3	2	6.3	3.66	1.004
Total Average		52.8%				35.1%		12.1%				3.45	0.752

4.3 Research hypotheses validity

Relationship between E-HRM Practices and Corporate Entrepreneurship.

The results of table 5 indicate that the correlation coefficient value between the study variables is 0.775 (Total index). The outcomes of Pearson's correlation analysis shown in table 5, there is a significant correlation between the independent variable E-HRM functions (E-Recruitment, E-Selection, E-Training and development, E-Rewards and compensations, and E-Performance Appraisal) and the dependent variable Corporate Entrepreneurship (r = .501, .680, .409, .799, .492) respectively. This indicates a positive correlation between E-HRM practices and Corporate Entrepreneurship, supporting the validity of the first primary research hypothesis.

Table 5 Correlation analysis

Dimensions of E-HRM	Recruitment	Selection	Training and development	Rewards and compensations	Performance Appraisal	Total Index
Corporate Entrepreneurship	.501**	.680**	.409*	.799**	.492**	.775**

** Correlation is significant at the 0.01 level (2-tailed)

Table 6 the impact of E-HRM on Corporate Entrepreneurship (Total Index)

Independent variable	E-HRM				
Dependent variable Corporate Entrepreneurship	**Beta**	**R^2**	**F**		**Sig.**
			Calculated	**Tabular**	
	.775	.601	45.184	4.17	.000

df= 1,30 N=32

As illustrated in the the table (Table 6) that the F value is (45.184) in df (1,30) at the Significant level (.000), and the R^2 is (.601), this refers that electronic human resource practices describes 60.1% Corporate Entrepreneurship changes and the remaining 39.9% is because of the other aspects and factors not involved in the present research model. Hence, the study conclude that electronic human resource management practices has a significant impact on Corporate Entrepreneurship as the calculated F value from the above table (45.184) is more significant than its tabular value (4.17). Thus, the second main research hypothesis has been accepted.

The impact of each practice of E-HRM on Corporate Entrepreneurship

To calrify the impact of each practice of electronic human resource on Corporate Entrepreneurship and investigate the sub hypotheses of the second main one in Telecommunication industry in Duhok govarnorate, the researchers depend on (F) value and (Sig). As presented in table 7.

Table 7 the effect of each practice of E-HRM on Corporate Entrepreneurship

I.V. E-HRM	D.V.	Beta	R^2	F		Sig.	Decision
				Calculated	Tabular		
Recruitment	Corporate Entrepreneurship	.501	.251	10.066	4.17	.003	Accepted
Selection	Corporate Entrepreneurship	.680	.462	25.754	4.17	.000	Accepted
Training and development	Corporate Entrepreneurship	.409	.167	6.010	4.17	.020	Accepted
Rewards and compensations	Corporate Entrepreneurship	.799	.638	52.824	4.17	.000	Accepted
Performance Appraisal	Corporate Entrepreneurship	.492	.242	9.596	4.17	.004	Accepted

df=1,30 N=32

According to the results in table (7), all five sub hypotheses from the second main one, have been supported as the calculated F value is greater than tabular F. Were the calculated F for electronic human resource management practices (Recruitment, Selection, Training & development, Rewards & compensations, and Performance Appraisal) (= 10.066, 25.754, 6.010, 52.824, 9.596) respectively, which is greater than (4.17) its tabular value.

5 Conclusion

Corporate entrepreneurship has gained significant research consideration with an emphasis on the factors that

influence the organization's willingness to initiate and sustain competitive advantage through entrepreneurial and creative behaviors. In the 1980th, entrepreneurship within established firms (CE) appeared as being the point of attention in today's corporations and the aim is to improve product/service innovation, risk acceptance and strategic renewal of the organization [13]. The current study aims to highlight and investigate electronic human resources management as an important factor in promoting CE. The finding of this research illustrated that there is a significant correlation between the independent variable E-HRM practices (E-recruitment, E-selection, E-training and development, E-rewards and compensations, and E-performance appraisal) and the dependent variable corporate entrepreneurship (r = .501, .680, .409, .799, .492) respectively with a total index of (0.775). As a result, the main first hypotheses has been accepted. On the other hand, the researchers conclude that electronic human resource management practices has a significant impact on corporate entrepreneurship based on the findings of data analysis as the calculated F value (45.184) is more significant than its tabular value (4.17). This proves the validity of the second main research hypothesis. This indicates that telecommunication corporations in Duhok governorate should be aware about the importance of using the E-HRM because it influences directly the corporate entrepreneurship.

Finally, the research is not free of limitations that can be addressed by future studies. One of the limitations is the fact that the study conducted in Duhok governorate and data have been collected only from corporation that are operating in this area. Future studies can add other variables as mediators and moderators, to improve the understanding of the role of E-HRM practices on promoting corporate entrepreneurship.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 405-410 ISSN 1339-5629

EXOSKELETONS - ROBOTIC SUITS IMPROVING WORK IN LOGISTICS
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doi:10.22306/al.v9i4.332 Received: 29 July 2022; Revised: 09 Oct. 2022; Accepted: 11 Nov. 2022

EXOSKELETONS - ROBOTIC SUITS IMPROVING WORK IN LOGISTICS

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Keywords: exoskeleton, logistics, supply, distribution, technology.
Abstract: Logistics, in the future, will be a decisive factor in the competitive struggle between organizations, economic regions and countries for value creation. The level of competence in logistics primarily determines success in this struggle. For modern companies, supply, production and distribution issues are becoming more and more relevant. It is possible to improve this process by strengthening logistic integration and coordinated interaction with external partners and between different departments within the company. Today, with the high development of technologies, it has become possible to automate not only production processes but also the movements of a person who, for one reason or another, cannot perform usual functions, in particular, to restore or replace partially or completely human limbs. This article deals with the issue of reducing logistics workers' workload. We are talking about the development of a robotic platform, namely exoskeletons, which are designed to supplement lost functions, increase human muscle strength and expand their physical capabilities, which will significantly increase the degree of worker efficiency. This article aims to optimize and facilitate workers' work by explaining the use of exoskeletons in supply and distribution logistics.

1 Introduction

Logistics, supply, production and distribution issues are becoming increasingly important for modern society. This process can only be improved in terms of strengthening logistics integration and coordinated interaction, both with external partners and between the various divisions within the company.

Its continuous improvement remains relevant in the conditions of rapid scientific and technical progress for the implementation of processes and digitization in logistics. Digitization in logistics aims to speed up all processes and make them more accurate and smoother. Digital data transmission, the use of new delivery methods, automation and robotization of business processes are already changing the logistics market. In addition to digitalization, the development of technical means that help workers directly in production, warehouses, dispatch or transport is also important for logistics. Industrial exoskeletons are also modern elements that are beginning to be asserted and used in the structures of industrial logistics. The exoskeleton, as a technical logistics device, is a device that can help increase human strength by supporting the outer skeleton. The exoskeleton mimics human biomechanics in order to increase an individual's effort during movement.

The use of exoskeleton robotics allows you to reduce the load during normal activities and static load, reduce fatigue and at the same time, increase efficiency without serious associated costs. Furthermore, exoskeleton robotics can be used to reduce muscle and joint tension, minimizing the risk of injury to workers who must constantly carry or hold heavy objects in inappropriate positions.

2 Methodology

The exoskeleton is a device that helps compensate for lost functions, strengthens human muscles, and expands the range of motion due to its outer frame and drive parts. When carrying loads through the outer frame and drive parts, an exoskeleton can also transfer the load to the leg support platform (Figure 1). Exoskeletons generally allow humans to perform movements with greater effort and protection against external forces [1].

Figure 1 Modern technical device in logistics – exoskeleton US Bionics [2]

Industrial exoskeletons are the collective name for mechanical devices used by workers whose design reflects the structure of the limbs, joints and muscles of the operator who works with them in tandem and is used as a means of increasing capacity or as a relief to relieve fatigue and tension. It also helps with weight support, lifting assistance, load support, posture correction and body stabilization are common features of industrial exoskeletons [3].

2.1 Exoskeletons classification

Exoskeletons that have been developed or are in development can be classified according to the following criteria [4].

According to the energy source and the principle of operation of the drive:

- passive exoskeletons (energy independent and do not require any energy sources),
- active exoskeletons (mechanisms equipped with electric drives).

By application point (location):

- upper limb exoskeleton (to increase the strength and range of motion of the upper limbs),
- the exoskeleton of the lower limbs (facilitates walking, increases strength and range of motion),
- whole body exoskeleton (designed to increase strength and endurance; provides protection against external factors).

By price (conditional):

- low cost (affordable): 1000-10000 €,
- medium costs: 10000-50000 €,
- high costs - more than 50000 €.

According to the weight of the construction:

- light - up to 5 kg,
- medium (average) - from 5 to 30 kg,
- heavy - more than 30 kg.

The most common areas of application of this technology are:

- medicine,
- defence,
- industry.

2.2 Active and passive exoskeletons

According to the mode of action, exoskeletons are divided into active and passive [5].

Active exoskeletons have actuators powered by energy sources connected to the exoskeleton itself. These devices, usually equipped with electric actuators (pneumatic and hydraulic components can also be used), significantly increase the force exerted by the operator on the objects and his endurance because the effort expended to control the exoskeleton is relatively low (Figure 2).

Advantages: high speed of movement, the significant increase in force and range of motion, adjustability and the possibility of programming allow you to perform a large amount of work.

Disadvantages: dependence on external energy sources, high price, large construction and weight, dependence on climatic conditions, need for repairs and maintenance, and lack of service [6].

Figure 2 Active exoskeleton [7]

Passive exoskeletons are devices that do not need any energy source to function (Figure 3). The principle of their operation is based on the basic laws of mechanics. Passive exoskeletons distribute the load to individual parts of the body using weights and levers. By the action of a passive exoskeleton, it is possible to reduce the load on active muscles by an average of 30% [6].

Advantages: independence from external energy sources, low weight of the structure, high reliability, and low costs for equipment and maintenance.

Disadvantages: they cannot be used in the absence of residual muscle strength, inability to program, relatively low speed of movement, individual need for anatomical parameterization, and movements with limited amplitude [6].

Figure 3 Passive exoskeleton [8]

3 Need of exoskeletons in logistics

Full automation of logistics processes can solve the problem of trauma to employees. But this is not always possible from a technical and economic point of view. A

new high-quality tool that improves working conditions in the field of logistics is the exoskeleton. The exoskeleton allows you to work for a long time without overwork and injury. It reduces muscle tension and allows one to maintain longer working capacity during change.

Moving objects of medium weight are considered the most dangerous work. Uncomplicated, repetitive work gives the worker a false sense of security. Fatigue from monotonous activities combined with incorrect postures reduces concentration and attention, which often leads to injuries that are expensive (Figure 4) [9].

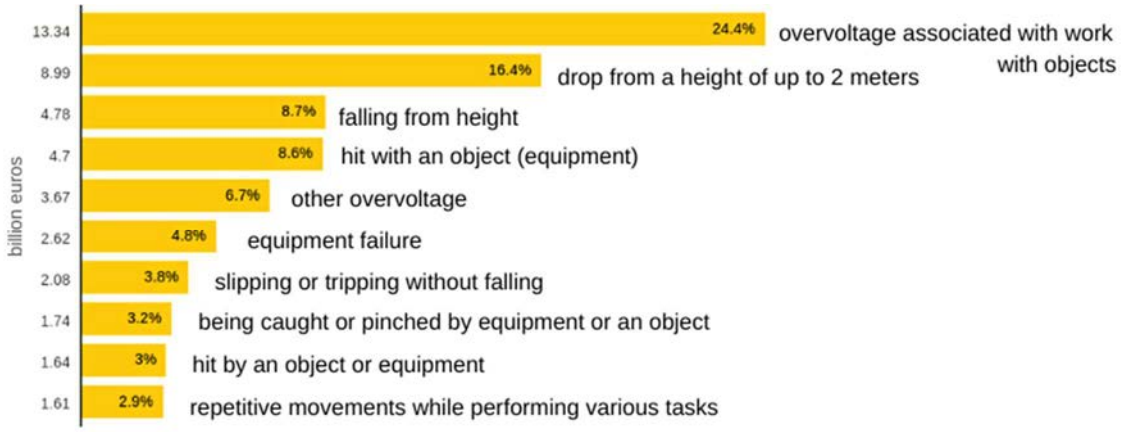

Figure 4 The relationship between the economy and accidents at work [9]

According to US sources, the compensation for the damage received is distributed as follows (Figure 5) [9]:

- 36% - injury in the lower back,
- 25% - overvoltage due to lifting, moving and throwing objects,
- 12% - knee and shoulder injuries.

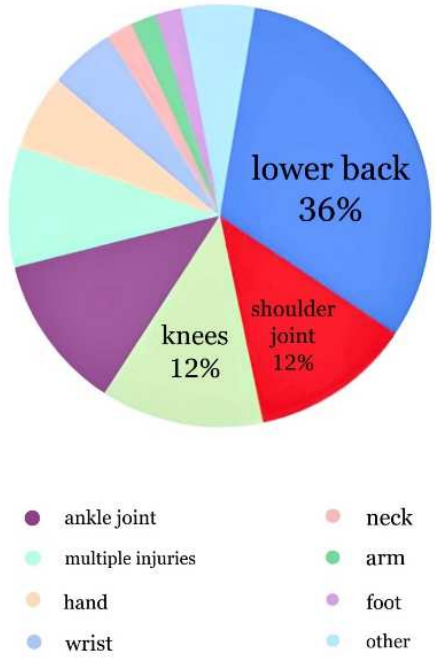

Figure 5 Diagram of the most common injuries [9]

The employee's long absence during the convalescence period leads to additional costs. Several organizations have already concluded that investing in measures to improve working conditions, including exoskeletons, is more beneficial than bearing the damage associated with temporary disability [9].

4 Characteristics of SuitX exoskeletons

The popularity of American exoskeletons is due to their high efficiency, ergonomics and quality.
Strengths of SuitX exoskeletons:

- comfortable to wear throughout the working day,
- possibility of self-regulation,
- modular design,
- intelligent user movement recognition,
- ability to drive without removing the exoskeleton,
- mobility, and lack of connection to energy resources.

A large number of tests prove the effectiveness of such structures. For example, muscle tension measurements using the ShoulderX model when working with the drill showed that the load was reduced up to 6 times. The support is particularly effective in the deltoid and trapezius muscles (Figure 6) [9].

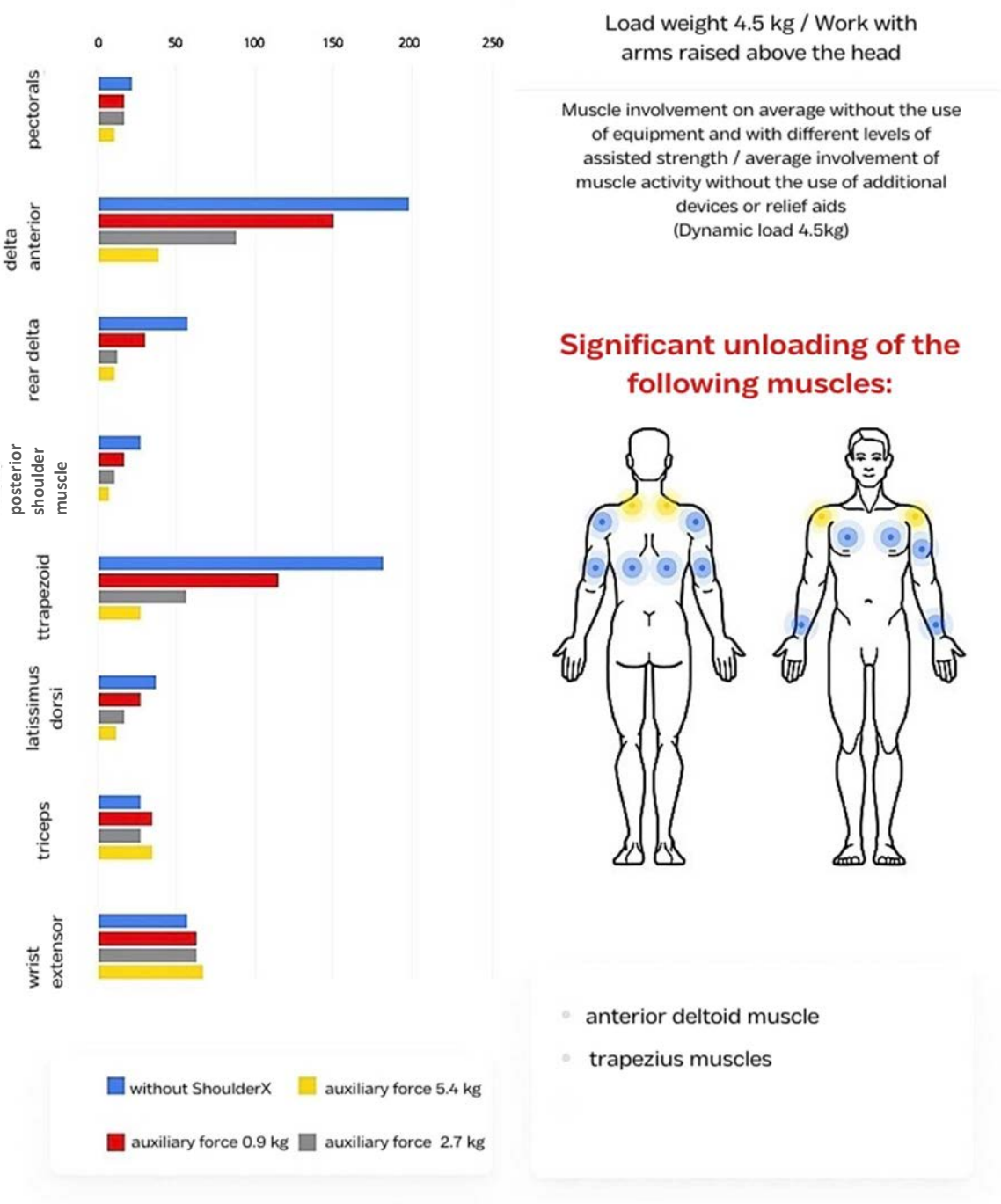

Figure 6 ShoulderX exoskeleton research [9]

Further research assessed worker fatigue during warehousing operations. As a result of the observation, the following data were recorded [9]:

- working with warehouse technology using our own resources led to feelings of fatigue after two minutes and fifteen seconds,
- when working in the ShoulderX exoskeleton, fatigue manifests itself within 15 minutes.

5 Advantages and disadvantages of exoskeletons

The key advantages of the exoskeleton for logistics workers are [10]:

1. Performance,
2. Increase workplace comfort with support,
3. Fewer injuries,
4. Improving the quality of work,
5. Reducing the risk of occupational diseases.

Disadvantages of the exoskeleton:

1. Costs,
2. Limited power range,
3. Material,
4. Power supply,
5. Management.

6 Current situation of exoskeletons on the market

As an ever-evolving market, exoskeletons today cannot yet provide many examples of practice, experience-tested practices, standards and business models. Nevertheless, the market is beginning to take shape, both in terms of expectations and challenges.

Due to a large number of producers, the Far East and China are expected to be the regions with the highest exoskeleton rental revenues (Figure 7).

The main driver of growth will be the ageing of the population. In Japan, for example, there is already a labour shortage, as the proportion of people over the age of 70 is 20% of the population. Exoskeletons are gaining popularity there and helping older people stay productive in areas requiring manual labour. Companies such as Daewoo, Guardian, Ford, and Hyundai are actively investing in this sector [11].

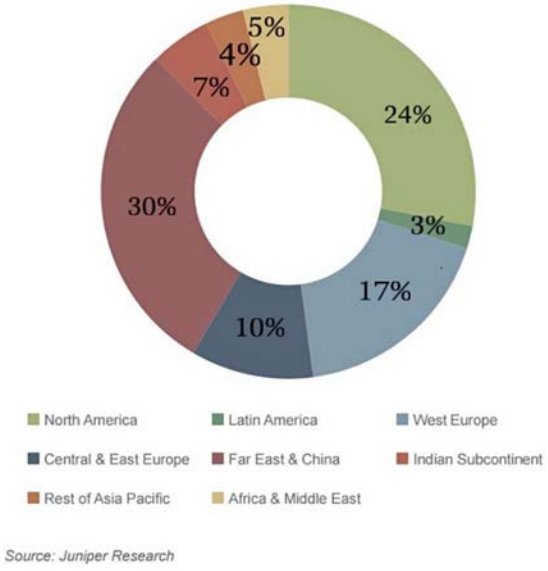

Figure 7 Regions with the largest use of exoskeletons

Nevertheless, the introduction of these types of devices provides a solution to three important business problems:

- increasing labour productivity and reducing labour intensity in manual production processes,
- reducing the number of social benefits and compensations associated with the occurrence of work accidents and occupational diseases,
- providing additional motivation for employees, which is achieved by creating more comfortable working conditions.

By 2026, the global robotic exoskeleton market will reach € 1.6 billion (Figure 8). The growth of the global market is due to the ageing of the population, technological innovations and the expansion of their application in the military industry, healthcare and industry as such [12].

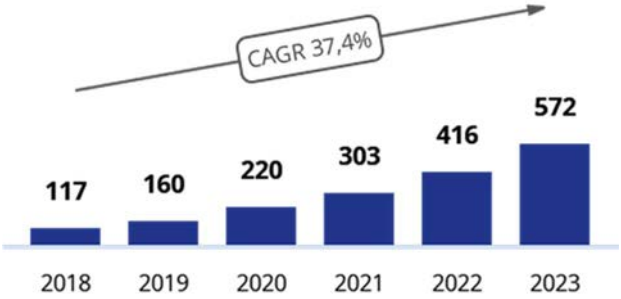

Figure 8 World exoskeleton market forecast, EUR million

7 Conclusions

Due to the constant change of products, the company needs to improve the system of technological preparation of production in order to ensure fast and high-quality implementation during the development of a large number of technological processes. The most modern and promising field of robotics is the creation of mobile robots, specifically exoskeletons.

In logistics and production, the physical workload of employees is often very high, which in the long run, represents a major burden on the health and productivity of workers. Workers are often tense or exceed their work capacity when moving heavy objects, which is a major problem today.

With the help of exoskeletons, it is possible to compensate for physical disadvantages and prevent posture deformities and physical deterioration of a person's condition because excess physical exertion is eliminated. This means that exoskeletons are actively used to help employees do their job safer, longer and more efficiently.

Suppose workplaces cannot be ergonomically optimized due to spatial layout or other specific conditions. In that case, the exoskeleton can help restore balance by stabilizing certain parts of workers and thus reduce the effort required to perform difficult or monotonous activities and increase efficiency and quality of work.

Acknowledgement
The VEGA Grant Agency funded this research. The submitted paper is a part of the project "Research and development of new smart solutions based on the principles of Industry 4.0, logistics, 3D modelling and simulation for streamlining production in the mining and building industry" VEGA 1/0317/19.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 411-415 ISSN 1339-5629

SELECTED INNOVATIVE APPROACHES IN THE WASTE TYRES MANAGEMENT
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doi:10.22306/al.v9i4.333 *Received: 02 Aug. 2022; Revised: 16 Nov. 2022; Accepted: 05 Dec. 2022*

SELECTED INNOVATIVE APPROACHES IN THE WASTE TYRES MANAGEMENT

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Keywords: waste tyres, monitoring, recycling, circular economy.
Abstract: Nowadays, waste is something that every country can handle in terms of disposing of it, storing it, or reusing it. However, waste is not only municipal waste but also other raw materials that wear out over time, and their primary purpose in life is over. The ideal case for such waste is its recycling and reuse in other forms. Preventing waste is the best way to recycle, but its life cycle needs to be addressed if waste is produced. The economic model of the current society is primarily linear so far. We extract natural resources and take them to the other side of the world, where products are made from them. These are distributed to other corners of the world, where consumers buy, use and throw them away. This is how waste is created and raw materials in the form of products end up in landfills, incinerators, or thrown in the wild. However, according to the institute, the circular model should, in addition to a stable economy, also ensure a healthy environment. This specific area of waste is under-discussed across society compared to plastics, where more emphasis is placed on recycling and reuse. The presented manuscript concerns the worst kind of waste, namely end-of-life tyres. Despite this, there are companies in Slovakia that are looking for innovative ways to evaluate this type of waste and are dedicated to traditional recycling methods. The number of fast-paced used tyres is increasing nowadays, which also adapts to the lifestyle of everyday life.

1 Introduction

Over 6 million tons of end-of-life automobile waste are produced annually worldwide, of which approximately 5 million tons are recycled [1]. In percentage terms, 87 percent of the total vehicle waste is recycled after the end of its useful life [2]. Among the EU countries, France is the largest producer of waste in this area, closely followed by the United Kingdom and Italy. These three countries produced just over 1 million tons of waste in 2018. For comparison, Slovakia produces only 38 000 tons of end-of-life vehicles per year [3].

The upcoming Figure 1 offers a graphical treatment of the European Union's recycling capacity from 1992 to 2019.

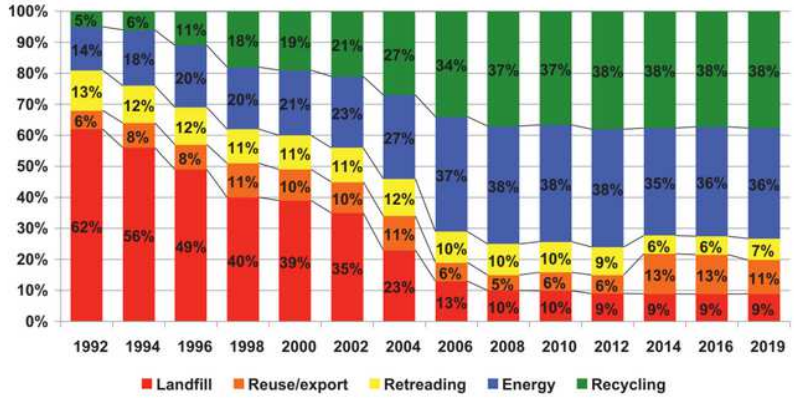

Figure 1 EU Recycling capacity (1992-2019) [3]

The share of landfilling is slowly disappearing in the European Union, and its percentage decreased from 62% in 1992 to 9% in 2019. The reuse share reached its lowest point in 2008 when its value was around 5%. On the contrary, in 2019, we can note an increase in the reuse of waste tires to a value of 9%. Retreading as a possible way of using waste tires has decreased within the EU to 7%. On the contrary, waste tyres' share of energy and material recovery is very close in percentage values from 1992 to 2019 [4]. The newly built plant near our neighbours in Hungary is worth mentioning, which also deals with the issue mentioned above of processing used tyres. The new plant in the Hungarian refinery Zala z recycles 10% of all used tires in Hungary. Behind this plant are the oil, gas, and petrochemical group MOL, whose portfolio includes the Slovak refinery Slovnaft. The construction of the plant cost 8.5 million euros [4]. The plant aims to produce so-called rubber asphalt from used tyres. It is an unusual composition of asphalt and granulated mixture from waste tyres. MOL developed this new production technology in cooperation with Pannonian University. Chemically stabilized rubber asphalt was patented in 2009, and later in 2014, it was awarded the ecological product trademark. The technology patented by the MOL company allows rubber asphalt to be transported, stored, and later used so that it can be produced in bulk, and at the same time, its use can be outside the place of its production [5].

On the other hand, rubber asphalt produced in the USA is produced directly at the site of road construction, as it must be used within a few hours. Due to the extraction of rubber particles. The mentioned plant can produce up to 20,000 tons of rubber asphalt annually. This production covers almost 10% to 15% of the domestic demand for asphalt [6]. Hungary can thus ensure the construction of nearly 200 kilometres of the two-lane road by recycling half a million used tyres. The conditions for expanding rubber-asphalt routes are favourable, as rubber-asphalt has excellent adhesion to mineral substrates. This reduces the probability of potholes, and its higher load capacity compared to traditional asphalt minimises the possibility of ruts on the road [5].

In the world, one of the cheapest and at the same time the simplest ways, which is burning used tyres, is often used. From an ecological point of view, this method is very unfriendly to the environment. When used tires are burned, oxidation reactions occur, where many of the tyres that burn turn into carbon oxides and soot. Substances such as butadiene, styrene, aliphatic and aromatic hydrocarbons, benzene, toluene, and phenylacetylene are released into the air [6,7]. Simply put, heavy metals are released into the air, which negatively impacts the environment. Despite these facts, this method of recycling tires is used in many countries worldwide. The result of the tire combustion process is fuel (Figure 2).

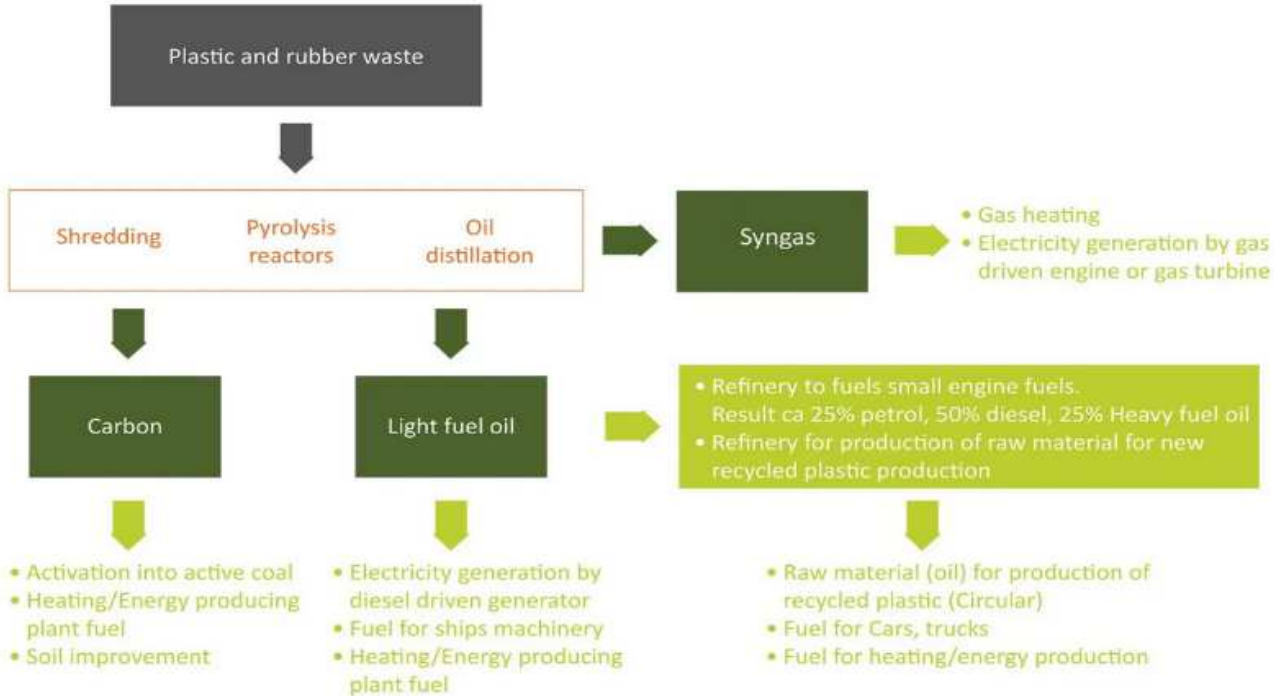

Figure 2 Process of waste tyres and plastics management [4,7]

To illustrate, if we burn 700 kg of used tyres, thanks to the burning, we will get a secondary processing product, which is fuel, but on the other hand, we will produce 720 kg of toxins and soot [6]. In Finland, it provides recycling of used tires with an innovative method that is friendly to the environment [6]. In 2007, the company developed dry pyrolysis technology. Compared to classic pyrolysis, which is very popular in the EU, dry pyrolysis does not

produce any excess emissions [4,5]. As the company's homepage states, their advantage over classic pyrolysis is that no cooling or heating cycles occur during their production, and no emissions are released into the air during processing, as the show takes place through closed processes (without a chimney). The resulting product of recycling is pyrolysis oil. Around 10,000 tons of old tyres are processed annually in this Finnish company [4]. The innovative method of using tyres consists of a modified thermal decomposition process - pyrolysis. The essence is to heat the recycled material at a high temperature without access to oxygen [7]. Under specific pressure conditions, high temperature breaks down tyres into individual components, such as oil, carbon, or gas. Pyrolysis oil made from rubber can be used for heating in industrial furnaces or converted into diesel or gasoline in refineries.

2 The waste tyres characterization

The input material is not only old tyres but also various plastics, which are either crushed on a crushing machine or sent to a pyrolysis reactor, where, thanks to pyrolysis, we obtain synthesis gas, which is suitable for gas heating or the production of electricity with a gas engine or turbines. The mentioned pyrolysis oil can even be used as fuel for ship engines or vegetable fuel producing heating energy [5,6]. The basic goal of the proper functioning of every enterprise is to ensure safety and health protection at work in the human-machine-environment system [5]. Despite implementing all available measures to increase safety and health protection and conscious compliance with the organization's occupational health and safety policy by employees, it does not exclude the emergence of an undesirable situation that leads to occupational accidents. If such an undesirable situation occurs, it is necessary to proceed according to the valid legislation [4]. Safety and health protection at work can be defined as the state of the workplace, which ensures that in compliance with rules such as technological procedures, safety regulations, etc., a situation will not arise that would endanger the health of workers [6]. To create safe work, in which the protection of the worker's health must be observed, it is required to develop and implement a system of measures such as legislative, economic, social, organizational, technical, health, and education [7]. We consider waste tyres, rubber scraps, and rubber waste as input to the recycling process. The annual capacity for the plant is 15,000 tons/year [4]. As an output from the recycling process, the mentioned three forms are rubber granulate, metal component, and textile component, which can be seen in Figure 3.

Figure 3 The Material Outputs from Recycling [4]

For truck tyres, in addition to chopping, the bead ropes are removed, and the tyre is cut into smaller parts. Passenger car tyres are somewhat simpler, as they can be chopped and crushed. The result of crushing, magnetic and pneumatic separation is rubber granulate, which has different fractions [5].

3 The future of waste tyres

Not all products are suitable for natural renewal, and just-worn tyres are a typical example. Ambition in this direction must be set against what is possible in the context of current technologies with a certain expansion of market demand. In other words, although our ambition may be fully circular, there will still be many areas of products in which full circulation will be unattainable [4,7].

Figure 4 describes the principle of understanding circular economy or circular economy. The circular economy model aims to preserve the value of products and materials as long as possible to minimize waste and use new resources [8]. Within the framework of the graphic expression of the circular economy of waste tires model, the input raw material is the tyre, which consists of components, followed by the design and production. After production, the distribution by companies dedicated to the sale of tyres to the consumer market begins [9]. After a certain time, the tire wears out, i.e. the end of its useful life [8,10]. At this moment, the tyre represents waste, intended for collection and subsequent recycling, where the output of the recycling process is a new type of raw material - granulate.

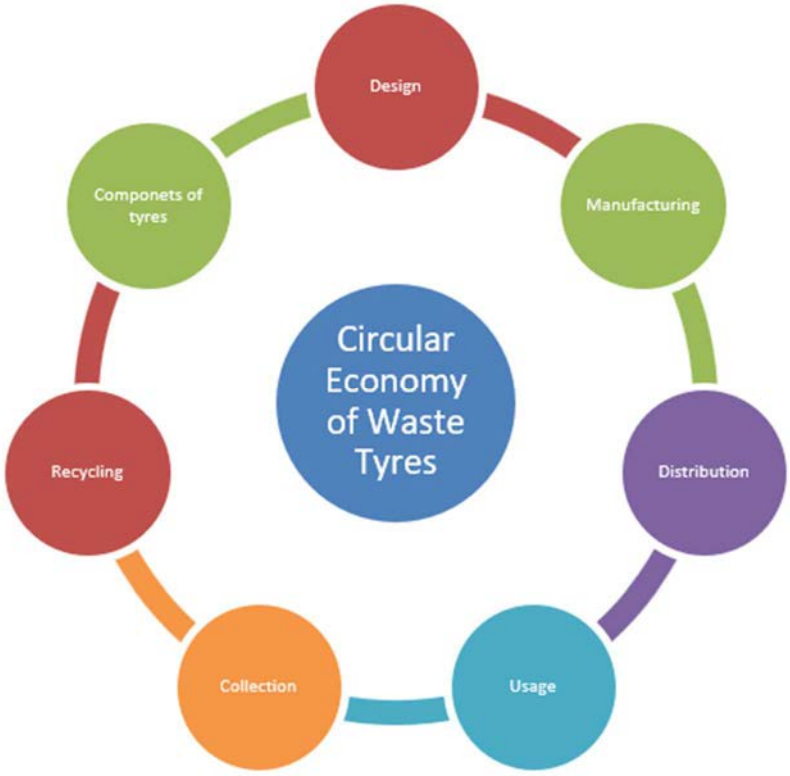

Figure 4 Circular Economy cycle [Authors own processed]

4 Conclusions

The 2030 Agenda for Sustainable Development, approved in September 2015 by the UN General Assembly, also belongs to the circular economy [11]. The 2030 Agenda represents the most complex set of priorities of a global nature, the goal of which is to achieve sustainable development [8,11]. Transformation, integration, and universality are its key principles. The 2030 Agenda includes 17 Sustainable Development Goals (SDGs), which are processed into 169 related sub-goals. The main ambition of these goals is to guide the structural political, economic and social transformation of individual countries of the world, where the Slovak Republic has also signed up to implement Agenda 2030. Agenda 2030 connects three dimensions of sustainable development: economic, social, and environmental. The goal of Agenda 2030 in Slovakia is to get closer to Green Slovakia through several strategic documents [6,12].

The potential of waste tyres is also very significant with the circular economy or the circular economy, as waste can be recycled and offers various possibilities for processing and subsequent use, whether it is the production of granules, alternative fuel, or the production of rubber asphalt. This area provides a large number of options for secondary processing of material and its subsequent transformation into various innovative forms of products originating from waste tyres.

Acknowledgement

This paper is part of a project that has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No.723274.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 417-431 ISSN 1339-5629

ANALYSIS OF THE IMPACT OF TRADE OPENNESS ON ECONOMIC GROWTH: THE CASE OF MOROCCO
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doi:10.22306/al.v9i4.336 *Received: 05 Aug. 2022; Revised: 17 Nov. 2022; Accepted: 30 Nov. 2022*

ANALYSIS OF THE IMPACT OF TRADE OPENNESS ON ECONOMIC GROWTH: THE CASE OF MOROCCO

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Keywords: trade openness, economic growth, Morocco, ARDL model, causality.
Abstract: The relationship between openness to international trade and economic growth has been a subject of perennial controversy. This has paved the way for various theoretical and empirical investigations which has yielded inconclusive results, particularly in the case of developing countries. As a good case in point, the Moroccan economy has been subjected to a thorough analysis in order to determine and evaluate the impact of trade openness on economic growth covering the period from 1980 to 2019. To this end, the methodology adopted consists of a complementary approach of statistical and econometric tests using the ARDL bounds test of cointegration and the Toda-Yamamoto causality test. The results have shown that Morocco's openness to international trade positively impacts economic growth in the short term. Yet, it produces adverse effects in the long term, especially with the presence of bidirectional causal relationship between the two variables– i.e economic growth and international trade.

1 Introduction

The impact of trade openness on economic growth is a long-standing controversial issue that has laid the foundations for subsequent and recurrent theoretical and empirical studies. Such studies have tried to explain the divergent consequences of this relationship across a number of countries.

Theoretically, it has been argued that in the long run trade openness potentially promotes economic growth through multiple transmission channels, such as access to technology and knowledge, international financial integration, effective and efficient allocation of resources, access to diversified markets, improvement in domestic factor productivity, attractiveness of foreign capital, and finally international cooperation [1,2].

These theoretical underpinnings have motivated almost all developing countries to both take a range of measures to facilitate global trade and reform their foreign trade policies so as to promote trade openness. The international institutions regulating the global liberal system have also fueled the demand to reform external strategies, especially those of developing countries. Furthermore, the failure of self-centered and inward-looking development strategies has paved the way for promoting this liberal choice extensively [3,4].

Despite the theoretical and empirical developments framing this issue, there is still a lack of consensus on the possible effects of trade openness on economic growth. Variables such as the diversity of countries economic structures and trade policies and the abundance of study techniques, analytical settings, sampling periods and cases selected weigh heavily on the effects of the relationship established between openness to international trade and countries' economic growth.

Morocco has adopted a policy of economic liberalization for several decades, focusing its strategic development on exports and attractiveness of international investment as a long-term development choice. As a result, the reduction of tariff and nontariff barriers, the development of logistics, the simplification of border control procedures and the adoption of an arsenal of multidimensional reforms have contributed to both increase in trade volumes and the restructuring of its foreign trade composition.

Indeed, the Moroccan economy has made significant progress in terms of economic growth and openness to the global market over the last decades. It averaged a growth rate of 7.6% in the period between 1980 and 2019 and a trade openness representing nearly 87% of GDP in 2019. This mixed performance is attributable to the country's commitment to a varied series of reforms and structural measures.

However, this relative performance does not only lay bare the structural deficits that restrain the economic transformation, but it also reveals the complications facing the Moroccan economy in the management of its openness process. Despite the gradual diversification impacting the manufacturing sectors, the national productive sectors suffer from deindustrialization in some specific sectors due to low labor productivity and the absence of high-tech, high-value-added industrial and technological transformation activities [5].

The purpose of this article is to analyze in a multivariate framework the relationship developed between openness to international trade and economic growth in Morocco

between 1980 and 2019. The study is conducted to answer the main question raised in this analysis: Does openness to international trade contribute to the promotion of economic growth in Morocco? Within this framework, the hypothesis to be tested is the following: foreign trade does or does not promote economic growth in the Moroccan economy.

Our study attempts to address this problematic by using the ARDL model of Pesaran [6] and the causality test of Toda-Yamamoto [7]. These two analytical tools will help us explain the evolution of the relationship between trade openness and economic growth in the short and long term and identify the causal inferences made among the variables of our hypothetical model.

The remainder of the paper will unfold as follows. The second section contains the theoretical development framing the relationship between trade openness and economic growth. The third section discusses the development of the hypothetical model, the variables adopted and the statistical data. The fourth section presents the econometric methodology, the main empirical results and a discussion of the main findings of the study.

2 Literature review

The role of international trade in promoting economic growth has been widely debated and much has been written in an attempt to confirm or refute the trade-led-growth hypothesis. Within this framework of analysis, the classical theory of international trade, driven by the principle of mutual prosperity between nations, stipulates that the specialization of countries combines the position they have acquired on the international market [8]. Indeed, this specialization, with the factor endowments that it reveals, will tend to stimulate scale production and trade exchange in the sectors with the most abundant factor.

As a result, the accumulation of physical capital generated by the increase in volumes traded on foreign markets implies an increase in national income and, consequently, high overall economic growth [9]. The theory of comparative advantage has been widely developed to combine the vulgate of the neoclassical liberal theory. The neoclassical approach asserts that openness to international trade provides relative compensation for the unequal geographical distribution of productive wealth in the world and thus replaces the exchange of factors of production among economies [10].

In this perspective, the new theories of endogenous growth reconsider international trade in economic development policies as a key factor and a strategic stimulus to the performance and promotion of economic growth. The development of human capital and the acquisition of new technologies, and new production techniques are now the major determining factors for stimulating this relationship developed between openness to international trade and the economic growth of countries [11,12].

Openness to foreign trade allows the least developed economies to benefit from an advanced level of technology and innovation produced by the developed countries in the international market. This kind of distribution on a global scale encourages developing countries, especially small ones, to imitate and produce products with low and medium technological content through the learning and experience effects accumulated by the human capital of those countries [13].

Theoretical analysis has been put forward to include global trade policy from strategic perspective by developing competitive advantages and enhancing the competitiveness of countries at the international level by the adoption of an interactive arsenal of public policies and actions in line with the free trade principles [14,15]. In addition, the management of the reforms undertaken by countries must be able to assist and complement their strategies of trade openness in order to achieve a high level of performance on the international scale.

In the global competitive market, the performance of international trade is intrinsically linked to the innovation and the performance achieved in the logistics at the macro and microeconomic level.

In the long term, trade openness, involving an active transfer of technology and knowledge, the transformation of productive structures, the qualification of human capital and the improvement of efficiency in the allocation of resources and thus increase economic growth, leads to a gradual and progressive convergence between economies [16,17].

The growing impact of foreign trade on the internal progress of countries and the emergence of MNC's as new active operators in the global economic architecture have played a key role in the flow of capital and technological externalities. This has prompted almost all countries to abolish barriers and open their borders to the free circulation of goods and services [18,19]. All these arguments encourage countries to integrate into the global economic sphere through a high degree of trade openness despite the existence of an alternative approach suggesting that trade openness inhibits economic growth and introduces adverse effects, particularly when the country specializes in low-value-added activities and its initial conditions and parallel reforms do not favor the adaptation and absorption of the external shocks initiated by excessive openness to foreign trade [20,21].

Empirically, the analyses of the impact of trade openness on economic growth are often contradictory. A number of studies point to the existence of positive effects of trade openness on economic growth [22,23]. However, other studies contradict the presence of a positive link in this relationship and confirm the existence of negative or the absence of impacts [24].

Moreover, empirical studies, which are scarce on the case of the Moroccan economy, have attempted to analyze the impact of foreign trade on economic growth with the objective of producing policy recommendations for the Moroccan authorities. By conducting a study on the productivity of Moroccan firms, Haddad [25] confirms the

existence of a strong positive relationship between the productivity of national firms and the share of exports they make, particularly those of the industrial sector. This indication is in accordance with the results of the study of El Alaoui [26] which also supports the presence of a positive long-term relationship between trade openness and economic growth. While the study of Currie and Harrison [27] demonstrates that trade openness has penalized the strategic sectors of the Moroccan economy through various reduction effects on employment, wages, prices and profits. Similarly, Bouoiyour [28] indicates in his study that there is a weak relationship between foreign trade and economic growth.

3 Methodology

Our hypothetical perspective is based on the model of Mankiw et *al.*, [29] which is founded on the original basic formulation developed by Solow [30]. To this can be added the contributions of [11,12] Lucas and Romer developed within the framework of a theoretical construction analyzing economic growth from an endogenous perspective.

The model tests the hypothesis of whether trade openness does or does not promote economic growth in the case of the Moroccan economy. In this framework, the ultimate objective is to explain the variations of the economic growth observed during the period of analysis dealt with in our study by the evolution of the variables including the foreign trade variable.

In view of the above, the formulation of a function of economic growth, inspired by the theoretical reflection developed on this subject, has led to formulating the following dynamic growth function (1):

$$\boldsymbol{Y_t = A_t\, K_t^{\alpha}\, KH_t^{1-\alpha}} \qquad (1)$$

$\boldsymbol{t} = 1, \ldots\ldots\ldots,$
$0 < \boldsymbol{\alpha} < 1$

The theoretically relevant variables induced in this formulation are based on the extended Cobb-Douglas production function, which must be augmented in the context of the design considered above. These variables are respectively the combination of physical capital stock **(K)**, human capital **(KH)** and technological progress **(A)**. the signs **(α)** denote the remuneration of the factors of production inserted in the equation and **(t)** indicates the time range.

Economic growth **(Yt)** is analyzed by the GDP per capita indicator as a key variable that generally tends to explain the evolution of the growth of countries and the standards of living of its population [11,12,29].

The stock of physical capital **(Kt)** is taken in an accumulated form, retained by the measure of gross fixed capital formation calculated by the competent authorities on the basis of annually established data. This stock is generated by the intermittent (perpetual) inventory method, which consists of reconstructing the series of physical capital stock by accumulation starting from the level of initial capital [31]. The initial capital is deduced by calculating the average rate of investment extended over the previous period from 1965 to 1980.

This first formula: $\boldsymbol{K_0 = FBCF_0/(\rho + \delta)}$ estimates the approximate value of the country's initial capital **(K_0)**, inserting a constant annual depreciation rate of **δ = 0.05 (5%)** (this rate was adopted in the HCP report in [32]). The estimation of this depreciation rate is based on several indicators, including mainly the nature of the physical capital accumulated, the production process and the technology used [33].

In contrast, the second formula estimates, in addition to the formula mentioned above (2), the accumulation of data for the construction of the physical capital stock series.

$$\boldsymbol{K_t = FBCF_t + (1-\delta)K_{t-1}} \qquad (2)$$

The stock of physical capital variable **(Kt)** includes the stock of equipment, basic infrastructure and structures of the economy intended for national production. For our purposes, it includes the panoply of structural and complementary reforms adjusted during the liberalization period to stimulate economic growth and enhance the trade performance of the Moroccan economy in the global market [34,35].

While investment in human capital requires a complex combination of income, education, health, and a multitude of interactive elements, especially at the social level [36], our empirical analysis emphasizes the interpretation of this variable from the perspective of the level of (secondary) education of the labor force, taken as a proxy for the human capital variable **(KHt)**, to refer to the relatively and moderately skilled labor force [37,38].

Regarding the technology variable **(At)**, this variable is manipulated as a mechanism for transferring innovation, knowledge and know-how from developed countries, which are the main producers of technology to less developed countries and thus, to our study context Morocco as a developing economy [16,39,40].

In developed economies, technology is driven by a high level of investment made by rational profit maximizing agents mostly in the private sector, creating a competitive environment of picking winners and thereby stimulating technological progress [41]. However, the process of stimulating technological advancement is usually initiated by public authorities as a part of complementary strategies, such as establishing a research and development platform and providing the necessary equipment and infrastructure for creative ideas and technological innovation [18,42].

Morocco's foreign trade structure reflects the country's technological level; the country exports a relatively small proportion of technology-intensive products compared to its considerable imports in this category of products (machinery and equipment).

However, human capital is crucial to activating these transmission channels in developing countries such as

Morocco. The human capital must develop its capacity to absorb technological progresses and the ability to adapt constantly to changes and advances made in scientific knowledge and innovation worldwide [43,44].

This provides an explanation for the developments in contemporary theories of endogenous growth that attribute a determining role to trade openness in the dynamism of economic growth [13,45]. We suggest in this framework that externalities and technological spillovers are transmitted by openness to international trade as well as by the entry of foreign direct investment to Morocco.

$$A_t = \beta TO_t^{\sigma} FDI_t^{\rho} X_t^{\omega} \quad (3)$$

Most empirical studies structuring theoretical thinking and analyzing the impacts of foreign trade on economic growth focus the measurement of trade openness on exports, neglecting the considerable role of imports, especially for the least advanced economies [46,47]. While the theory of comparative advantage asserts that an efficient allocation of resources is possible by importing goods that are more expensive to produce and producing the factor-intensive goods that are vastly abundant in the country [48].

Morocco has a structural trade deficit that favors imports (equipment, machinery, inputs, finished products, semi-finished products and raw materials) for the dynamism of its domestic economy. Trade openness **(TO)** is calculated as a ratio of exports and imports divided by GDP. This index refers to the trade intensity in the creation of added value. The foreign direct investment **(FDI)** indicator is calculated by the net inflow of FDI to the Moroccan territory. This flow provides an active transfer of imported technology and know-how in the form of machinery, equipment, organizational model and various knowledge [49, 50]. The constant in equation **(2)** is identified by **(β)**.

Based on the previous equations **(1)** and **(3)**, the canonical model adapted is formulated in the following equation **(4)**.

$$Y_t = \beta TO_t^{\sigma} FDI_t^{\rho} K_t^{\alpha} KH_t^{1-\alpha} X_t \quad (4)$$

The variable **(X)** is a constant that frames other variables affecting the evolution of the relationship under study and the overall efficiency of the economy, including governance, the quality of institutions, the climate and geographic location of the country and many others. These factors, different from a country to another, are considered a country-specific shock and therefore imply a divergence in growth, living standards and initial conditions for trade openness across countries.

The function is a simple mapping from inputs to outputs of production [51]. This functional form consists of examining the different mechanisms that influence the relationship between economic growth and openness to international trade by specifying the transmission channels that regulate this relationship [52]. A linearization of the adopted model becomes necessary at this stage of analysis by log-linearizing the entire equation (dependent and independent variables) in order to allow a correct estimation of the specified parameters (5).

$$\mathrm{Ln}Y_t = \alpha_0 + \alpha_1 lnK_t + \alpha_2 lnKH_t + \alpha_3 lnTO_t + \alpha_4 lnFDI_t + \mu_t \quad (5)$$

The error term is represented by (μ_t) and the constant is symbolized by this sign (α_0). On the other hand, the parameters to be estimated are the signs of **α0**, **α1**, **α2**, **α3**, **α4** and assumed to be positive.

4 Results and discussion

In order to study the impact of openness to international trade on economic growth in Morocco, our econometric methodology is divided into three main steps that are progressive and complementary. The ultimate objective is to verify the existence of a causal relationship between trade openness and economic growth in Morocco as well as to test the robustness of the hypothetical model to empirical examination. Therefore, the study relies on time series data that spans over a 40-year period from 1980 to 2019.

Our econometric approach is based on a complementary process of statistical tests. First, the stationarity test of the time series is used to detect the order of integration of the variables by unit root tests. The next step is to examine the presence of cointegration and short to long term relationships between the variables by the ARDL model. Finally, the Toda-Yamamoto causality test is adopted to verify the existence of causal relationships, particularly between economic growth and openness to international trade.

Table 1 Descriptive statistics

	LnY	LnK	LnKH	LnFDI	LnTO
Mean	7.654962	8.689475	2.361596	2.160755	-0.423228
Median	7.586447	8.616020	2.343214	2.153621	-0.450791
Maximum	8.130371	9.475094	3.242592	2.248667	-0.093651
Minimum	7.166648	7.975233	1.845300	2.076341	-0.702220
Std. Dev.	0.298542	0.459705	0.342340	0.052694	0.167706
Skewness	0.116442	0.222040	0.634930	0.165137	0.304441
Kurtosis	1.761417	1.771748	2.856217	1.761629	1.853991

Jarque-Bera	2.647207	2.843019	2.722032	2.737737	2.806790
Probability	0.266174	0.241349	0.256400	0.254395	0.245761
Sum	306.1985	347.5790	94.46385	86.43022	-16.92911
Sum Sq. Dev.	3.475963	8.241816	4.570664	0.108290	1.096890
Observations	40	40	40	40	40

The descriptive statistics table above (Table 1) displays a set of specifications that characterize and describe the trends of data and provides insight into the size, variation, central tendency, mode of dispersion and normality of the variables over the period of the study [53].

The univariate observation and the analysis of the data show that the logs of the two main variables, trade openness and economic growth, reached the highest level in 2019 with 8.130371 and -0.093651, respectively against an average that reaches 7.654962 and -0.423228 successively for the same variables.

Pursuing the analysis by the correlation matrix developed in the following (Table 2), which illustrates the apparent nature of the relationship developed between the variables and determines the linearity of this probable links. Hence, a positive relationship is observed between trade openness and economic growth by a value higher than 90% as well as between the majority of variables that drive economic growth as presented in the Table 2. On the contrary, a positive correlation does not imply a significant causality.

Table 2 Correlation matrix

	LnY	**LnK**	**LnKH**	**LnFDI**	**LnTO**
LnY	1.000000				
LnK	0.995459	1.000000			
LnKH	0.958096	0.969898	1.000000		
LnFDI	0.995974	0.999753	0.967738	1.000000	
LnTO	0.910108	0.928102	0.896530	0.925562	1.000000

At this level, stationarity tests are applied to determine the order of integration of the variables in our model. The ultimate objective is to identify the econometric method adapted for this study. The data in the series must not contain trend, seasonality or cycle, which by their presence and ignorance will be capable of biasing the results of the study and making them fallacious [54]. These characteristics, affirming the stationarity of time series, are generally invalid in the majority of cases manifesting macroeconomic and financial phenomena; those are dominated by stochastic trends, as demonstrated in the studies conducted by [55,56] Nelson and Plosser and Campbell and Perron.

In order to have a real analysis of the relationship established between the variables, it is necessary to eliminate the effects or shocks often manifested by crises, economic policies and structural reforms, political or institutional changes that lead to non-stationarity of the data [57,58]. To this end, the stationarity test used is the Kwiatkowski, Phillips, Schmidt and Shin (KPSS/[59]), test since it is more robust for small data and observations like in this case study. This test is applied to validate the null hypothesis of stationarity (H0 = stationary series) of the time series.

Table 3 Results of unit root test of (KPSS)

Variables	**KPSS**				**integration order**
	Level		**First difference**		**KPSS**
	C	**T&C**	**C**	**T&C**	
LnY	1.312795**	0.112582**	0.096760**	0.080476**	**I(1)**
LnK	2.392508**	0.456402**	0.188889**	0.091309**	**I(1)**
LnKH	0.401873**	0.173038**	0.455472**	0.189708*	**I(1)**
LnTO	0.506674*	0.131233**	-	-	**I(0)**
LnFDI	4.743531**	0.423788**	0.124602**	0.091875**	**I(1)**

Note: The tests were conducted with individual constant and trend and constant equations and the lag intercepts for each variable were automatically selected by default by the software (Default Barlett Kernel/ Andrews Bandwidth).
Significance level is represented by **critical value at 5%, *critical value at 1%. These critical values are calculated by Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1).

The table 3 displays the results calculated for each data series and asserts the assumption of the stationarity of the time series at first order **I(1)** for all the variables and at level **I(0)** for the trade openness variable in the different stationarity equations (constant, trend & constant) adopted according to the advancement of the stationarity tests. In other words, the results indicate that most of the series are derived from a non-stationary process in level, except for the variable **(LnTO)**. For this purpose and for the non-stationary variables, new series are formed with values that indicate the difference between the observation of the time being and before.

The next step consists on analyzing the cointegration relationship established in the long term between variables. In this framework, the technique of cointegration developed by Pesaran et *al.*, [6], through the specification of the ARDL bounds test, is used to determine the presence of vectors and equilibrium relationship between the series in the long term.

This test requires either level **I(0)** or first order **I(1)** stationarity or a combination of both and it's conducted to examine the movement on a long-run equilibrium path of the dependent variable alongside with the set of explanatory variables designated as regressors in this model.

The relevance of this cointegration technique compared to other conventional and traditional methods, such as those of Granger and Engel, 1987, Johansen and Juselius, 1991, lies in its high capacity to deal with multivariate cases and at various degrees of integration. Besides, this test has relatively more efficient statistical properties that fit with the characteristics of small sample sizes [60].

Considering the results in the table 4 and with the determination of the GDP variable as the dependent variable (first equation), the hypothesis of no cointegration (*H0: α1 = α2 = α3 = α4 = α5 = 0*) was rejected in order to accept the hypothesis of existence of cointegration (*H1: α1 ≠ α2 ≠ α3 ≠ α4 ≠ α5 ≠ 0*) in the long run between all the variables, in particular between the dependent variable and the set of independent variables over the determined period for the case of the Moroccan economy. Thus, the presence of a strong cointegration reveals that any state of imbalance between the variables is only a short-term phenomenon.

For the rest of the equations and adopting each variable individually as dependent variable, the result also confirms the existence of long-run cointegration relationships between all the variables, which are in this case, GDP per capita growth, physical capital, human capital, foreign direct investment and openness to international trade.

Table 4 Results of the ARDL cointegration test

Estimated Models	**Optimal lag length**	**F-statistics**	**Diagnostic tests**		
			Serial correlation	**Normality**	**Heteroscedasticity**
Y = f(K, KH, FDI, TO)	ARDL (5, 2, 0, 0, 1)	4.236924	0.2689	0,030214*	0.0591
TO = f(Y, K, KH, FDI)	ARDL (1, 1, 4, 3, 4)	8.112997	0.3461	0,767647	0.8272
K = f(Y, KH, FDI, TO)	ARDL (5, 3, 4, 4, 3)	10.66637	0.6408	0,098088	0.9047
KH = f(Y, K, FDI, TO)	ARDL (1,0, 4, 4, 1)	4.301396	0.0667	0,520628	0.2767
FDI =f(Y, K, KH, TO)	ARDL (5, 3, 4, 4, 3)	10.52026	0.6290	0,134895	0.9494
Level	**Critical values (T=35)**				
	Lower bounds I(0)		**Upper bounds I(1)**		
10%	2.696		3.898		
5%	3.276		4.63		
1%	4.59		6.368		

Note: The optimal lag number for each variable is selected automatically by the Akaike Info Criterion (AIC) with a maximum lag estimate of 5.
Values are generated with the unrestricted constant model and no trend.
The signs *, **, *** represent the significance of the values at the 1%, 5% and 10% levels respectively.
Probabilities of diagnostic tests are significant at 5% and *1%.
The test for normal distribution of series and residuals is advanced by the Jarque-Bera statistical test. The problem of autocorrelation of series is tested by the Breusch-Godfrey test. The test of heteroscedasticity is checked by the Breusch-Pagan-Godfrey statistical test to determine the variance of the error term.

In this framework, the table 4 presenting the results exposes the F-statistic that indicates a significance with respect to the upper bounds generated in the same table at significance levels of 5% and 10% for all equations. Thus, the results of the cointegration at the bounds reveal the presence of a strong cointegration in the long run between all the variables.

For data samples with a limited number of observations (in our case 40 observations in each series), which varies between T = 30 and T = 80, the upper and lower bounds determined in the table 4 are defined by Narayan, [61] instead of those of Pesaran et *al.*, [6], rather adapted to large samples size (T = 500 to T = 40.000).

Moreover, given the limited data of our time series, the ARDL model is sensitive to the structure of the estimated

lag numbers. As explained by Lütkepohl, [62] the dynamic links developed between the time series are detected by this optimal lag number because an appropriate lag in the model used removes the endogeneity and correlation problem between the residual series. Therefore, the optimal lag numbers for each equation are shown in the second column of Table 4 with a maximum lag length of 5 for the dependent variable and 4 for the independent variables. These lags are distributed automatically for each variable by the Akaike Info Criterion (AIC) selection criterion.

To test the robustness of the results, it is important to designate a number of diagnostic tests such as the normality test, the heteroscedasticity test, the error autocorrelation test as well as the stability test of the model (CUSUM) in order to consolidate the results estimated by the ARDL model. All of these tests are significant at the 5% level and confirm the existence of appropriate econometric properties for the tests and, consequently, do not violate the validation assumptions of the selected econometric model.

The cointegration of all variables in the long-term and their stationarity at different levels I (0) and I (1), requires the use of the ARDL model to identify the nature and significance of the short- and long-term relationships between the variables. The ARDL model, which is a dynamic model, will be used to justify the evolution of the dependent variable by both its past variations with respect to the short- and long-term equilibrium and the lagged and current values of all the other variables as explanatory variables since this model is a combination of endogenous and exogenous variables.

This model supports the specification of the short-term results by an error correction model (*ECM*) in order to produce relatively correct estimations in the long run. The empirical formulation of the ARDL test for the dependent variable LnY (6), which is GDP per capita growth, is presented below:

$$\begin{aligned}\Delta \boldsymbol{LnY_t} = {} & \alpha_0 + \alpha_1 LnY_{t-1} + \alpha_2 LnK_{t-1} + \alpha_3 LnKH_{t-1} \\ & + \alpha_4 LnFDI_{t-1} + \alpha_5 LnTO_{t-1} \\ & + \sum_{i=1}^{m} \theta_{1i}\, \Delta LnY_{t-i} + \sum_{i=0}^{n} \theta_{2i}\, \Delta LnK_{t-i} \\ & + \sum_{i=0}^{p} \theta_{3i}\, \Delta LnKH_{t-i} \\ & + \sum_{i=0}^{q} \theta_{4i}\, \Delta LnFDI_{t-i} \\ & + \sum_{i=0}^{k} \theta_{5i}\, \Delta LnTO_{t-i} + \mu_t \end{aligned} \quad (6)$$

All variables are defined previously. Δ is the difference operator, **(*m, n, p, q, k*)** are the estimated lag or offset number for each variable and μ represents the error term. This equation is subdivided into two major parts: the first specifies the long-term relationship between the variables profiled by the variables in level, and the second frames the importance of the short-term relationships simulated by the variables in first difference. In this regard and to detect the existence of short-term relationships, the equation is displayed as follows (7):

$$\begin{aligned}\Delta \boldsymbol{LnY_t} = {} & \theta_0 + \textstyle\sum_{i=1}^{m} \theta_{1i}\, \Delta LnY_{t-i} + \\ & \textstyle\sum_{i=0}^{n} \theta_{2i}\, \Delta LnK_{t-i} + \sum_{i=0}^{p} \theta_{3i}\, \Delta LnKH_{t-i} + \\ & \textstyle\sum_{i=0}^{q} \theta_{4i}\, \Delta LnFDI_{t-i} + \sum_{i=0}^{k} \theta_{5i}\, \Delta LnTO_{t-i} + \\ & \beta ECT_{-1} + \mu_t \end{aligned} \quad (7)$$

The cointegration equation, referred to as ECT (Error Correction Term), reflects the coefficient of adjustment and Cointegration between the variables in the long term while marking the short-term dynamics [63]. This cointegration coefficient is calculated by the following formula (8):

$$\begin{aligned}\boldsymbol{ECT}_{-1} = {} & LnY_{t-1} - \hat{\alpha}_0 + \hat{\alpha}_1 LnY_{t-1} + \hat{\alpha}_2 LnK_{t-1} + \\ & \hat{\alpha}_3 LnKH_{t-1} + \hat{\alpha}_4 LnFDI_{t-1} + \hat{\alpha}_5 LnTO_{t-1} + \hat{\mu}_t \end{aligned} \quad (8)$$

Table 5 Short run estimates of the relationships between the explanatory variables and the dependent variable (GDP)

Explicative Variables (regressors)	**Dependent Variable ΔLn(Y)**		
	Coefficient	**t-statistic**	**Probability**
ΔLnK	-	3.349153	0.0396*
ΔLnKH	0.118839	1.230321	0.2329
ΔLnFDI	35.90226	1.249125	0.2260
ΔLnTO	-	6.384810	0.0072*
Constant	-0.018934	-0.958181	0.3494
ECT (-1)	-0.830843	-3.127157	0.0053*

The two missing coefficients on the table represent variables with estimated lags in the equation, their joint significance is tested with the Wald test.
*Significance at 5%.

The results of the short-run dynamics between the variables are presented in the table 5. The coefficient of the error correction term lagged by 1 is statistically significant, its negative sign indicates the presence of a stable relationship in the long run between the different variables in the model, and its coefficient reflects an adjustment and

a return of economic growth to its general equilibrium of 83% if a deviation occurs in the long run.

The physical capital variable and the trade openness variable exert a simultaneously significant and positive short-run effect on the evolution of GDP per capita; their short-run elasticities have been represented by several coefficients because they have lagged and, therefore, have been tested jointly by the Wald statistical test. However, the human capital variable and the foreign direct investment variable do not have a significant direct short-run impact on economic growth in the Moroccan economy represented in our model by GDP per capita.

After estimating the coefficients of the short-run relationships and with the existence of a long-run cointegration, we proceed to the next step to identify the presence of relationships between variables in the long-term. For this very reason, the equation is limited to the following formulation (9):

$$\boldsymbol{LnY_{t-1}} = \alpha_0 + \alpha_1 LnY_{t-1} + \alpha_2 LnK_{t-1} + \alpha_3 LnKH_{t-1} + \alpha_4 LnFDI_{t-1} + \alpha_5 LnTO_{t-1} + \mu_t \quad (9)$$

This empirical approach is utilized to demonstrate the existence of relationships between the dependent variable and the explanatory variables in the long run by the ARDL model specifying the Ordinary Least Squares (OLS) method and by the Fully Modified Ordinary Least Squares (FMOLS) model cointegration regression in order to assist and confirm the initial results.

The results reported in the table 6 show relatively similar coefficients and signs for the two estimated models (OLS) and (FMOLS). These results indicate a long-term relationship between trade openness and GDP per capita growth as well as between human capital formation and the performance of the economic growth. However, the impact of these relationships in the long run on the promotion of economic growth in Morocco is relatively negative because the signs of the coefficients are negative. While the other variables like physical capital and foreign direct investment show no direct long-term effet on the variable GDP per capita.

In other words, and according to the main model ARDL-OLS of the study, the 1% dynamic of human capital in the long run leads to a 0.09% decline in GDP per capita. Similarly, the 1% change in trade openness leads to an indirect decline in GDP per capita of 0.16% in the long run.

Table 6 Long run estimates of the relationship between the explanatory variables and the dependent variable (GDP)

Explicative Variables (regressors)	**Dependent Variable Ln(Y)**					
	ARDL-OLS			**FMOLS**		
	Coefficient	**t-statistic**	**Probability**	**Coefficient**	**t-statistic**	**Probability**
LnK	0.315024	0.667510	0.5088	0.237561	0.463751	0.6458
LnKH	-0.093893	-1.778787	0.0840**	-0.128968	-2.376927	0.0232*
LnFDI	3.960424	1.012841	0.3181	5.090290	1.192808	0.2412
LnTO	-0.161228	-2.349854	0.0245*	-0.231182	-3.304405	0.0022*
Constant	-3.486433	-0.789777	0.4350	-5.202642	-1.074729	0.2901

*Significance at 5% and **significance at 10%.

Taking into account the results obtained, the hypothesis of trade-led-growth, which is the framework of our study, has been rejected in this empirical testing for the case of Morocco over the period cited in this analysis. This result is confirmed in other recent studies analyzing the case of Morocco, such as Okuyan et *al.*, and Ayad and Belmokaddem [64,65].

All the tests carried out above have provided an array of information on the existence of long- and short-term relationships between the variables as well as on the nature of this relationship, omitting the analysis of the probable causality developed between all the variables.

For this purpose, the test of causality in the sense of Granger will be advanced with the aim of apprehending the asymptotic behavior of the studied phenomenon. Causality in the sense of Granger, like most econometric models, is restricted by its sensitivity to the optimal lag and lag numbers that are adopted in its application.

The optimal number of lags to include in our model is considered decisive to have appropriate results. A high number of lags could introduce multi-linearity problems, display statistically insignificant coefficients and reduce the degree of freedom in the manipulation of the model while a low number of lags leads to difficulties in the error specification.

The optimal number of lags is framed by the calculation of several selection criteria as presented in the table 7. This optimal lag number is determined by the value of 5 in most of the selected criteria in table 7. Most often, the Akaike Information Criterion (AIC) is adopted for its accuracy in measuring the quality of a statistical model [66]. In our case, this selection criterion indicates an optimal number of lags of **5**, which must necessarily be incorporated into the estimations constructed in the following test.

Table 7 Results of optimal lag numbers by the lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	354.5478	NA	1.46e-15	-19.97416	-19.75197	-19.89746
1	666.6058	517.1247	1.11e-22	-36.37747	-35.04432*	-35.91727
2	695.7358	39.94975	9.65e-23	-36.61348	-34.16936	-35.76977
3	733.0988	40.56554*	6.15e-23	-37.31993	-33.76485	-36.09272
4	775.6413	34.03396	3.97e-23	-38.32236	-33.65631	-36.71164
5	842.4857	34.37714	1.22e-23*	-40.71347*	-34.93646	-38.71925*

Note: *indicates the order of lags selected by the criterion.
LR: sequential modified LR test statistic (each test at 5% level).
FPE: Final prediction error.
AIC: Akaike information criterion.
SC: Schwarz information criterion.
HQ: Hannan-Quinn information criterion.

The equation that consists in examining the presence of causality in the sense of Granger is formulated as follows (10):

$$\begin{bmatrix} Y_t \\ K_t \\ KH_t \\ FDI_t \\ TO_t \end{bmatrix} = \begin{bmatrix} \alpha_t \\ \alpha_t \\ \alpha_t \\ \alpha_t \\ \alpha_t \end{bmatrix} + \sum_{i=1}^{p} \begin{bmatrix} \beta_{1i} & \theta_{1i} & \gamma_{1i} \\ \beta_{2i} & \theta_{2i} & \gamma_{2i} \\ \beta_{3i} & \theta_{3i} & \gamma_{3i} \\ \beta_{4i} & \theta_{4i} & \gamma_{4i} \\ \beta_{5i} & \theta_{5i} & \gamma_{5i} \end{bmatrix} \times \begin{bmatrix} Y_{t-1} \\ K_{t-1} \\ KH_{t-1} \\ FDI_{t-1} \\ TO_{t-1} \end{bmatrix} + \sum_{i=p+1}^{p+d} \begin{bmatrix} \beta_{1i} & \theta_{1i} & \gamma_{1i} \\ \beta_{2i} & \theta_{2i} & \gamma_{2i} \\ \beta_{3i} & \theta_{3i} & \gamma_{3i} \\ \beta_{4i} & \theta_{4i} & \gamma_{4i} \\ \beta_{5i} & \theta_{5i} & \gamma_{5i} \end{bmatrix} \times \begin{bmatrix} Y_{t-i} \\ K_{t-i} \\ KH_{t-i} \\ FDI_{t-i} \\ TO_{t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix} \quad (10)$$

The causality in the sense of Granger [67] established between the variables, especially the dependent variable and the explanatory variables, will be calculated by the causality approach developed by Toda and Yamamoto [7], adapted simultaneously to integrated series with different orders of stationarity and cointegrated in the long-run. For this purpose, an augmented VAR model is used with the insertion of an additional lag number that indicates the maximum order of integration and stationarity **I(1)** of the series to the lag number of 5 held in the optimal lag specification (Table 7) [68]. The VAR estimate as specified in Toda Yamamoto's [7] technique is of order 6.

Table 8 Results of Toda-Yamamoto causality tests

Dependent Variable	Causal Variable				
	Y	Capital	human Capital	FDI	Trade Openness
Y	-	0.2740	0.6466	0.2601	0.0538
Capital	0.0192	-	0.2941	0.3220	0.0298
Human capital	0.0392	0.5740	-	0.6001	0.0236
FDI	0.0136	0.3239	0.3984	-	0.0119
Trade Openness	0.0192	0.5053	0.8816	0.5065	-

The values shown in the table are the probabilities of the Wald statistical test.
Significance is at the 10% and 5% level.

In order to have a causal inference, the Wald statistical test is applied to the lagged explanatory variables with the objective of validating or refuting the null hypothesis which suggests the absence of causality (*H0: c25 = c26 = c27 = c28 = c29 = c30 = 0* / null hypothesis: trade openness does not cause in the Granger sense GDP growth and *H0: c125 = c126 = c127 = c128 = c129 = c130 = 0* / null hypothesis: GDP growth does not cause trade openness). In this sense, the Wald statistical test verifies the significance of the explanatory variables in a given model and their presumed impact on the dependent variable.

Causality in the Granger sense is unidirectional and statistically significant among all the variables, in this case physical capital, human capital, foreign direct investment and trade openness, on the dependent variable, which is GDP per capita. In other words, these variables cause and contribute to the growth of GDP per capita (**K, KH, FDI, OC → Y**).

Similarly, for the variable trade openness, adopted as a causal variable to test its effects, there is a strong unidirectional causality among the variables: physical capital, human capital, foreign direct investment. Also, a bidirectional causality was revealed between trade openness and GDP per capita growth, wich attests to the existence of a strong potential between the dynamics of economic growth and the foreign trade of the country. This result is confirming the significance of the short- and long-run coefficients (**Y, K, KH, FDI → OC**).

In other words, this result confirms the existence of an active and dynamic link between trade openness that is also present both in the short and long run and in a bidirectional causal sense (**Y↔OC**).

To complete the analysis of the results yielded by the Granger causality test, the table 9 illustrates a diverse set of tests and calculations involving the generalized forecast error variance decomposition method, which highlights the variance of the different indicators in the study, via the adjusted VAR system [69].

This method permits the total variability of a variable to be decomposed by its own shocks and fluctuations as well as by innovations and shocks emanating from other

sources presumed to have an influence on its variance as a key independent variable over different time horizons without determining the type of reaction (positive or negative) that it might experience [68].

Analyzing the variance of the GDP variable over the long term (15 years), this variable is explained by its own shocks to the extent of 21.7%, as well as by the innovative shocks affecting trade openness variable and the variable representing physical capital to a significant proportion of 26.8% and 51.4% respectively. While the effects of human capital and foreign direct investment are insignificant in this decomposition and do not reflect any improvement in the long run.

As for trade openness variable, it is explained by its own innovative fluctuations to the extent of 20.2%, as well as by shocks of GDP per capita with a share of 15.3% and shocks to the physical capital variable with a significant proportion reaching 64.3%. While the impact of human capital is limited compared to the first variables despite its important role in the promotion of trade openness; in parallel with a negligible impact of foreign direct investment on the dynamics of foreign trade.

The human capital variable is determined by the innovative variations of physical capital, the evolution of per capita income and the openness to foreign markets, with various shares of 54.5%, 19% and 26.4% respectively. In this line, the coherence of the results indicates that the trade openness and the evolution of the physical capital by their own fluctuations and by the innovative shocks of the other variables are determining factors of the promotion and the performance of the economic growth, the formation of the human capital as well as the attractiveness of the international investments on the long run.

Table 9 Variance decomposition analysis

Variance decomposition of LnY:						
Period	S.E.	LnY	LnTO	LnK	LnKH	LnFDI
1	0.006392	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.019649	13.01093	29.16206	57.82702	7.72E-09	8.88E-07
3	0.023384	21.70058	24.43327	53.86615	2.13E-07	1.44E-06
4	0.024502	20.61024	25.31947	54.07029	1.99E-07	1.64E-06
5	0.025712	24.85243	25.54350	49.60407	1.82E-07	2.01E-06
6	0.046842	14.10271	13.51875	72.37854	2.77E-07	1.23E-06
7	0.060308	19.83610	14.16656	65.99734	6.27E-07	9.58E-07
8	0.088277	19.10686	19.17184	61.72131	6.61E-07	1.65E-06
9	0.098051	19.17709	27.70203	53.12088	9.48E-07	2.73E-06
10	0.109941	15.49536	25.98314	58.52149	7.72E-07	3.07E-06
11	0.199740	16.67028	9.148065	74.18165	3.86E-07	9.81E-07
12	0.412744	16.78078	8.804878	74.41434	4.46E-07	3.99E-07
13	0.678347	19.18385	13.67737	67.13878	6.15E-07	6.77E-07
14	0.894729	20.72539	19.95391	59.32070	7.93E-07	1.39E-06
15	0.964837	21.73767	26.82286	51.43947	9.64E-07	2.72E-06
Variance decomposition of LnTO:						
Period	S.E.	LnY	LnTO	LnK	LnKH	LnFDI
1	0.009369	37.51464	62.48536	0.000000	0.000000	0.000000
2	0.023208	86.39473	12.27544	1.329825	3.62E-07	5.21E-06
3	0.028637	56.74173	13.69275	29.56552	2.38E-07	3.48E-06
4	0.033075	54.76701	11.27839	33.95460	2.18E-07	2.86E-06
5	0.036628	44.71839	16.69741	38.58419	2.56E-07	2.80E-06
6	0.062861	15.52268	11.01640	73.46092	1.40E-07	1.07E-06
7	0.066771	16.87003	12.13055	70.99942	3.29E-07	1.02E-06
8	0.075511	32.48950	10.87955	56.63095	4.02E-07	1.21E-06
9	0.087603	41.65467	8.378913	49.96641	3.76E-07	1.59E-06
10	0.099094	34.96638	7.203871	57.82974	3.06E-07	1.49E-06
11	0.133581	21.07564	7.890721	71.03364	3.06E-07	8.21E-07
12	0.183151	18.10210	10.12156	71.77634	4.65E-07	7.31E-07
13	0.242248	18.29122	15.43660	66.27218	6.37E-07	9.71E-07
14	0.276885	18.53360	22.13862	59.32778	8.16E-07	2.03E-06
15	0.303993	15.37562	20.24583	64.37854	7.14E-07	2.82E-06

Variance decomposition of Lnk:

Period	S.E.	LnY	LnTO	LnK	LnKH	LnFDI
1	0.005719	18.19214	8.533997	73.27386	0.000000	0.000000
2	0.007446	12.61777	11.59305	75.78918	2.52E-07	8.27E-07
3	0.008388	15.74519	9.807680	74.44713	2.82E-07	2.10E-06
4	0.014937	4.971418	15.40575	79.62283	1.87E-07	1.01E-06
5	0.024970	4.130401	18.55038	77.31922	3.25E-07	3.65E-07
6	0.037712	8.460029	21.57515	69.96482	4.98E-07	2.93E-07
7	0.049555	9.489401	26.75850	63.75210	6.28E-07	6.27E-07
8	0.053924	8.860887	34.71699	56.42213	7.45E-07	1.23E-06
9	0.063329	8.675782	26.34376	64.98046	5.41E-07	1.24E-06
10	0.127117	11.95062	10.57914	77.47024	3.75E-07	3.19E-07
11	0.245561	13.66816	12.51938	73.81246	4.99E-07	3.59E-07
12	0.376873	14.73487	17.96745	67.29767	6.58E-07	8.03E-07
13	0.459057	15.65011	25.53545	58.81444	8.52E-07	1.72E-06
14	0.483784	14.31147	29.76194	55.92659	9.00E-07	2.96E-06
15	0.787796	11.33160	11.72218	76.94622	4.12E-07	1.32E-06

Variance decomposition of LnKH:

Period	S.E.	LnY	LnTO	LnK	LnKH	LnFDI
1	0.026299	5.066459	25.82873	69.10481	4.12E-07	0.000000
2	0.040381	11.82940	30.72967	57.44093	6.16E-07	4.68E-07
3	0.058377	7.220845	32.87095	59.90821	4.13E-07	2.29E-07
4	0.071806	6.069487	39.68384	54.24667	5.18E-07	1.05E-06
5	0.085456	13.49667	30.35456	56.14877	3.66E-07	9.61E-07
6	0.190921	14.12005	12.27836	73.60159	3.32E-07	2.08E-07
7	0.352403	14.95006	13.99605	71.05390	4.94E-07	2.74E-07
8	0.533466	16.74615	18.82726	64.42659	6.67E-07	7.56E-07
9	0.657394	16.09195	26.67028	57.23776	8.29E-07	1.56E-06
10	0.692863	14.58580	31.94352	53.47067	8.85E-07	2.71E-06
11	1.103466	12.14439	12.89096	74.96464	4.17E-07	1.25E-06
12	2.344424	14.08433	8.938872	76.97680	4.07E-07	3.38E-07
13	4.130008	15.88274	13.02376	71.09350	5.54E-07	5.05E-07
14	5.788182	17.68643	18.94838	63.36518	7.32E-07	1.10E-06
15	6.502943	19.04118	26.40995	54.54887	9.27E-07	2.26E-06

Variance decomposition of LnFDI:

Period	S.E.	LnY	LnTO	LnK	LnKH	LnFDI
1	0.000652	17.42702	8.775810	73.79717	1.98E-10	2.57E-09
2	0.000841	12.08026	11.97865	75.94109	2.67E-07	8.97E-07
3	0.000953	15.83966	9.889125	74.27121	2.97E-07	2.22E-06
4	0.001684	5.084662	14.84868	80.06666	1.89E-07	1.08E-06
5	0.002810	4.342123	17.85148	77.80640	3.25E-07	3.92E-07
6	0.004264	9.002047	20.82514	70.17282	4.98E-07	3.03E-07
7	0.005633	10.29527	25.87221	63.83252	6.31E-07	6.40E-07
8	0.006156	9.837162	33.73440	56.42844	7.55E-07	1.25E-06
9	0.007128	9.015042	26.55028	64.43468	5.63E-07	1.34E-06
10	0.014158	11.65990	10.56752	77.77259	3.74E-07	3.45E-07
11	0.027515	13.44865	12.34285	74.20849	4.93E-07	3.49E-07
12	0.042545	14.57987	17.72214	67.69798	6.51E-07	7.79E-07
13	0.052212	15.56388	25.19594	59.24018	8.45E-07	1.67E-06
14	0.054937	14.39504	29.91468	55.69028	9.09E-07	2.94E-06
15	0.087580	11.24636	12.14742	76.60622	4.21E-07	1.39E-06

Cholesky Ordering: LnY LnTO LnK LnKH LnFDI

5 Conclusion

The causal relationship identified between trade openness and economic growth has been the subject of vigorous and intense debate for the diversity of results and consequences that it implies across countries. The case of the Moroccan economy is not an exception; the empirical analyses carried out concerning this issue in the Moroccan economy provided varied results as demonstrated in the works of [26,65,70]. The results of those studies confirm the existence of divergent impacts stemming from this relationship (positive, negative or insignificant).

Our empirical analysis confirmed the existence of a bidirectional causality between trade openness and economic growth. The reverse causality reflects an interdependence and a transitional dynamic that could occur if the economy reaches a threshold of emergence ensuring economic and industrial development.

On the one hand, the results confirm the presence of a positive short-term relationship between the accumulation of physical capital, the openness to international trade and economic growth. This asserts that the dynamics of the Moroccan economy can be partially explained by a strong demand for national consumption, resulting in an increase in imports of raw materials, semi-finished products and finished products. The evolution of national economic production oriented mainly toward exports, revealing the comparative and competitive advantages of the Moroccan economy in the international markets, play also an important role in the dynamic of trade and economic growth.

On the other hand, the results indicate the presence of a negative long-term relationship established among foreign trade, human capital and growth of GDP per capita for our case study. For this, the hypothesis of trade-led-growth has been refuted in the case of the Moroccan economy.

A substantial part of Morocco's national economic growth is driven by domestic factors. Trade openness is not an obstacle to development since this variable develops a strong bidirectional causality with economic growth and the dynamics of the country's national productive sectors. The difficulty lies in implementing and managing economic and trade policies simultaneously to a restructuring social field.

The development of human capital requires a multidimensional strategy, encompassing a set of strategic sectors targeting mainly health, education, training research and development in order to stimulate its productivity and its capacity to absorb new production techniques and technologies over the long term. This explains the magnitude of investments needed to develop human capital. Interactive and complementary links have been found between Human capital and economic growth for the case of the Moroccan economy.

This implies a reorganization of the reforms undertaken during these last decades and a reformulation of export-oriented strategies in order to adapt its products to the requirements and standards of the foreign markets and of the international supply chain management and to operate a restructuring of the commercial exchanges by targeting the production and export of technological products with high added value. Also, the development and the investment in both logistics capacities and logistics skills results in easier access to foreign markets and thus, an increasing integration in international trade [71].

Our results in terms of long-run causality affirm the importance of human capital formation and qualification for the economic growth performance, trade openness and the relationship developed between these last two variables.

The aim objective of the different policies and reform measures is to place human capital at the heart of economic development and social welfare in order to improve the competitiveness of the Moroccan economy, increase private sector productivity, neutralize external shocks, take advantage of the positive externalities of free trade, stimulate good governance and institutions, and through all these variables promote economic growth [13].

Like any field of empirical analysis, our study has a number of limitations. First of all, the analytical framework and the estimation method adopted, which may be subject to endogeneity problems and omitted variables for the case of the Moroccan economy. Therefore, future research perspectives should include other variables relevant for the activation of the economic growth process driven mainly by foreign trade in order to derive a broader and more detailed representation of the Moroccan economy in its complex and heterogeneous international environment. Similarly, the study needs to adjust the trade openness index to assess individual sectors' impact of foreign trade on the country's economic growth.

Acknowledgments

We thank anonymous referees for their valuable comments and remarks on this initial draft of the paper. The usual disclaimer applies and views are our sole responsibility.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 433-440 ISSN 1339-5629

doi:10.22306/al.v9i4.341 Received: 08 Oct. 2022; Revised: 09 Dec. 2022; Accepted: 21 Dec. 2022

MODELLING AS A TOOL OF MAKING THE COMPANY'S LOGISTICS MORE EFFICIENT

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Keywords: modelling, layout, design, manufacture, logistics.
Abstract: The subject of this article was connected with the problem of finding an effective layout of manufacturing mechanisms in a particular manufacturing hall in DELTA Company, where we were part of a project team. The project team's goal was to solve the problem associated with the actual layout with the help of modelling and designing. It was necessary to analyse the actual layout and also opinions and possibilities of changes in this particular manufacturing mechanism. It is the manufacturing hall. For the analysis of the actual layout, we decided to work with different analytical methods because there were a lot of elements in this manufacturing system which have their own characteristics that are also connected itself or with others. It was necessary to look at all of these characteristics and their connections, and the result will be based on a prime scheme model of design variations for finding an effective layout of manufacturing mechanisms for a particular hall in DELTA Company.

1 Introduction

Nowadays, logistics is one of the most important factors that dynamically effect the world economy. The common trend is globalisation, which is changing the traditional management of company objects and the management of the company itself. The literature made by *Malindzak, D.* [1] states that "the objects of logistics are financial, material and information flows, flows of people, goods and materials". In the publication of *Madarasz, L. et al.* [2] is mentioned the fact that "by process management, we understand the provision of a predetermined goal by means of controlling specific devices based on evaluation and processing information that aforementioned devices will receive back not just about the object itself, but as well as about the effects of the environment on this object." This leads to the so-called global optimisation, which requires considerable attention from experts and engineers whose goal is to continuous improvement, innovation and elimination of system deficiencies, which will ultimately lead to an increase in the quality of work, products and the working environment itself while maximising the use of capacities and potential while incurring minimal costs connected with it. The definition of the global goal by *Takala et al.* [3] states that a global goal "is given by optimisation criteria" meanwhile "logistics management directly or indirectly solves the problem of multi-criteria optimisation, such as maximum use of equipment capacities, minimisation of energy and material consumption, profit maximisation, etc." where "these criteria can be supportive or conflicting".

However, the goal of logistics is to meet these criteria, especially from a time point of view, which will lead to cost minimisation and profit maximisation [3]. Practically optimising the problem and finding an effective solution and subsequently achieving the global goals can be easily achieved not only thanks to an in-depth analysis of the problem itself but also by fulfilling smaller sub-goals. One of the tools with which it can be achieved is the process of modelling and planning. *Straka, M. et al.* [4] relies in their work on the fact that "modelling is the process of replacing a dynamic system with its simulation model" and also "modelling includes the creation of non-simulation models, and their use can also be used for production purposes."

During modelling, we can not forget about the rule, which is a state in *Hradecka, J.* publication [5] "when planning and creating, it's also necessary to pay attention not only to the practical, aesthetic but also to the ergonomic side" which will lead to the effective layout. When we are talking about layout, we mean objects that are organised and arranged according to a certain taste under certain conditions. In our case, it will be from the point of view of architecture. The interior design tries to create a functional layout as a part of the overall concept.

2 Literature review

When it comes to the definition of redesign, there are plenty of meanings. For example, it depends on the dictionary that we use. In Merriam-Webster dictionary, redesign is definite as a "revise in appearance, function or content [6]. When it comes to Cambridge dictionary, redesign is the definition of changing "the way something looks, is made, or works" [7]. Portal Seobility states that redesign is "visual upgrade or rearrangement of an existing" subject, system, etc. [8] easily said it is a plan for making changes. In the publication, Universal Principles of Design by Lidwell, W. et al. [9] mentioned that the key principles of design were selected from various design disciplines based on several factors. The authors also stated the fact that even the best designers sometimes disagree on the principles of design. When they do so, however, there is usually some merit attained at the cost of the violation.

Therefore, unless you are certain of doing as well, it is best to advise the principles [9]. But we can sum it up in the following steps:

1. definition of a goal – what we want to achieve,
2. who is responsible for the redesign,
3. design process – examination of the monitored object, its elements and description of how it works, limitations,
4. modelling – creation of an idea of the monitored object and its functioning,
5. verification of correctness,
6. verification of truthfulness,
7. testing,
8. application [4,8].

Modelling includes the creation of models and designs other than simulation, and their use can be for other purposes as well. It is important to remember that when creating and designing a layout, it's important to know the dimensions of the space we are working with. In addition, it's necessary to pay attention to requirements such as:

- structures,
- security,
- medical and psychological,
- economic,
- manufacturing,
- and others.

It is also important to be aware of the basic functions of the space with which we are working, i.e. all activities must be kept in mind, as well as the functions mentioned above that will be performed and occur at the given workplace. In this case, it's necessary to consider the fact that in a specific production hall, the workplace will mainly involve the movement of people, material handling equipment, and the movement of storage handling equipment. If we are planning the layout of the workspace, it's necessary to take into account a place for relaxation and rest, as well as other facilities. In addition, we must pay attention to the following:

- environmental quality (heat, light, ventilation, air extraction, air circulation, …)
- the comfort of space and security
- spatial solutions
- necessary workplace equipment [10].

3 Methodology

The DELTA Company, which is the subject of the investigation, is currently one of the world leaders in refrigeration in the field of hermetic compressor manufactures. The idea of DELTA Company is continuous improvement and innovation to increase the quality of products, work but also the environment where we work or live. Because the company prefers modernisation, it decided to innovate one of its production processes in a particular manufacturing hall in one of its factories. The project we were a part of was financed by various investors, who, however, all set one condition, which was presented by the global optimisation of the entire production hall and not only the production process. The problem which we worked on was associated with finding an effective layout of the manufacturing mechanism in the particular manufacturing hall, which we mentioned earlier. Reconsidering the condition of investors, we set our goal, which was not also to find the most effective layout of a particular manufacturing hall but we needed to include the most effective layout of all mechanisms. Thanks to this, we can get closer to global optimisation. But before that, we needed to start by analysing the current state. For this purpose, we used system analysis.

System analysis is a method of general systems theory for exact and empirically intuitive investigation of basic properties and target systems in various areas of human activity. In the analysis process, we look for individual systems and try to modify or replace activities, connections or relationships in the given system. The process of system analysis represents the main activities, such as the definition of the problem (what we are investigating), the research and analysis of the associated systems, the determination of the appropriate method of solving the given problem, the introduction of a new proposal and the subsequent evaluation and feedback. For this reason, system analysis represents a relatively wide set of different methods and procedures for the most detailed analysis and analysis [11]. System analysis is a suitable tool for analysing the state of the system, as it examines not only its elements and the relationships and connections between them but also the elements, their properties, and the connections between them. Thanks to this, we can get to know the system's functioning in detail and subsequently derive individual results of observations and evaluations from the research. This analytical method is used especially in cases where we want to improve the given system or completely replace and create a new one, which was our case.

3.1 Current state analysis

After we decided which type of analysis we would use, we could start with an analysis of the current state of the company's manufacturing hall.

3.1.1 Manufacturing process

Before we could start with modelling and creating a design of a particular manufacturing hall, it was necessary to understand how the production works and what limitations may occur in the process. Usually, it all starts with entering materials into production, which in these cases are direct and indirect materials. Direct material is supplied in 900 kg blocks of Aluminiu from the supplier, and then they are processed into 8 kg ingots in one of the manufacturing halls in DELTA Company. Indirect materials are rotor packets, which are manufactured directly in the company. The real production process

begins with preheating rotor packets at a temperature of 450 °C at the induction heating robot. Meanwhile, the ingots are melting in a melting furnace at a temperature of 750 °C. Both temperatures must be at exact numbers to maintain the production process's accuracy, which leads to the final product's final quality. The next step is a new innovation in the production process: the centrifugal casting of rotors. Then the process continues with chilling, and subsequently, the finished products are moved to the finishing station. Under final processes, we can imagine processes such as cutting, rolling and, of course, quality control. The last step is to load the final products into pallets. More specific information is in the publication of *Spirkova, S.: Analysis of the possibility of changing the layout of production facilities in a particular company* [12].

3.1.2 Requirements

Even if we learned how it would work, checking all the details connected with the new production process was necessary. First, we started with the production process, machinery and equipment itself. There were a lot of technical (separation requirements for machinery and equipment), technological (efficiency, performance, speed), mechanical (temperature transfer and absorption) and one of the most important time requirements (scheduled times within the technological and production process) which must be observed, because then the final product will not be able to satisfy the final quality of products, which is most important. Because we are speaking about global optimisation, it was also necessary to check all requirements for the workplace, inputs, and outputs cause they're also part of the successful completion of the product. As we are speaking about, workplace requirements include manufacturing mechanisms and also handling space. But what is specifically important it's the quality control of inputs before they enter the production process. If it comes to direct material, it is necessary to have 99.9% content of Aluminium. Indirect material includes quality requirements such as strength, hardness or weight, but also measurements where important are length, diameter, thickness and angle of the rotor. All of the inputs must satisfy exact requirements, which will lead to reaching the highest quality of the final products, which is connected with requirements for output. The company demands control of compliance with production and technological processes, quality and measurements of final products. It's necessary to mention daily manufacturing standards, which we couldn't forget because they must be strictly observed according to the stated manufacturing plan, which you can see in Table 1 [12].

After observing and recording all requirements, we could start analysing the current state of the company's manufacturing hall. Supplying the production process is based on forklift and handling units. It's good to point out that some special handling units are used in the company, which are connected with supplying the ingots. More detailed information and photos are in *Spirkova, S.* publication [12] which I mentioned earlier. The supplying system may be considered a small detail, but in the end, it is also an important part of the system, and we are speaking about global optimisation, so it was necessary to notice that in our analysis. The whole place looks really crowded, which can lead to many collisions and injuries. Due to that, we decided that we would make an FMEA analysis.

Table 1 Daily manufacture standard

Request for individual manufacturing lines			
Manufacturing line	The average weight of used Al (g/pcs)	Manufacturing cycles (s/pcs)	Daily intake (pcs)
T	184	10.7	3800
J	204	10.7	1500
NB	163	7.4	9500
EM	169	6.7	9100

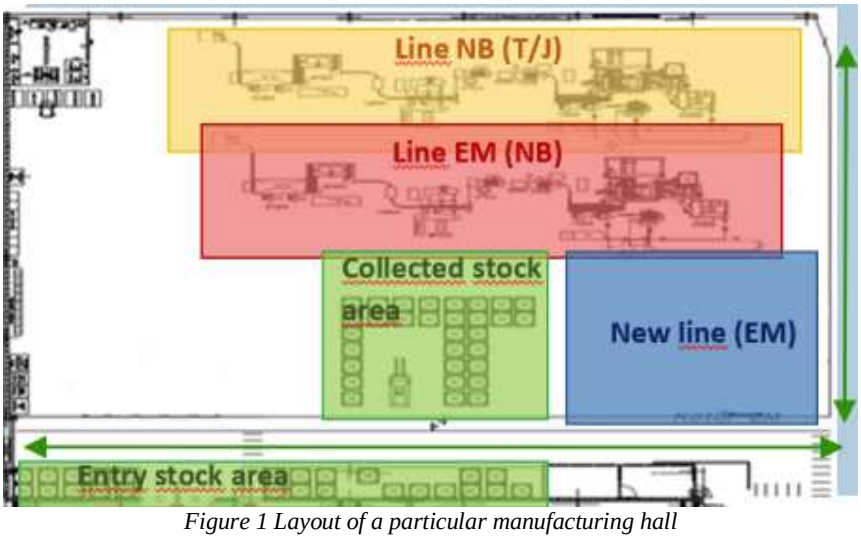

Figure 1 Layout of a particular manufacturing hall

Failure Mode and Effect Analysis (FMEA) belongs to the group of basic analytical methods, but it is mainly used in the field of quality, reliability and safety management. It acquires its use not only in the field of production, services, and many other industries and processes. The first step is the definition of the problem, the error. In the second step, we approach the numerical expressions, which we calculate based on the monitoring and evaluation of the individual investigated phenomena. It is, therefore, necessary to find out the values of the occurrence of the error or problem and their significance and assign the degree of detection of that problem and error. The last step is the product of the individual values, which will give us the so-called risk number. According to experts, the risk number should not exceed 125. This value is considered critical, and errors or problems whose risk number exceeds this value must be corrected or eliminated. We must not forget the values that approach this value, where it is also necessary to consider their correction [13,14].

Thanks to all information mentioned earlier, conversations with employees and managers, and our observation. We were able to puncture risks and problems connected with this layout, which you can see below.

The analysis of errors and risks in the particular manufacturing hall can be easily found in *Spirkova, S.* publication [6]. FMEA analysis describes in detail all subjects of analysis, the manifestation of errors, their potential causes and effects, occurrence, detections and also possibilities of control, which led us to risk number. Since it is global optimisation, it was also necessary to recalculate the costs associated with the production process with this particular layout. You can see the leading indicators and monetary expressions connected with the current layout in Table 2 [12].

The total costs associated with this workplace amounted to a total of 4.310 euros. The costs in the table are averaged according to the data that the company monitored for a period of 5 years. However, we have also included a potential risk indicator in the table. It represented up to 50 possible risks, which is relatively large given the dimensions of the production hall of 42,000 x 36,500 cm. We obtained a potential indicator of safety risks based on the FMEA analysis we created. As part of this analysis, we made Table 3 based on observations.

Table 2 Costs and indicators associated with the current layout

Leading indicators and monetary expressions	
Indicators	Expressions
Fuels consumption (euro/month)	2280
Electric energy consumption (euro/month)	230
Maintenance costs (euro/month)	1125
Labour costs (euro/month)	675
A potential indicator of security risks	50

Table 3 FMEA analysis

Analysis of errors and risks in the manufacturing hall									
Nr.	Subject of analysis	Manifestation of error	Potential effect	Potentional cause of the error	Possibility of control	Meaning	Occurrence	Detection	Risk nr.
1.	workplace enviromen	crowded working space	chaotic movemts	wrong decisions of managment	system aproach	6	20	2	240
		small space for manipulation and movements	opacity	wrong decisions of managment	system aproach	10	11	3	330
2.	working methods	improper way of using devices	high change of failures	human factor	education and motivation for taking responsibility	3	3	9	81
		losses and wainting	production ineffeciency	human factor	work organization	10	8	1	80
3.	employees	inattention	high change of risks	human factor	education and motivation for taking responsibility	10	2	2	40
		weak/bad qualification	faulty piece	human factor	trainings	10	6	1	60

Table 3 includes the basic areas of risks, their manifestations and potential impact. The areas of risk were mainly represented by the workplace environment, work methods and the employees themselves. We then assigned the most common possible manifestations of risks to these areas. Each risk was assigned a degree of importance, which we chose according to the degree of danger from the interval from 1 to 10. The greater the degree of importance, the greater the risk. The greatest degree of danger occurred in the area of the workplace environment, where this risk manifested itself in the form of a small space for manipulation and movement, in the area of methods in the form of losses and waiting, and in the area of employees in the form of inattention and unqualifiedness [12].

Next step, according to the results of observations and monitoring, we assigned values for the number of occurrences of given risk manifestations. Subsequently, we assigned detection values to each of these manifestations of risks, which represent the values of the expected chances for finding out whether or not it is a risk. Values were assigned from an interval of 10 to 1, where the value with the largest number was likely to be the most noticeable. We then multiplied all these indicators to obtain a risk number. The risk number represents the value by which we determine the degree of danger. Whether the risk needs to be eliminated or removed, we find out according to the limit value, which is given as the number 125. In our case, we exceeded this value in 2 cases, in the form of a risk associated with an overcrowded workplace space and a small space for manipulation and movement itself. The risk number for an overcrowded workplace was 240, which is almost two times the limit value. Much worse was the risk number for the small space for manipulation and movement, which reached a value of up to 330, which is even more than 2.5 times the limit value. Both cases recorded alarming values and gave us an idea of the magnitude of the danger, which must be eliminated as much as possible or removed completely. The other values were around the values of 80, 60 and 40. These values are not so alarming, but in general, the FMEA analysis gave us an idea and an indication of the main problem of creating risks and the dangers associated with them [12].

4 Discussion and results

The analysis of the current state helped us to set our goal, which was simply to design and create the most effective layout where will be minimal risks and errors, which will lead to global optimisation in the particular hall of DELTA Company.

4.1 Modelling as a turning point

The aim of this work was the analysis of the possibilities of efficient distribution of production equipment in the production hall, while the problem is related to the search for efficient distribution of production equipment in a specific production hall. This task also results from the results of the FMEA analysis from the previous chapter, where deficiencies were identified precisely within the workplace environment. We were able to come up with results thanks to the workplace modelling process.

4.1.1 Model nr. 1

In this model, we keep maintaining material flow and the original area of manufacturing lines and the entry area stock. We suggested removing the kanban table, washing machine and cylinder cover because these types of machinery were not connected to our production process and also just to make the whole place less crowded. We also suggested adding a new line in the original position of the kanban table and cylinder cover and replacing the washing machine with the collected stock area. You can see the first variation of the model below.

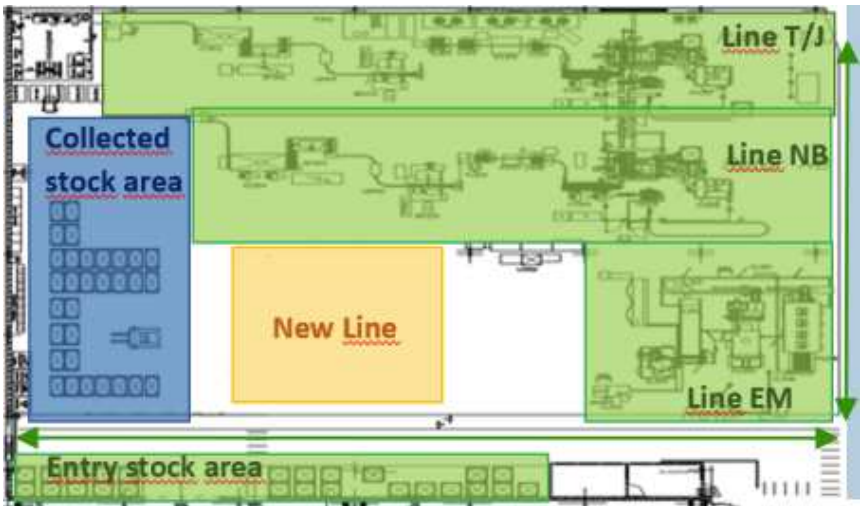

Figure 2 Variant nr. 1

But then there was a question if this is really global optimisation and if we will keep all the old lines and just add a new one. So that was the reason why we decided to make a second model.

4.1.2 Model nr. 2

Again in this particular layout, we decided to keep maintaining material flow and entry stock area. We also insist on removing the kanban table, washing machine and cylinder cover for the previously mentioned reasons. But we also suggested removing line T/J because this particular line was the oldest one. Conversations with managers and employees confirmed that there were often a lot of problems and they required to be repaired all the time. So after removing the mentioned machineries and equipment, we suggested relocating a line NB in an original line T/J and relocating the production process from T/J to the NB line. Next, we did the same with lines NB and EM. We also replaced the cylinder cover with the collected stock area, which ultimately created a new larger space, which you can see below.

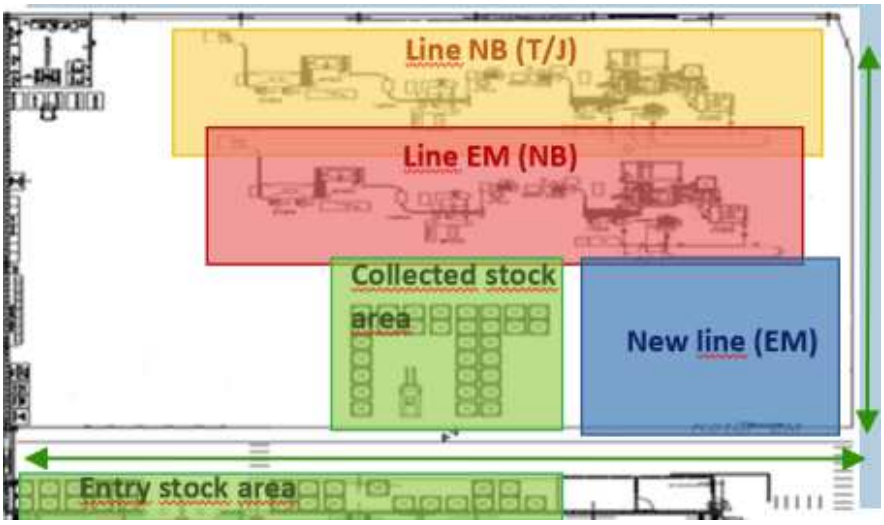

Figure 3 Variant nr. 2

4.1.3 Model nr. 3

After modelling variant nr. 2, we realised that this new space was located at the end of the manufacturing hall, and we would like to add the collected stock area in the end so there will be less manipulation with the final products. Based on that, we just slightly changed variant nr. 2, everything is almost the same, but the change is in the relocation of the new line and collected stock area to the other side of the manufacturing hall, which you can see below.

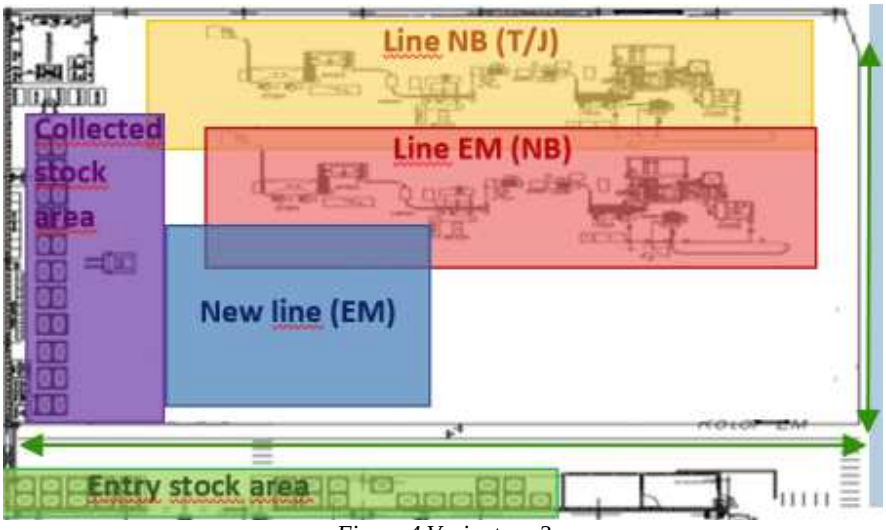

Figure 4 Variant nr. 3

4.2 Results of the modelling process

Our next step was to submit our models to the company. The company project team decided to work with our last design, which was slightly edited. After studying our models, the company's project team decided to develop a new layout, which will be the final model.

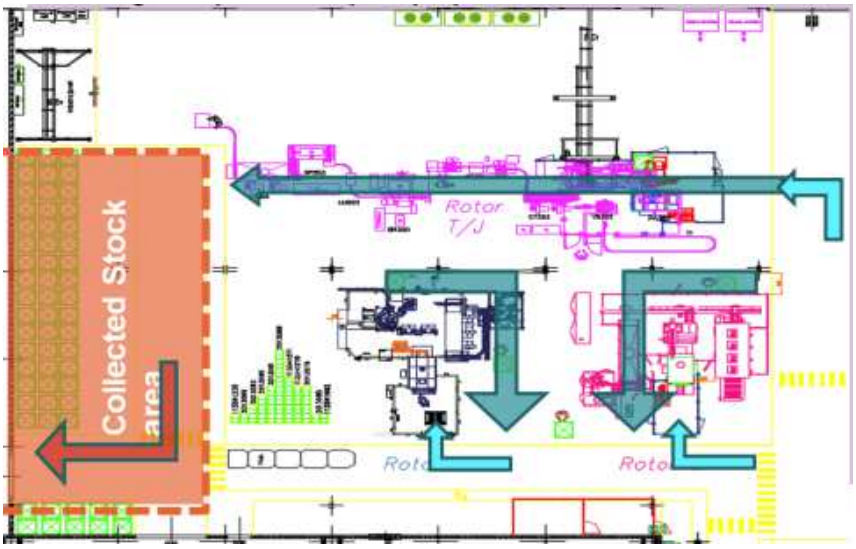

Figure 5 Final layout

It was decided to remove line T/J and replace the production process with line NB. They also edited the new line and line EM layout, so it will take a smaller place and keep our suggestion to produce rotors NB at line EM and rotors EM at a new line. The washing machine with the collected area was replaced, but for a specific reason, they decided to keep the kanban table for future plans. This whole decision is also connected with empty space in the back of the hall. As we look for results, whether it is the global optimisation or not, the company project team defines new monetary expressions and leading costs connected with the new layout, which is in Table 4 [12].

Table 4 Costs and indicators associated with the new layout

Leading indicators and monetary expressions	
Indicators	Expressions
Fuels consumption (euro/month)	1115
Electric energy consumption (euro/month)	55
Maintenance costs (euro/month)	425
Labour costs (euro/month)	0
A potential indicator of security risks	0

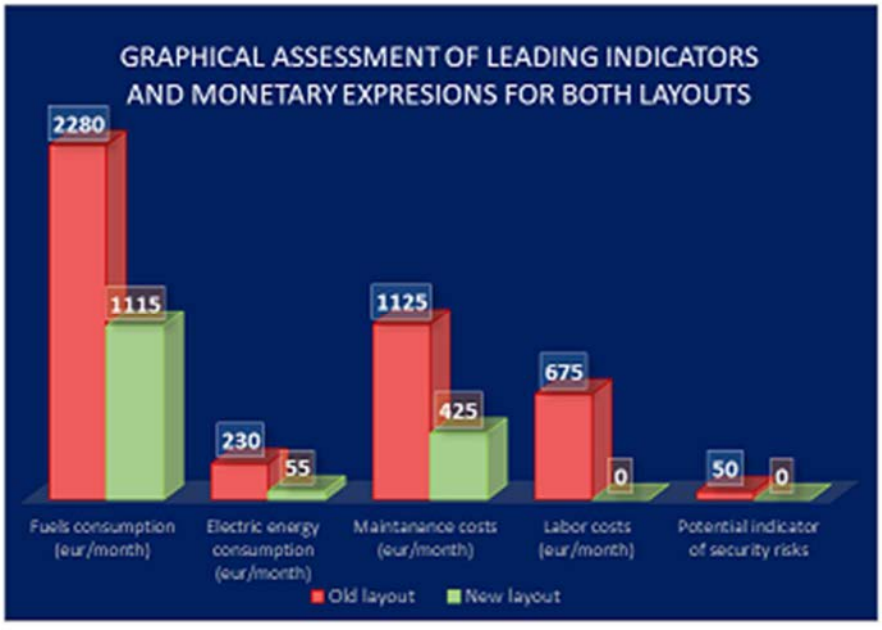

Figure 6 Comparison of the costs

In the end, we can state that even if our model was not final, it was the basis for the final layout, but that was already the company's intention for the future, which we couldn't know about, but we still influenced that. We helped to make an effective layout for global optimisation, and our last step was to review what was achieved. When we compared the results, we found out that the company can save 68.75% of the original monetary, while it decreased from 4310 euros to 1595 euros per month, as you can see in Figure 6 [12].

We can consider this a huge achievement, but a small "huge" problem is connected with it. Company states and insist that with this particular layout, it can be reached unbelievably zero potential indicators of risks and problems, which, to be honest, is not possible, and we can call it utopia because it's practically impossible to achieve something like that. Even if we made the most effective layout and succeeded in global optimisation, there is no proof that it can be much better in the future and that nothing will happen. It's impossible to state that there will be no collisions or injuries and no risks and errors. If we neglect this "fact", we can still state that saving almost 69% of original costs is a pretty nice achievement and satisfaction, because all the money that will be saved can be used for new inventions in the future so the company can continue to fulfil its motto.

5 Conclusion

The purpose of the article is to point out the importance of modelling in terms of industrial engineering. Modelling and redesigning the investigated object provides an opportunity to study the expected results of different types of designs or models far cheaper than manufacturing prototypes, not to mention trying it in real life. It's easier to point out what is wrong and what's not working and make collisions or errors in the system, which give us to givin the best chance for an optimal result in just a few variants. Thanks to modelling, we can test and improve hypotheses and make it the most efficient system possible. What is also important is that it helps us to make and test real-world problems safely without any further harm. We could simulate things in a few hours or months, which could take years if we did not simulate them. Modelling saves time and lowers costs but creates safe and effective solutions. In the current position of technologies and usage of Industry 4.0 in companies, there is no doubt that modelling and redesigning is a key parts of the way to efficiency and competitiveness. The logistics industry will for sure continue to advance and integrate new technologies and methods to make companies more efficient. In the upcoming years, strong and adaptable companies will survive, while resistant companies will languish and fall far behind their competitors.

Acknowledgement
The VEGA Grant Agency funded this research. The submitted paper is a part of the project "Research and development of new smart solutions based on the principles of Industry 4.0, logistics, 3D modelling and simulation for streamlining production in the mining and building industry" VEGA 1/0317/19.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 441-448 ISSN 1339-5629

SUPPLY CHAIN RISK MANAGEMENT IN DAIRY INDUSTRY OF THE CZECH REPUBLIC
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doi:10.22306/al.v9i4.343 *Received: 10 Oct. 2022; Revised: 07 Nov. 2022; Accepted: 29 Nov. 2022*

SUPPLY CHAIN RISK MANAGEMENT IN DAIRY INDUSTRY OF THE CZECH REPUBLIC

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Keywords: agri food chain, diary industry, management, logistic, risk.
Abstract: Food production is one of the key sectors of the food industry in the Czech Republic and the European Union. Its direct link to the primary agricultural sector is also crucial, from which it takes inputs, which it further processes and markets. A necessary condition for this process is the quality and safety of the commodity produced. The businesses must demonstrate food quality and safety through an effective system of traceability and traceability of these criteria. These conditions significantly affect aspects of production and logistics. The paper is focused on the dairy industry. This industry forms an essential part of the entire agri-food chain. Processes in enterprises of this type are specified in that several regulations affect production and logistics operations. Raw materials and products are perishable. On the other hand, the customer expects a quality and safe product at the right time. The paper's main aim was the identification of risks in individual phases of the dairy industry logistics processes. The area of purchasing, production, and the transport was examined in particular. The secondary aim was to expand theoretical knowledge of dairy management. Expert studies and scientific articles in this area are insufficient.

1 Introduction

The food industry is a mainstay of all European and world economies [1,2]. Lukiewska and Juchniewicz state that the sector is significant for long-term sustainable growth in Central European national economies [3]. The food sector is one of the critical branches of the processing industry in the Czech Republic. Trnková et al. stated that supplies food to the market and thus ensures the population's diet [4]. Farmers are the backbone of our society, and they support the whole world´s population [5]. The food industry also plays a significant role in essential macroeconomic aggregates. According to the Ministry of Industry and Trade, the food industry accounted for CZK 322.2 billion in sales of its products and services in 2019, which is approximately 6.1% of sales in the entire manufacturing industry 2019. In 2019, the food industry employed over 95,000 employees, representing 7.2% of employees in the Czech manufacturing industry. These indicators rank the food production sector among the essential domestic employers [6].

As stated by Syrůček et al. and Naglová et al., the production of dairy products is a mainstay of the Czech food industry [7,8]. A number of studies deal with the performance of the dairy and food industry in the Czech Republic [8-10]. High performance and competitiveness of the dairy industry and the ability to finalize the primary raw material into products with higher value-added (and successfully face the competition within the European and global market) are essential prerequisites for keeping the dimension of the milk production in the EU regions [10]. Businesses in the food chain are forced by the pressure of global markets and the ever-increasing demands on consumers and end-users to take a comprehensive approach to managing their activities. This management involves integrating food quality and safety with a risk management approach. They point to the significance of an integrated management approach within the agri-food chain [11,12]. Rapid and dynamic changes in the environment, technologies, consumer behaviour, policymaking, and climate are putting extra pressure on the food supply chain, especially in efficiently managing food security, food surplus, food loss, and waste [13]. Higher quality and safer food are still the highest priority in the food industry [14]. Food safety is an essential prerequisite for ensuring the health of the population. The Food Safety System was established in the Czech Republic in 2001. The essential tool legislation requires is the Hazard Critical Control Point (HACCP). As Havinga demonstrates, private standards are prevalent in the food industry in numerous

European countries [15]. Private food safety standards have become a critical governance mechanism in contemporary food supply chains [16]. International food safety management systems standards can be applied to all or part of the food chain. The standards can then be used as a risk identifier in individual logistics processes. The most commonly used standards include the British Retail Consortium (BRC) and International Food Standard Logistics (IFS Logistics). Several studies address international food safety standards and highlight the significance of their implementation in food safety management throughout the food chain [17-19]. The production and logistics process of the dairy industry has its specifics.

In research papers, we can find several definitions of logistics. The basic definition based on the Cambridge Dictionary states that it is the process of planning and organizing to ensure that resources are in the places where they are needed [20]. An activity or process happens effectively. Ghiani et al. add that it represents the functional activities determining the flow of materials and the relative information [21]. In this publication, we will learn that we can include here as well the service sector (water services, postal services, urban solid waste collection, and others). These definitions can be supplemented by Rushton et al., who list logistics as critical components – transport, inventory, and warehousing [22]. Kumarage explains that logistics is mainly associated with the supply chain processes and handling goods, not people [23]. The supply chain represents the processes that need to be done, from the primary raw material to the delivery of the final product to the final customer. As the title of the article suggests, the paper focuses on the field of agriculture, specifically in the dairy industry. In research articles, we come across concepts such as food supply chain and agriculture supply chain. Van der Vorst defines the agricultural supply chain involves all stakeholders, from farmers, agro-processors, distributors, transporters, and retailers to end consumers, aiming to provide a wide variety of consumer products that consists of fresh foods, meat products, a wide variety of processed food including beverages, canned foods, confectionery, and bakery or dairy products [24]. Rossini et al. added that practitioners and researchers identified the agricultural supply chain as a significant area [25].

On the other hand, we can find the definition of the food supply chain by the European Commission. The food supply chain is the direct exchange of food from the farmer to the consumer, or the different stages of activities such as the processing of raw agricultural commodities as well as the checking of consumer safety standards and packing or transport activities which add value to food products before they are sold. Based on these definitions, we can conclude that we are using two concepts – food supply chain and agricultural supply chain – which are identical [26]. Kumar presents A food supply chain network (see Figure 1) [27].

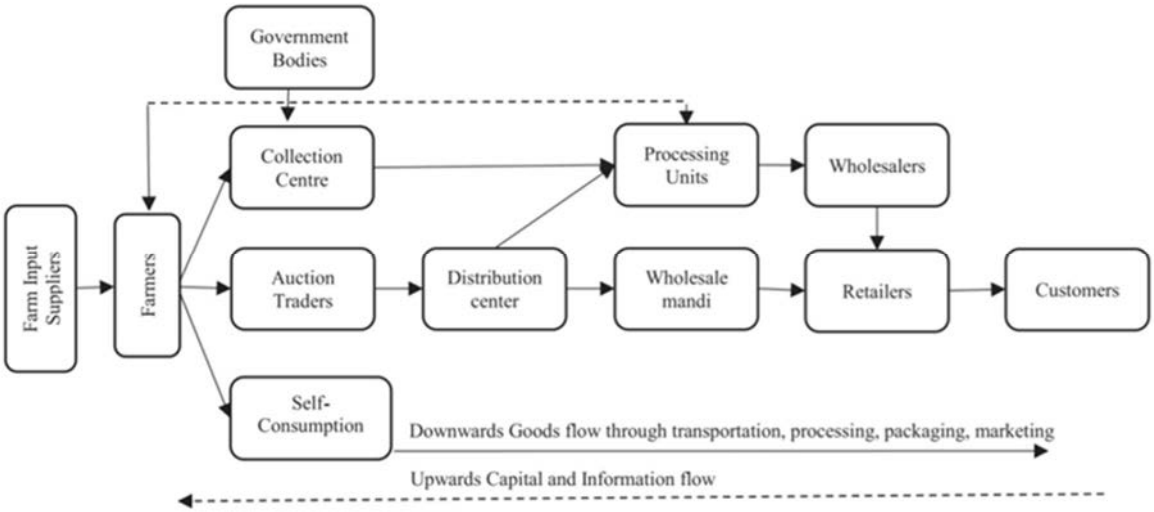

Figure 1 A food supply chain network, Kumar [27]

For all supply chain steps to work correctly, supply chain risk management must be implemented. Several authors recommend the implementation of supply chain risk management [28-30]. Within the supply chain, we may encounter several risks, such as risks in physical flow [31,32], currency, information, partnership, innovative opportunities [31], environmental and organizational risk [33], safety risk [34], and chemical and biological risk [32]. The ISO 31000 certificate is suitable for effective Food Supply Chain Risk Management. The paper aims to address risks in individual phases of the logistics chain in the dairy industry in the Czech Republic.

2 Methodology

Several scientific methods were used in this paper. It was mainly analysis, synthesis, comparison, and using statistical methods. The methods of analysis and synthesis were used by writing introduction. The method of

comparison was used when comparing the results of own research with already conducted studies. The main methods were Chi-square, which confirmed the statistical dependence between the method of transport of input raw materials and the size of the dairy enterprise. Furthermore, the evaluation was performed using basic descriptive statistics and box fences representations. The questionnaire survey took place in the month of September-November 2021. The questionnaire addressed a total of 72 dairy enterprises in the Czech Republic. Contact addresses were taken from the database of the Food Chamber of the Czech Republic. Thirty-five were received, and wholly completed questionnaires were processed. Incomplete or incorrectly completed questionnaires were excluded from the research. Therefore, the return is about 49%, which in this case is also the share in the basic statistical set. The questionnaire consisted of closed and open questions, and the size of the enterprises according to the number of employees also served as an identifier. In the category of up to 50 employees, 15 completed questionnaires were available. In the category of 51-250, it was again fifteen respondents, and in the size category of more than 250 employees, it was five respondents.

3 Results and discussion

The research was divided into four parts. Firstly, the issue of certification of voluntary quality, safety, and risk management systems in the dairy industry was addressed. It is generally possible to use the international certificates ISO 9001, ISO 31000, ISO 22000, the BRC, and IFS standards. Sixty percent of the addressed enterprises hold a quality certificate according to the ISO 9001 standard. Regarding differences in size groups, only larger enterprises have 100% representation of ISO 9001 quality certificate holders. For the other two groups, the holder: non-holder ratio is 8:7; in other words, about 53% of holders of a quality certificate are in other groups. Only two of the 35 enterprises surveyed hold an ISO 31000 certificate. The vast majority (94%) of enterprises do not.

On the contrary, a food safety certificate is a necessity. Eighty-nine percent (33 out of 35) of the addressed enterprises hold this certificate. Only four enterprises do not hold a certificate and fall into the category of small businesses. Of the food safety certificates (ISO 22000, standard BRC, and standard IFS), the most frequently used certificate was standard IFS when it was mentioned by 18 out of 35 (51%) enterprises contacted.

International standards for food safety management systems can be used as an essential tool for risk management in individual logistics processes of the entire agri-food chain [35] and certification of food safety systems affects the trust of individual links in the agri-food chain [36-38]. Hassan's study addresses the security of the milk supply chain and its failure factors, emphasizing the need to emphasize, inter alia, operational and transport management systems [39].

The second part is focused on the process of entry (purchase) of milk into the transformation process. The questions focused on importing raw materials and the selection and evaluation of suppliers. It was ascertained which criteria (location, quality, and price) they preferred for all the surveyed enterprises. At the same time, it was ascertained whether there were differences between the answers in the individual size groups of the addressed enterprises. Each addressed enterprise had the opportunity to determine the importance of individual criteria using the ranking method. To simplify the processing of the results, the first place was evaluated by three points, the second by two points, and the third by a single point. The best average point gain can be observed for all surveyed enterprises in the quality criterion (average = 2.46), followed by location (average = 2.14) and price (average = 1.4). Regarding the individual size categories, for small enterprises (up to 50 employees), there was an interesting agreement in all 15 addressed enterprises in this size category, where all enterprises are the most important criterion was chosen location (average = 3.00), followed by quality (average = 2.00) and then the price (average = 1.00). It is interesting to agree on the order of small businesses. However, a similar agreement has not been reached for medium-sized enterprises (up to 250 employees). In addition, there is a noticeable change in the order of the individual criteria. The best result can be observed for quality (average = 2.87), followed by price (average = 1.7) and last location (average = 1.40). For a small number of addressed large enterprises (over 250 employees), the resulting averages are more balanced; however, quality was determined as the most essential criterion (average = 2.60), followed by location (average = 1.80) and price (average = 1.60). It is clear from the results that for small enterprises, the location for the selection of suppliers is important; for other enterprises, it is mainly quality.

Due to the coronavirus pandemic and other external threats, flexibility in supply chains is being disrupted. Therefore, it is essential to have rules in selecting suppliers incorporated into the purchasing management system. As Rahman States, with the advancement of manufacturing technology and globalization of supply chains in the fourth-generation industrial revolution, manufacturing industries face significant pressure to improve customer satisfaction and maintain their position in the global market [40]. It is confirmed by the Pakula study that correctly defined criteria for the selection of suppliers of raw materials have the effect of reducing operational risks [41]. Only 5 out of 35 enterprises contacted do not require any standard or certificate from their suppliers. The HACCP law requires the remaining 30 enterprises (63.3%), followed by the IFS or BRC food safety certificate (43.3%), and 20% of enterprises request the ISO 9001 certificate. Only 3 out of 30 enterprises require more standards or certifications from their suppliers, equal to 3. Only one is enough for the remaining ones. Research confirms that international food safety standards are

necessary for the agri-food chain. As further studies show [36-39]. 11 of the 15 small enterprises contacted (up to 50 employees) to import input materials through their suppliers. In comparison, medium-sized (51-250) and large enterprises (over 251 employees) use mainly external carriers. Together, 18 of the 20 enterprises contacted are used by external pages in this combined category. Combining the two largest size categories made it possible to examine the dependence using a four-field table, where the results confirmed the statistical dependence, where X2 (1, N = 35) = 14.7261, p = 0.000124. We can accept hypothesis H1: The mode of transport of input raw materials is affected by the size of the enterprises. Input raw materials are imported using suppliers' means of transportation more often in smaller enterprises than larger ones.

Thirdly, the research is concerned with the production process and the associated operational risks. As already established, the production process is harmonized with the requirements of international food safety standards at most dairies; regarding the use of the information system, 27 of the 35 enterprises contacted use an information system, which is about 77% of respondents. At the same time, there is a significant dependence between size categories. With the larger size of the enterprises, the greater the likelihood of using the logistics information system. For small enterprises, 60% of enterprises use the logistics information system, in the middle category, it is already 87%, and in the highest category of large enterprises the share is already 100%. By combining the two largest size categories, it was possible to examine the dependence using a four-field table, where the results confirmed the statistical dependence, where X2 (1, N = 35) = 4375, p = 0.03647. We can therefore accept hypothesis H2: The size of the enterprises affects the use of the logistics information system. The main benefit of introducing the logistics information system in 24 of the 27 enterprises is the traceability of the quality of milk/products and their batches from each order. Other frequent benefits are up-to-date data and time savings in administration.

Aung and Chang emphasize that traceability is essential in ensuring food quality and safety [42]. Traceability is a tool for meeting quality and safety requirements throughout the food logistics chain. It is confirmed by Aworth's study that traceability has become an essential feature of the global food supply chain with the growing food safety concerns and the globalization of food production and distribution [35].

Digital technology can profoundly positively impact agriculture outcomes in developing countries by improving market transparency, enhancing farm productivity, improving rural households' food security, strengthening logistics and optimizing supply chain management, and improving food quality and safety [35]. Of the 35 enterprises contacted in this survey, 16 enterprises are considering or have already implemented complete digitization; the remaining 19 com enterprises panies are not considering full digitization even within five years. Two-thirds of the small businesses contacted (up to 50 employees) do not consider complete digitization within five years. On the contrary, the remaining third of the addressed enterprises have already implemented complete digitization (= 5). Two enterprises have fully implemented digitization for the medium-sized category, and seven medium-sized enterprises are considering complete digitization within five years. No enterprise already has complete digitization in place for large enterprises (over 250 employees). Two enterprises are considering complete digitization within five years. The remaining three enterprises are not considering complete digitization.

Risk mitigation is one of the essential aspects of supply chain risk management [43]; 24 of the 35 enterprises contacted to have a designated department or risk manager. All large enterprises have a risk department or employee in terms of size structure. It was observed in only 8 out of 15 enterprises and 11 out of 15 enterprises for smaller enterprises. A specific dependence can also be observed concerning a department or representative dealing with risks and the level of risk management in enterprises. Till 8 out of 11 enterprises that do not have a department or employee responsible for risk management address risks only by legal requirements. On the contrary, out of 24 enterprises with this responsibility, 15 enterprises have developed a risk register, and the remaining nine enterprises even have a set risk management system.

One of the things needed for risk-based management of food safety systems is understanding the risks and how they are generated in the food system [44]. Paillin et al. conducted research on risk assessment and mitigation throughout the food chain in social, environmental and economic dimensions [45]. In manufacturing, research on operational risks. Operational risk can be defined as the risk resulting from the shortcomings in information and internal control systems or external events such as fraud, resulting in unanticipated losses. Next, it could be the risk related to either human errors, system failures, and inefficient procedures that occur due to breakdown in internal control procedures, either in the front, middle or back-office activities, leading to unanticipated losses [46].

The frequency of operational risks was monitored at the surveyed enterprises in six primary areas:

A. Low-quality raw materials at the entrance,
B. Power failure,
C. Machinery and equipment,
D. Technology,
E. Human error,
F. Increase in operating cost.

The answers from the survey was evaluated according to a four-scaled evaluation of all six research questions A.x, B.x, C.x, D.x, E.x and F.x where x = 1 determines small-sized enterprises, x = 2 determines medium-sized enterprises, x = 3 determines large-sized enterprises and x

= all determines all enterprises together. The individual grades of the rating scale of frequency are defined as follows: 1 – (Hardly) ever, 2 – Rarely, 3 – Sometimes, and 4 – Often.

Measures of the location of the cases were found by mode and median. Measures of variability were found by discrete ordinal variance that was converted to the standardized form (NOR) for better comparison of indicators. All used statistical characteristics of collected data are presented in Table 1.

Table 1 Measures of location and variability of the cases A.-F

Cases	**A.all**	**A.1**	**A.2**	**A.3**	**B.all**	**B.1**	**B.2**	**B.3**	**C.all**	**C.1**	**C.2**	**C.3**
NOR	0.494	0.711	0.462	0.000	0.670	0.711	0.628	0.960	0.596	0.391	0.747	0.960
Mode	2	1	2	2	1	1	2	3	2	2	2	3
Median	2	1	2	2	2	1	2	3	2	2	3	3
Cases	**D.all**	**D.1**	**D.2**	**D.3**	**E.all**	**E.1**	**E.2**	**E.3**	**F.all**	**F.1**	**F.2**	**F.3**
NOR	0.647	0.782	0.687	0.000	0.431	0.711	0.308	0.000	0.522	0.332	0.664	0.000
Mode	2	2	3	1	3	2	3	3	3	3	3	3
Median	2	2	3	1	3	2	3	3	3	3	3	3

Poor input raw materials are perceived as a potentially small operational risk and are often not addressed by businesses. For small enterprises, it is possible to identify a larger degree of dispersion; however, the mode and median are equal to 1. Medium and large enterprises address the poor quality of input materials much more often than smaller enterprises. Still, the risk is not perceived as large because the median and mode are equal to 2, and the variance rates are quite small. Differences in responses can be traced to a power outage. With the enterprises growing in size, enterprises address energy issues much more often, at least based on mode and median. However, some ambiguity can be seen in the variance rates, which are quite high. The operational risks related to machinery and equipment are also not perceived as large, but their frequency and position increase with the enterprise's size. Technology-based operational risks are an unexpected outcome. In this category, risks occur most frequently in medium-sized enterprises, less frequently in small enterprises, and least (barely sometimes) in large enterprises. The last two research areas (human error and growth in operating costs) reach the highest median and mode values across size categories (human error in smaller enterprises to a lesser extent). Therefore, it is possible to label them as the most important and the riskiest due to the relatively frequent frequency and importance in operation. Like the first six areas of operational risk, methods for identifying operational risks were also examined:

G. based on experience and estimates,
H. brainstorming in a team,
I. Check-list,
J. Ishikawa Diagram,
K. What-if,
L. HAZOP,
M. FMEA.

The same methodology was used as in the previous case. The four-point range of responses remained unchanged, mode, median, and normalized variance were determined and compared. The change occurred only in the designation of individual examined areas.

Table 2 Measures of location and variability of the cases G.-M.

Cases	**G.all**	**G.1**	**G.2**	**G.3**	**H.all**	**H.1**	**H.2**	**H.3**	**I.all**	**I.1**	**I.2**	**I.3**
NOR	0.522	0.521	0.540	0.320	0.488	0.512	0.308	0.320	0.705	0.569	0.770	0.000
Mode	4	3	4	4	3	3	3	4	3	3	3	4
Median	3	3	4	4	3	3	3	4	3	3	3	4
Cases	**J.all**	**J.1**	**J.2**	**J.3**	**K.all**	**K.1**	**K.2**	**K.3**	**L.all**	**L.1**	**L.2**	**L.3**
NOR	0.516	0.474	0.415	0.640	0.466	0.581	0.154	0.000	0.135	0.154	0.154	0.000
Mode	1	2	1	1	1	1	1	2	1	1	1	1
Median	1	2	1	1	1	2	1	2	1	1	1	1
Cases	**M.all**	**M.1**	**M.2**	**M.3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
NOR	0.261	0.154	.0415	0.000	-	-	-	-	-	-	-	-
Mode	1	1	1	1	-	-	-	-	-	-	-	-
Median	1	1	1	1	-	-	-	-	-	-	-	-

Operational risk identification based on own experience and estimates is more often used in medium and large enterprises, to a lesser extent in small. On the contrary, the brainstorming method is widely used, especially in large enterprises. We observe relatively consistent responses in this area due to smaller variances.

The outputs of using the checklist method also look similar. It is also widely used for large enterprises, even in this size category of enterprises, even with zero variance. Ishikawa's cause and effect diagram is very rarely used in monitored enterprises and, if so, in small enterprises. The remaining methods, i.e., What-If, HAZOP, and FMEA, are rarely used. With the exception of the What-IF method, the frequency is very small, and no major disproportions were observed between the size categories of the enterprises surveyed.

4 Conclusion

Food safety and quality are essential aspects of the competitiveness of every food business. The dairy industry is the third most efficient food production branch in the Czech Republic. A whole range of legislative regulations affects dairy products' production and logistics. In addition, dairies can implement food safety standards that help them identify and manage risks that arise throughout the processing process. The research goal was to identify which risks this type of business encounters most often and which tools it uses to manage them. The research confirmed that businesses use voluntary risk management tools in connection with food safety, up to 89%. Companies eliminate entry risks by requiring these certificates from their suppliers. Within the processing process itself, traceability is a crucial factor. This is related to using an information system that eliminates the risk of losing traceability. The research confirmed the hypothesis that the company's size is related to implementing an information system for managing production logistics chains. Digitalization helps improve the traceability process. Research has shown that large and medium-sized enterprises are implementing digitization. While small dairies do not consider digitization in the five-year horizon. The research confirmed the hypothesis that the size of the dairy enterprise has an influence on the method of transport of input raw materials. Small businesses use supply means, large and medium-sized businesses use external carriers. The most severe operational risks for businesses in the dairy industry are human error, rising operating costs, and technological risk. The risk of low-quality raw material at the input is perceived as low. It is more common in medium and large dairies. Technological risk is also more common in medium-sized enterprises. The results were compared with the results of foreign studies. Further research will be expanded to include elements of reverse logistics and sustainability of food chains as stated by Fidlerová [47].

Acknowledgement

This paper was developed under the support of projects: RVO/FLKR/2021/03 Peterek, K.: Risk management in logistics, RVO/FLKR/2022/04 Heinzová, R: Lean and Project Management in manufacturing Industry in the Czech Republic.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 449-456 ISSN 1339-5629

doi:10.22306/al.v9i4.345 Received: 18 Oct. 2022; Revised: 11 Nov. 2022; Accepted: 03 Dec. 2022

QUALITY COST FLOWS IN MANUFACTURING COMPANIES

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Keywords: quality management, cost, cost of quality, PAF model.
Abstract: Companies have increasingly focused their attention on quality costs. Therefore, raising awareness of this group of expenses is essential. This paper aims to present a survey on the topic of costs of quality management in manufacturing companies in the Czech Republic. This paper opens with a literature review that focuses on the existing cost of quality models and then focuses on empirical research results. Manufacturing companies represent the framework of this research. The research with a total of 159 respondents provides information about the real market situation. The aim was to determine the significance of costs and cost-effectiveness. The study's findings revealed that 73% of organizations quantify their quality costs completely, 21% of companies quantify their costs only partly (external costs), and 6% of companies do not. 36% of surveyed companies (42 companies) that monitor quality costs use some of the recommended models, mainly the PAF model. The research was confirmed by hypothesis 1 that companies that use some type of evidence cost of quality have lower levels of these costs.

1 Introduction

Quality is a critical factor that significantly influences a customer's decision to purchase a product from a particular provider. Contemporarily, the market is affected by globalization pressures, which are characterized by an extensive portfolio of products that can be renewed, motivating companies and encouraging them to permanently improve their level of production and find new competitive advantages. Cost versus quality is the everyday question for the management of an organization. Everybody wants the best products but at the lowest price. However, it is complicated to find a boundary between minimum cost and maximum quality [1]. The company must always try to improve the quality of its production while at the same time striking a balance between the best quality and extraordinary costs for the company. [2]. Many studies have examined the measurement of quality costs and the quality level. Behmer and Jochem [3] claimed that the annual costs of poor quality amounted to approximately 15% of sales. Chiadamrong [4] estimated their proportion is around 10% of production costs and Evans and Lindsay [5] declared that costs of quality care from 20% - 40% of total costs in the company. These statements confirm that the high proportion of quality costs in the structure of overall company costs confirms that quantification of these costs cannot be ignored and requires an interdisciplinary approach.

The following chapters describe quality definitions and the different approaches and benefits of monitoring quality costs. The next part focuses on the research methodology and presentation, leading to the conclusion.

1.1 Definition of cost of quality

The first mention of quality costs dates back to 1951, but Juran states that there are different meanings for the term quality costs. It should be pointed out here that there is no clear definition for the term "cost of quality" Some people may see the term as a cost incurred in the separation of management [6,7]. From the perspective of quality-related costs, costs incurred due to coordination activities are hidden costs of non-quality. If these costs are excluded from the costs of quality, it systematically underestimates the total costs of quality[8]. Authors Evans and Lindsay [5] argue that in the case of costs, it depends on the actual situation of the business and its operations. According to Ireland [9], the term quality cost must be properly explained and understood in order to maintain optimal functioning and improvement of product and service quality. Some authors [5,7,11,12] describe quality cost as a set of three main categories: costs of failure (internal and external costs), evaluative costs and preventative costs. These descriptions are explained in overview Table 1.

1.2 Classification of cost of quality

Several tools and methods could be used for the costs of quality analysis. The most common models are the PAF model.

Table 1 Descriptions of quality costs

Type of costs of quality	Definitions
Insider costs	These costs are associated with defects that tend to be detected before they are delivered to the customer, making it impossible to satisfy the customer's needs [7].
Externalities	These costs are often discovered by customers and are reported as product defects [10].
Assessment Costs	These costs are aimed at meeting quality and performance requirements and are also associated with ratings, revisions and verifications [11].
Prevention Costs	These costs are set to keep breakdown and valuation costs as low as possible.

1.2.1 The PAF model

The measurement of quality costs was first done by Dr. Armand V. Feigenbaum in 1956. He divides the costs of quality into three categories [12]. These are the costs of prevention, evaluation and non-conformance.

The British Standard Institution as well as the American Society for Quality Control (ASQC) have adopted this breakdown and incorporated it into their standards. In production and services, this model is the most used [13]. According to author *Laura* [14] , it is possible to take advantage of this model to obtain easier data for processing and time lag. Another benefit is the fact that with the proper management of quality costs, the cost of prevention and cost of appraisal have an impact on the reduction of the cost of failure and the overall cost of quality [15-18].

1.2.2 The PCM model

The PCM model brings only two costs categories: Costs of compliance and non-compliance costs. According to Ireland [9], these are categorized as costs of planning, control processing, verification and controls and so on. Scrap, reworking and guarantee service, etc., are in the secondary classification. In the eyes of Goetsch and Davis [19], the costs of conformity cover the money for the products or services supplied in the most efficient way following the standard requirements.

It is a situation in which every activity is executed for the first time in conformity with the requirements. Not all costs of non-conformance are the costs that are linked with failures.

It is possible to apply this process model to any process, but it is necessary to identify the key steps process and the following parameters [19]. According to the authors Pires et al. [20], this approach follows the flow of activities in various departments of the company, while the traditional approach focuses on the activities of specialized departments. Lari and Aslanni [21] use the idea that using the cost of quality as a measure of the performance of the operating processes leads the organization to better performance results. The benefits of this model can be seen as the fact that exact costs are allocated to the process and that a specific person is established as responsible for the mistakes in the process [22]. This model allows the underestimated processes to become opportunities for improvement, helps management manage processes, allows for systematic management processes and improves customer service activities [21].

1.2.3 COPQ Model

This model is based on the assumption that non-compliance with customer requirements always causes producers considerable economic losses [23]. The uniqueness of this model is that it only records non-productive losses and thus neglects efficiently spent resources [24]. It monitors the cost in these four categories: cost of internal defects, cost of external defects, the cost associated with investment and the use of opportunities and costs associated with environmental damage. Very often, there is no evidence that would be able to track items from the last two groups [13].

1.3 Quantification of costs of quality

Cost of quality information helps the organization's management to evaluate its important quality issues and identify the most significant opportunities to reduce these costs [25]. Last but not least, it helps the organization to evaluate success in achieving quality objectives. Many authors have described quality costs as a necessary process for management in companies [26]. This process brings many benefits to businesses, such as achieving a higher level of product and service quality, reducing the cost of products and services, greater customer satisfaction [27] and improvements in efficiency, effectiveness and quality management system, including financial performance [28]. In addition, it reduces the number of complaints, lowers the cost of failure and increases sales volume [29]. Other benefits include the ability to report a complete overview of the company's quality costs, classification and analysis of associations, costs for different levels of management and assistance for the development of tracking methodologies. [30]. Although it is shown that quality cost tracking has many benefits, it must be said that this concept is not being given sufficient attention [31]. The authors Sower and Quarles [16] and Kiani [15] provide evidence in their work that monitoring quality cost is not as widespread as expected in the world. The concept of quality cost management enterprises was not accepted despite the fact that this indicator should be included among business performance indicators [32]. Reasons for the problem are the lack of standardization and an inadequate

understanding of the concept principles [33]. The next type of problem could be the fact that the relationship between the people in the organization is such that costs can not be discussed openly without fear of punishment [34]. In an organization where the atmosphere is open and problems are communicated without fear and punishment is, the quality system more effective [33-34]. Authors Mantri and Jaju [35] draw attention to the fact that a lot of companies use their own methodology for evaluation and that the data was collection still manually although technologies are implemented.

2 Methodology

The aim of the research was to find out the level of implementation of quality cost control in manufacturing companies of the Czech Republic.In the first step, the authors performed a quantitative analysis to get fundamental knowledge about the current situation. Based on the results of theoretical research, the following hypotheses were defined:

H1: Companies that quantify quality costs and use for it some systems have lower costs of quality than others.
H2: Characteristics of companies that quantify quality costs are different compared to companies that do not quantify quality costs.
H2a: Large companies quantify quality costs to a greater extent than small and medium-sized companies.
H2b: Multinational companies quantify costs more than domestic companies.
H2c: Companies with mass and serial types of production quantify costs to the extent that companies with piece types of production.
H3: Companies see the biggest problem with monitoring costs of quality in inappropriate methodology.

Questionnaire-based research was used to obtain data for evaluating the above-mentioned hypotheses. Besides the initial basic information and classification questions (industry, size of the company, type of production and owner structure), the questionnaire includes five questions related to the level of cost of quality management and the next four questions describing the results of this system in the companies. The type of questions is shown in Table 2.

Data were collected through an electronically distributed questionnaire. A total of 159 manufacturing companies from different industrial areas participated in this survey. The questionnaire was sent to 1412 companies, and the effective rate of returned questionnaires was 11.3% which is considered satisfactory. The questionnaire was designated to the representatives of the quality departments as the most known persons in this process in the company. The structure of respondents is described in Figure 1. This figure represents the structure according to the European classification of economics activities (NACE classification)

Table 2: Type of questions

Number	Question
Q1	Interest in monitoring costs of quality
Q2	Costs monitoring using the model
Q3	Type of using models
Q4	Type of monitored costs categories
Q5	Type of monitored current costs
Q6	Level of costs of quality
Q7	Improvements in specified areas
Q8	Advantages and disadvantages
Q9	Obstacles and opportunities

Source: Authors

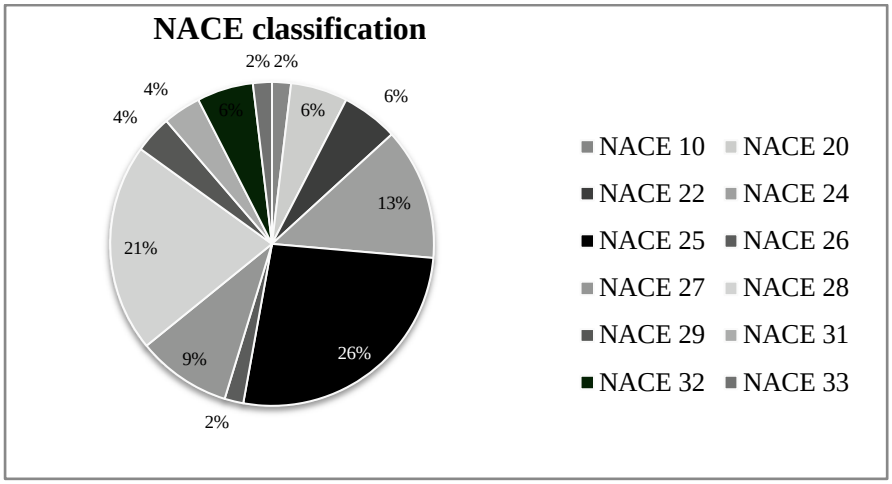

Figure 1 Structure of respondents
Source: Authors

The following Table 3 shows additional basic information on the composition of respondents. Most of the companies in the sample are small and medium (62.2%), while large companies account for 37.8% of the sample. More than half of the companies (53.5%) have a foreign majority owner, while only 46.5% of companies have a domestic owner. Almost of companies is with mass or serial type of production (59.7%) while companies with piece type of production is 40.3%.

Table 3 Sample description

Characteristics	Variable	Companies	%
Company size	Small and medium	99	62.2%
	Large	60	37.8%
Business segment	Domestic majority owner	39	24.5%
	Foreign Majority owner	49	30.9%
	Subsidiary company - foreign majority owner	36	22.6%
	Subsidiary - domestic majority owner	35	22.0%
Type of production	Piece production	64	40.3%
	Mass production	20	12.5%
	Serial production	75	47.2%

Source: Authors

In order to test the research propositions, several statistical methods were used. One of the applied methods was the t-test for independent samples. This test was deployed to test the differences in the characteristics of the costs of quality. The second test was the Chi-square test. This test was used to test the differences between companies that quantify and those that do not quantify costs, considering their size, type of production and ownership structure. The main goal of this study is to analyze the situation in our market and to understand better the main barriers influencing the management of costs of quality.

2.1 Data

The quantification of quality costs was observed on a nominal measuring scale. The results show that 73% of companies quantify their quality costs completely, 21% of companies quantify their costs only partly (only external costs), and 6% of companies do not. 36% of surveyed companies (42 companies) that monitor quality costs use some of the recommended models. The other companies (75 companies) do not use any of these models and only follow some categories or use their own system. If a company already uses one of the models, it is a PAF model (69% of respondents - 29 companies).

2.2 Evaluation of the first hypothesis

In order to test the first hypothesis, the t-test procedure was applied. The results of the t-test used to test the existence of statistically significant differences in the characteristics of the costs of quality depending on the decision to quantify the costs of quality are shown in Table 4. In the part of the paper, the level of quality was observed through dimension costs of quality. The respondents were asked to rate their level of costs of quality in their companies. These characteristics were measured on a five-point Likert scale.

According to the results presented in Table 4, there is a statistically significant difference in the level of costs of quality depending on whether the company quantifies quality costs ($p<0.005$). By comparing these two groups of companies, it is evident that companies that quantify costs of quality gave significantly lower costs of quality ($x = 4.147$, $s = 1.061$) than those that do not quantify quality costs ($x = 3.326$, $s = 1.307$).

Table 4 T-test results

	Quantification	n	Mean	s	t test	p - value
Quality costs	YES	117	4.147	1.061	3.0096	0.003
	NO	42	3.326	1.307		

Source: Authors

2.3 Evaluation of the second hypothesis

The hypothesis number 2 a) states that large companies quantify costs of quality to a greater extent than small and medium companies. It is expected that large companies to be more concerned with monitoring and evaluating the cost of quality. The Chi square test was used to test differences among companies that quantify and those do not quantify costs of quality. The significance level was selected at 0.05. The results are shown in the Table 5. The Chi square test shows interesting results. In the total number of companies that quantify costs of quality 53.9% are small and medium companies while 46.1% are large companies. Therefore our hypothesis number 2 a) is not rejected at level 0.05.

Table 5 Chi square test results

	Small and medium companies	Large companies	Total	Chi square test
Quantify quality costs	63 (53.9%)	54 (46.1%)	117 (100%)	Chi square = 13.3585 p value = 0.000257
Not quantify quality costs	36 (85.7%)	6 (14.3%)	42 (100%)	
Total	99 (62.3%)	60 (37.7%)	159 (100%)	

Source: Authors

Hypothesis number 2 b) states that multinational companies quantify costs of quality to a greater extent than domestic companies. The Chi-square test was used to test differences between companies that quantify and those that do not quantify costs of quality. The significance level was selected at 0.05. The results are shown in Table 6. Of the total number of companies that quantify costs of quality, 57.3% are multinational companies, while 42.7% are domestic companies. The chi-square statistic is 2.5786. The p-value is 1.10832. Therefore our hypothesis number 2 b) is rejected at the level 0.05.

Table 6 Chi square test results

	Multinational companies	**Domestic companies**	**Total**	**Chi square test**
Quantify quality costs	67 (57.3%)	50 (42.7%)	117 (100%)	Chi square = 2.5786 p value = 1.10832
Not quantify quality costs	18 (42.9%)	24 (57.1%)	42 (100%)	
Total	85 (53.5%)	74 (46.5%)	159 (100%)	

Source: Authors

Hypothesis number 2 c) states that companies with mass and serials types of production quantify costs of quality to a greater extent than companies with piece type of production. The Chi-square test was used to test differences between companies that quantify and those that do not quantify costs of quality. The significance level was selected at 0,05. The results are shown in Table 7. The Chi-square test shows these results. Of the total number of companies that quantify costs of quality, 63,2 % are the serial and mass type of production, while 36,8 % are piece type of production. The chi-square statistic is 2.2554. The p-value is 0,13315. Therefore our hypothesis number 2 c) is rejected at the level 0,05.

Table 7 Chi square test results

	Piece type of production	**Serial and mass type of production**	**Total**	**Chi square test**
Quantify quality costs	43 (36.8%)	74 (63.2%)	117 (100%)	Chi square = 2.2554 p value = 0.13315
Not quantify quality costs	21 (50%)	21 (50%)	42 (100%)	
Total	64 (40.3%)	95 (59.7%)	159 (100%)	

Source: Authors

The Chi-square test shows some exciting results. Of the total number of companies that quantify quality costs, 53.9% are small and medium-sized companies, while 46.1% are large companies. However, it could be said that 90% of large companies quantify quality costs. A similar result is visible in multinational companies, where 78.9% of companies quantify quality costs. This result was expected considering the fact that large and multinational companies have more significant resources than small and medium-sized companies. Furthermore, it is evident that 63.2% of the total number of companies that quantify quality costs are companies with the serial or mass type of production, while 36.8% are companies with the piece type of production.

From the questionnaire survey results, it is clear that a total of 117 (73%) companies are involved in quantifying quality costs.Table 8 lists the problems that prevent more comprehensive monitoring of quality costs in different firms.

Table 8 Problems

Problem	**Mass and serial type of production**	**Piece type of production**	**Total**
Reluctance to cooperate	16	16	**32**
Inappropriate methodology	21	7	**28**
Time-consuming cooperation	14	7	21
Insufficient software support	13	8	21
Little management support	10	3	13
Subjectivity of costing	0	1	1
Conceal nonconformities	0	1	1
Total	74	43	117

Source: Authors

3 Result and discussion

To sum up the findings from our testing strategy. On the one hand, the study fulfilled expectations in the form of original assumptions. Large and multinational companies give more attention to this issue than small and domestic companies. This result was expected because large and multinational companies have more significant resources than small and medium-sized companies. On the other hand, these numbers were not as different as the study's authors initially anticipated. Detailed results are given in chapter four. The study also found unexpected conclusions

that refute the claims of other authors. The research of Amiya Kumar Pattanayak [36] declares that the cost of quality management is not a widely used concept. The newest research by Elizondo [32] states that companies do not pay much attention to this issue because they are not sufficiently acquainted with this issue. However, the opposite was the result of our study. 73% of all surveyed companies are engaged in this issue which means that companies use a system to monitor quality costs (either have their internal rules or use some of the recommended models). If the company use some type of model, it is the PAF model. This model is a widely used model because it is applicable in most companies [37].

However, on the other hand, only 69% of companies use it for monitoring quality data. The research was confirmed by hypothesis 1 that companies that use evidence cost of quality have lower levels of these costs. Research has shown that large and multinational companies are the most involved in monitoring and evaluating, which was expected. However, in all cases, similar obstacles can be identified. These include in particular reluctance to cooperate, inappropriate methodology and time-consuming data collection. It is necessary to develop suitable approaches and methods to reduce the burden of data collection. This would be a big challenge for research.

4 Conclusions

In the introduced paper, the present state of the subject matter was analyzed on the basis of the literature review with a focus on the core of the costs of quality management. Consecutively via the questionnaire survey, the level of costs of quality management in the manufacturing companies was researched. The benefit of this study was mapping the current situation of cost of quality management in the environment of the Czech Republic. Based on 159 respondents, the study gives an insight into companies and how quality costs are related. It can be seen that companies increasingly make an effort to determine quality costs to improve the processes in the company. It can be identified the similar type of problems with the related costs of quality. These include, in particular, the reluctance to cooperate, inappropriate methodology and time-consuming evaluation.

The topic of further research will be a study of quality costs in companies. At the same time, this study showed that companies are involved in quality, but many of them do not use any of the recommended models for evaluation. It is also a question of further exploring whether companies quantify these costs correctly. Knowing the quality costs is the basis for further management decisions for each business and must be based on the correct and relevant data to help companies make these decisions. For most quality costs, it is possible to eliminate them by using an effective and efficient quality management system. Companies should do a systematic and comprehensive financial analysis of various processes. While all people know the rule stating that it is better to do things right from the first time, they do not know how much better it is.

Acknowledgement

The authors are thankful to the Internal Grant Agency of FaME TBU No. IGA/FaME/2021/ 014 New competitive advantages based on risk management of the work environment.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 457-466 ISSN 1339-5629

POTENTIAL OF SMOKED FISH INDUSTRIAL CLUSTER IN THE ISLANDS AREAS
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doi:10.22306/al.v9i4.347 *Received: 24 Oct. 2022; Revised: 25 Nov. 2022; Accepted: 12 Dec. 2022*

POTENTIAL OF SMOKED FISH INDUSTRIAL CLUSTER IN THE ISLANDS AREAS

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Keywords: industrial cluster, smoked fish and fishery potential.
Abstract: Potential utilization of owned natural resources is the advantage of each region as an industrial competitiveness strategy. Moreover, each existing industry can be grouped (clustered) according to the characteristics of the industry which in turn can support regional economic growth and improve the welfare of its people. This study seeks to map of potential of smoked fish industrial cluster product in the archipelago by focusing on the Ambon Island area. The results showed that, there were 78 smoked fish industries that formed 6 (six) groups of smoked fish industry agglomerations in the Ambon Island region with an average distance between point (industrial) with its closest point is 0.208 km. A total of 78.79% or 78 points (industry) has a distance to their nearest industry which is less than the average distance. The Average Nearest Neighbour Analysis using ArcGis 10.5, found that the distribution of the fishery processing industry in the Ambon Island region has a ratio of 0.203416 with a Z-score of -15.008879 and a significance of 0.000. This ratio is within the parameters that indicate a spatial clustered pattern, which means that the distribution of smoked fish industry on Ambon Island is identified as having the potential to develop into industrial clusters.

1 Introduction

Industrial clusters are believed to have an important and strategic role in industrial development and increasing industrial competitiveness, which supported by the availability of adequate natural resources in an area. Furthermore, the existence of this industrial cluster is expected to reduce high production costs, such as raw material costs, transportation, and transaction costs. Industrial clusters can be viewed as specific groups of industry, which is linked by a network of links, the process of creating added value through business and non-business relationships. [1] argues that industrial clusters (including the fisheries sector) refer to a close and binding relationship between companies and certain industries together in various aspects. These aspects can be viewed from the geographical location, sources of innovation, suppliers, and production factor. In other words, it can be said that industrial clusters are interrelated industrial groups that encourage the creation of an "industrial area" in an area through the activities of exporting goods and services [2].

The Moluccas region itself has many islands with an ocean area larger than the mainland, which make Moluccas a rich area in fisheries and marine potential [3]. A data from [4], shows that Moluccas Province has an area of 46,914.03 km2 which consist of 92.4 percent of the ocean area and 7.6 percent of the land area with reach to 1,392 islands. Ambon as the capital of Moluccas province, which is located on the island of Ambon, has played an important role in various aspects of people's lives including the development of industrial centers. Based on fishery data from Ambon City in 2022, the existing aquaculture production includes seawater and freshwater aquaculture. In 2019, marine aquaculture commodities including grouper, trevally fish and snapper, with a total production of 124.94 tons. Meanwhile, freshwater fish farming commodities include carp, tilapia, and catfish with a production volume of 49.80 tons. Meanwhile, from the aspect of fishery investment in Ambon city in 2019, there were 30 companies engaged in marine and fishery business with processing, frozen and fresh product types. Data on processed fish products in the city of Ambon was recorded in the form of smoking and frozen with the production volume of processed smoked fish of 3,828.32 tons and frozen processing of 4,461.69 tons.

Regarding the potential of the fisheries sector, the same picture is also expressed by [5] which mentioned that the potential of fishery resources in Moluccas reaches 1,640,160 tons per year. Nevertheless, the reality proves that, until now, Ambon City and Ambon Island do not yet have a fishing industry that can be used as a strategic sector for regional economic growth through the contribution of income and employment. In this context, the author thinks that the existence of Ambon City, which is supported by the ownership of such large potential fishery resources, should have a fishing industry area that can be used as a

strategic sector, however, this situation is the exact opposite.

In other words, it should be with a large fishery production potential as mentioned above and supported by the presence of fish catching and landing centers scattered in several locations on the island of Ambon, such as in Laha, Hitu, Waai and Latuhalat [6], then the island of Ambon should have a fishing industry grouping or what is known as a cluster. [7] research, in South Korea, revealed that the development of a fishing industry cluster must consider several aspects, for governance structure of local government and delegation of authority to the government below them. This includes the management of fishing ports which have a strategic role in the fishing industry cluster [8]. Meanwhile, the study of [9], found that, in the development of industrial clusters, the creation of markets and financial support through government's role is absolute and very important. Things that are different but have a significant impact on the development of industrial clusters are shown through research by [10] that managerial problems, public partnerships, and even social barriers are problems that are often faced in the process of developing industrial clusters. Furthermore, [1] mentioned that clusters show a very close relationship that binds certain companies and industries together in several general aspects such as geographic location, sources of innovation, suppliers, production factor and others.

Meanwhile, the study of [11] mentioned that the cluster approach in managing regional development is a new management technology that allows the increasing of competitiveness of the region or industry, as well as the country. This is supported by the research of [12] which mentioned that the formation and operation of fishing clusters will allow to achieve a synergistic effect through a single production, technology base, infrastructure, as well as through the distribution of shared resources which will produce the following economic effects for the regional economy, which is increase the competitiveness of fish products, increase the share of added value in products sold to external and domestic markets, stimulate innovative potential, increase staff, and increase economic employment in the region.

On the other hand, [13] in their research also mentioned that if the state has the capacity to stimulate the formation of clusters that have the potential for economic development, which can become points of growth, it is advisable to use an appropriate public administration economic mechanism because the cluster objectively has all the advantages that economic integration affords on the basis of cooperative ties.

Based on the trajectory of the studies related to the cluster above, it shows the focus on managerial issues, partnerships, and government support [9-10]; local government governance [7-8]; regional economic development and increasing regional and industrial competitiveness [11-13].

In fact, the existence of industrial clusters in an area has a relationship with the potential of available natural resources as a means of sustaining the development of industrial clusters starting with the support of natural resources. This condition is quite reflected in the existence of the island of Ambon which has abundant natural resources in the fisheries sector [5-6] but until now the existence of industrial clusters on the island of Ambon is not yet available. For this reason, this study tries to offer a potential map of smoked fish clusters through the formation of industrial clusters. Thus, this study contributes to the development of industry in the archipelago as well as small and medium-sized industrial enterprises and increasing regional competitiveness.

2 Methodology

This study uses a quantitative method with the approach of Average Nearest Neighbour. The research locations on the island of Ambon include Nusaniwe District, Sirimau District, Baguala District, Teluk Ambon District, Leihitu District and Tulehu Village, Salahutu District. This research was conducted for 9 months, starting from October 2021 to June 2022. There are considerations for choosing the location of this research are as follows: a). most of the people who live in the area are on the coast and make a living as fishermen, b). There are quite a lot of smoked fish industrial centers in these areas, c). There is support for abundant fish raw materials.

Then, the data collection process was carried out through in-depth interviews, observations and questionnaires. The interview process was carried out by means of direct interviews with the business owners of the smoked fish industry spread throughout the island of Ambon, as well as to the related of government agencies that support the smoked fish production and marketing process; Observations are made to directly see the process of producing and marketing smoked fish, both at the location where the industry is located, as well as to the target markets for product sales; The questionnaire is used to determine the supporting institutions that support the production process and the survival of the smoked fish small and medium industry. Furthermore, data has been collected was analysed by using Average Nearest Neighbour analysis which using ArcGIS 10.5. The Average Nearest Neighbour analysis aims to determine the distribution pattern of the smoked fish industry on the island of Ambon.

3 Result and discussion

3.1 Potential of fishery industry on Ambon Island

Fisheries activities on the island of Ambon are dominated by fishing activities at sea. This is caused by the geographical condition of the island of Ambon which is indeed surrounded by the ocean so that at any time fishermen can carry out fishing activities taking into account the condition of the season (weather). Ambon

Island experiences two seasons, namely the west and east monsoons.

When the west season arrives, fishermen have a great opportunity to catch fish with fishing grounds up to the Banda Sea. Meanwhile, during the east season, fishermen will move to Ambon Bay. Data from [14] in 2022 shows that Fishery Households (RTP) in Ambon City are 3,820 RTPs with fishing boats in various sizes as many as 2,475 boats. Furthermore, BPS data in the same year also shows that the ownership of fishing boats at the landing center in Ambon City is 2,493 units. Meanwhile, fishing gear owned consists of various types, for example beach trawl (17 pieces), ring trawl (89 pieces), gill nets (630 pieces), lift nets (515 pieces), huhate (541 pieces), tug fishing line (368 pieces) as well as nets, traps, scoops (1,832 pieces).

The various conditions which described above, shows that Ambon Island has a quite large industrial potential in the fisheries sector to be developed. In fact, field findings show that there are numbers of fishery processing industries scattered throughout the island of Ambon. The fishery processing industry can be categorized as traditional or modern. The traditional fishery processing industry is generally still carried out by the community using traditional methods or based on knowledge from previous generations. Meanwhile, modern fishery processing has used production facilities with machines. The fishery processing industry on the island of Ambon consists of the frozen fish industry and smoked fish industry as shown in table 1 below.

Table 1 Potential of fishery industry in Ambon island region

Fishery Industry	Quantity
Frozen Fish Industry	42
Smoked Fish Industry	99

Data source: Research Results, 2022

This fishery processing industry consists of small-scale industries (IKM) or individual industries to large-scale industries and business entities whose products have been exported. The detailed data on the fishery processing industry can be seen in the following table 2.

Table 2 Grouping of fisheries industry in Ambon Island region by type of business entity

No.	Type of Business Entity	Number	Type of Industry
1.	Perseroan Terbatas (PT)	31	Frozen Fish
2.	Perseroan Komanditer (CV)	8	Frozen Fish
3.	Usaha Dagang (UD)	2	Frozen Fish
4.	Koperasi	1	Frozen Fish
5.	Perorangan dan Kelompok (IKM)	99	Smoked Fish

Data Source: Research Data, 2022

3.2 Identification of potential smoked fish industrial clusters on Ambon Island

Cluster has a literal meaning as a collection, group, set, or combination of certain objects that have similarities or based on certain characteristics. Findings in the field indicate similarities in the production process as well as several other factors in the smoked fish industry on the island of Ambon. In this study, the identification of potential industrial clusters for 99 smoked fish industries was carried out in the Ambon Island region. Based on the data on the location of the smoked fish industry on the island of Ambon mentioned above, the position or location of the company can be mapped as shown in the picture below (Figure 1).

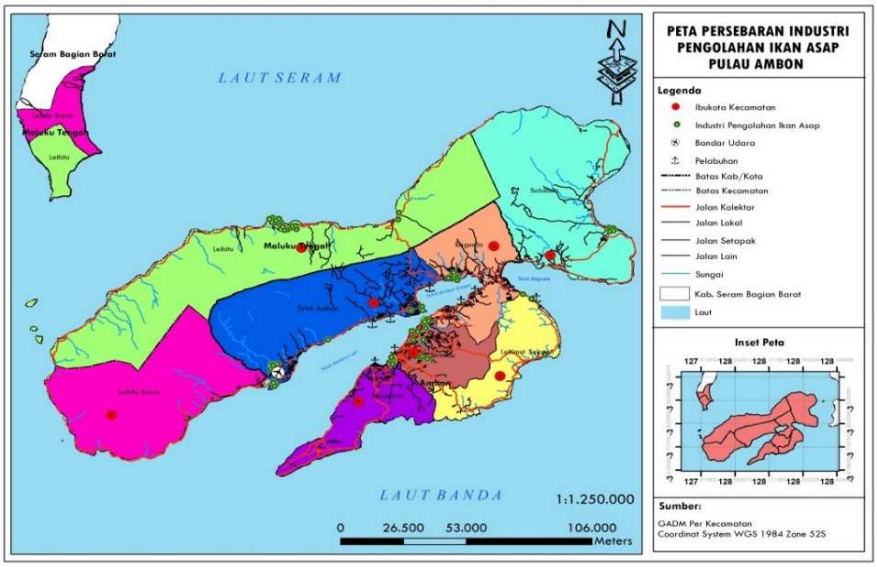
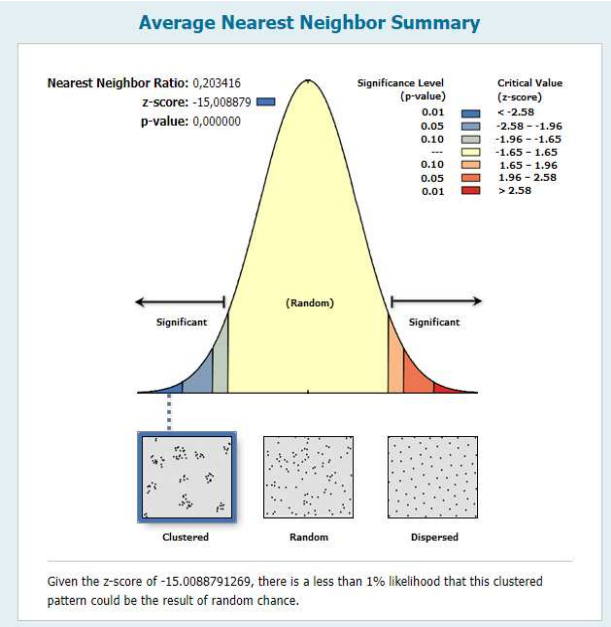


Figure 1 Distribution Map of Smoked Fish Industry on Ambon Island
Source: Research Data, 2022

Industry groupings or agglomerations can be identified by mapping the distribution of the 99 smoked fish industries in the Ambon Island Region and assessing the ratio of their closest neighbours. The results of the Average Nearest Neighbour analysis using ArcGIS 10.5, it was found that the distribution of the smoked fish industry in the Ambon Island region has a ratio of 0.203416 with a Z-score of -15.008879 and a significance of 0.000. The ratio is within the parameters that indicate a spatial clustered pattern.



Average Nearest Neighbor Summary

Observed Mean Distance:	208,5739 Meters
Expected Mean Distance:	1025,3558 Meters
Nearest Neighbor Ratio:	0,203416
z-score:	-15,008879
p-value:	0,000000

Dataset Information

Input Feature Class:	DATA_IKAN_ASAP__DISPERENDAK
Distance Method:	EUCLIDEAN
Study Area:	407925535,783040
Selection Set:	False

Figure 2 Analysis results of average nearest neighbour smoked fish industry in Ambon Island region
Data Source: Research Data, 2022

The next analysis is carried out by calculating the comparison of the number of points (industry) which tend to be clustered and random. The average distance between the (industrial) point and its closest point is 0.208 km. A total of 78.79% or 78 points (industry) has a distance to their nearest industry less than the average distance. These results indicate that the comparison of the number of industries that tend to cluster is bigger than the number of industries that tend to be random.

This view is supported by the Cluster Life Cycle theory according to [15], where industrial clusters at the embryonic stage are characterized by a comparison of the number of industries that clustered together more than similar industries which are randomly distributed. Then, the embryo cluster can develop to strengthen the cluster's focal point, which is indicated by the growth in the number of business units exceeding the growth of business units in the same non-clustered sector. The emergence of an industrial cluster cannot be separated from the symptoms of industrial agglomeration that can be formed due to the concentration of production factors. [16] even realized that clusters can undergo an evolutionary process from the beginning of their emergence to its decline.

Based on his study of industry in Italy, [17] identified that industrial clusters have evolved over time. There are three stages in the industrial cluster cycle, which are:

a. Embryonic: groups of companies in the same industry, or in related industries, can be considered a potential group; limited to local/regional markets; companies that work as subcontractors for large companies.
b. Consolidation: activate the innovation mechanism; expanding market; increasingly specialized companies and begin to acquire identity as a cluster.
c. Mature: achieve high endogenous innovation capacity; international market; focus on increasing product value and level of specialization.

[18] describe the cluster life cycle as follows:

a. Agglomeration: an area with several clustered companies.
b. Emerging Cluster: As a cluster embryo, several actors in the agglomeration are connected, cooperate with each other, and realize common opportunities.
c. Developing Cluster: New and related companies are emerging near the location of the agglomeration. Institutions began to emerge.
d. Mature Cluster: Cluster member has reached critical mass. Clusters are also starting to build relationships with clusters in other areas. The dynamics of creating new companies with start-ups, joint ventures, and spin-offs.
e. Transformation: Over time, markets and technologies change, as do clusters. In order for the cluster to avoid

stagnation and decline, the cluster must be able to innovate and adapt through change. Adaptation can be in the form of transformation into new, more specialized clusters.

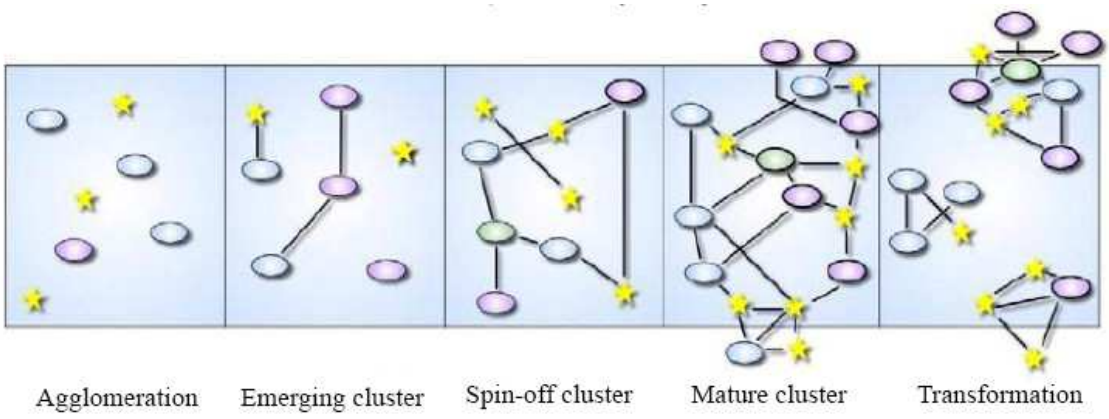


Figure 3 Cluster Life Cycle [18]

[18] explain that clusters are formed from spatial agglomerations of similar and related economic activities which form a basis of local environments that can facilitate knowledge gathering and stimulate various forms of learning and adaptation. This cluster is generally formed by SMIs and the core of their success is centered on the strength of social capital and geographical proximity. [15] divide the cycle stages into four, namely cluster embryo, growth stage, survival (adult cluster), and decline stage. According to [15], it is quite difficult to identify at the embryonic stage, because the shape of the cluster does not resemble an ideal cluster.

Cluster embryos usually only contain a few business units with a fairly small number of employees, but enough to show the orientation of a particular product. Industrial agglomeration can be the beginning of the formation of clusters. According to [15,17,18] not all industrial agglomerations can develop into clusters. There are different prospects or potentials in the industrial agglomerations that are formed to evolve into clusters. The potential for agglomerations to develop into clusters can be assessed based on the following criteria.

The potential for agglomeration to be developd into a cluster if it is associated with the Cluster Life Cycle theory, can shows at which stage the agglomeration of the industry is. The following map illustrates the strengthening of the focal point of smoked fish industry cluster embryos in the Ambon Island region.

Table 3 Assessment criteria

Aspect	Indicator	Source
Size of Agglomeration	The more concentrated the number of business units, the more potential	[17] [19]
Actors involved	• Completeness of related actors (horizontally and vertically) with industry agglomeration • The more concentrated the actors, the more potential	[16] [17] [18] [15]
Form of relationship between actorr	• Mechanism of relationship between actors • Condition of vertical relationship (industry with its suppliers and distributors) • Conditions of horizontal relations (industry with institutions)	[17] [18] [15]
Marketing Reach	The wider the marketing reach of the product, the more potential it has	[17] [18] [15]

Source: Research Data, 2022

POTENTIAL OF SMOKED FISH INDUSTRIAL CLUSTER IN THE ISLANDS AREAS
Ariviana Lientje Kakerissa; Hendri Dony Hahury; Fredy Hendry Louhenapessy

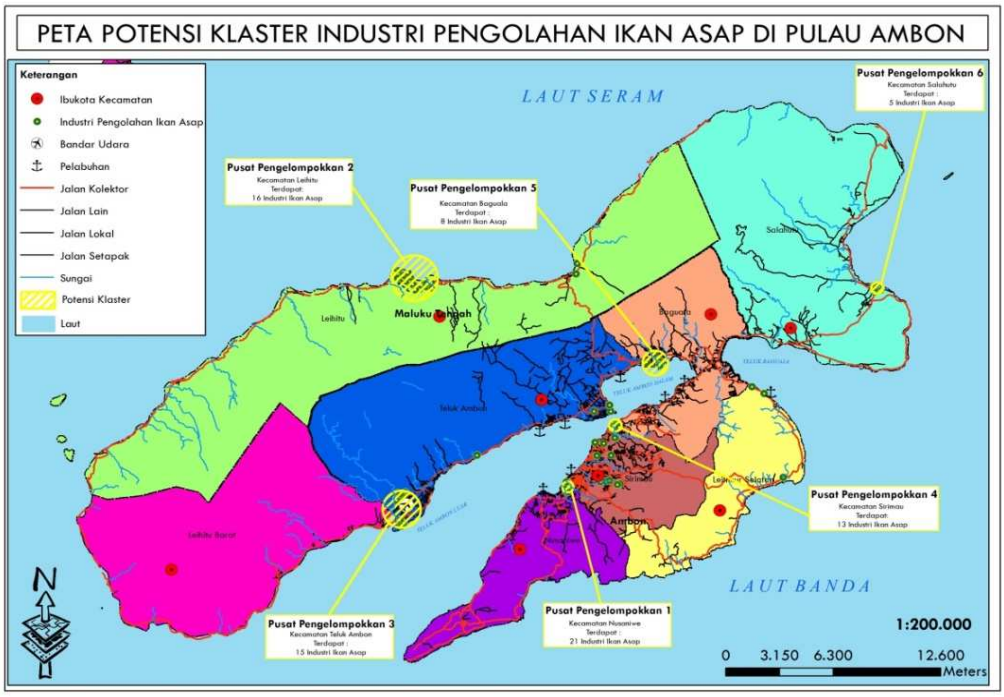


Figure 4 Center for grouping/agglomeration of smoked fish industry in the Ambon Island region
Source: The results of data processing using ArcGis 10.5

The above map shows that there is a strengthening of the focal point or the formation of a grouping center for the smoked fish industry in the Ambon Island Region. There are 6 (six) centers for grouping or agglomeration of smoked fish industries in the Ambon Island Region, which is 21 industries in Nusaniwe District, 13 industries in Sirimau District, 8 industries in Baguala District, 15 industries in Teluk Ambon District, 16 industries in Leihitu District. and 5 industries in Tulehu Village, Salahutu District.

In its production process, the agglomerated smoked fish industry establishes good relationships, vertically (with suppliers and distributors) and horizontally with other institutions which aim in improving business and consulting mechanisms. The following institutions that are horizontally related to the smoked fish industry in the Ambon Island Region are the Regional Government through the Marine and Fisheries Service and the Industry and Trade Office, as well as the Cooperatives and MSMEs (Provincial and City/Regency) Service in the form of production facilities assistance, such as fumigation equipment, fresh fish storage equipment, raw materials for packaging, labour assistance, capital assistance, and others, Banking in this case Bank Rakyat Indonesia, Universities and other Institutions.

Regarding the relationship with the determination of potential suppliers, the determination of industrial clusters can not only rely on the intuitive nature of determining potential suppliers but it also requires scientific steps involving the mathematical principles of decision making which involving multi criteria [20]. To assess the potential of smoked fish industry agglomerations in their development into clusters, the following is a description of each smoked fish industry agglomeration in the Ambon Island Region, based on the theoretical principles of industrial clusters.

1. Agglomeration size: the number of business units, each in cluster I as many as 21 industries, in cluster II as many as 16 industries, in cluster III as many as 15 industries, in cluster IV as many as 13 industries, in cluster V as many as 8 industries and in cluster VI as many as 5 industries.
2. Parties involved:
   a. The Parties in the vertical relationship in the six clusters formed are the same, including:
      - Fishermen
      - Fish processing industry
      - Fish processing unit
      - Fish collector
      - Fish retailer collector
      - Raw material suppliers
      - Supporting material suppliers
      - Production tools and machines suppliers
      - Exporter
      - Local distributors

   b. Parties in a horizontal relationship include:
      - Fishing industry
      - Department of Industry and Trade of Moluccas Province
      - Department of Maritime Affairs and Fisheries of Moluccas Province

- Department of Industry and Trade of Ambon City
- Ambon City Maritime Affairs and Fisheries Service
- Department of Industry and Trade of Central Moluccas Regency
- Department of Marine Affairs and Fisheries of Central Moluccas Regency
- Bank Rakyat Indonesia
- Universities
- Other Institutions

3. Collaboration between parties:
   a. Vertical relationship: production chain, including supplier-industry-distributor/consumer relationship, which is related to distribution and marketing mechanisms.
   b. Horizontal relationship: relationship between businesspeople and institutions which includes:
      - The Department of Industry and Trade, as well as the Department of Marine Affairs and Fisheries at the Provincial and City and Regency levels in terms of policies and regulations, information on capital assistance, infrastructure assistance, appropriate technology, product marketing, business assistance.
      - Bank Rakyat Indonesia: partner in capital and infrastructure assistance.
      - Universities: project oriented.
      - Other Institutions: Joint Venture Cooperatives (KUB) and Cooperatives.
   c. Results of collaborations between parties:
      - Vertically:
        - Mechanism: joint distribution and marketing
      - Horizontally:
        - Government: There are regulations and policies related to the business world
        - There is a donation of production equipment for IKM
        - There is a capital loan for SMEs
   d. Marketing reach: on average 97% of products are sold to meet local market demands and the remaining 3% are sold as souvenirs to another region.

Based on the completeness of parties involved, all industrial agglomerations have potential as indicated by the involvement of parties both vertically and horizontally. Another potential is also shown by the emergence of attention from local governments to all industrial agglomerations that are formed, even though they are not evenly distributed in form and number. Industrial agglomeration has also been able to attract higher education institutions and the City-Regency Government, through related agencies. The response from this institution influences the emergence of innovation in the production process and business management. Universities help SMEs through the provision of fish smoking equipment. Each local government also provides technical assistance and training for the fishery processing industry in their respective administrative areas.

In addition, each IKM also exchanges information informally regarding the production process and solves problems together. This shows the close relationship between industry players in this agglomeration. According to [18], this condition shows that this industrial agglomeration is entering a developing phase which is marked by the active participation of related institutions. If referring to the cluster life cycle theory according to [15], the emergence of collective activities indicates that the cluster has entered a growing phase. On the other hand, there are still smoked fish industry agglomerations that have not been able to attract responses from various cluster supporting institutions, for example in industrial agglomerations V and VI. Meanwhile, the existence of institutions according to [16] is one of the important components to stimulate innovation.

3.3 Potential of smoked fish industry cluster in archipelago region

The industrial cluster is an approach which is considered appropriate for economic development in an area and in accordance with the current dynamics of the development of the business world. By strengthening industrial clusters, an area (region or country) has more opportunities to develop its best potential and compete in the global industry. Clusters as an approach have proven to be increasingly accepted in development approaches that involve grouping patterns, both industry and infrastructure, so that the nature of clusters will be increasingly used. With regional autonomy, urban development will occupy a central place in regional development, the implication is that the construction of business premises is an important component of urban economic life in the region. Therefore, the cluster approach will be part of the model development in each region. In line with this, optimal agglomeration must produce synergies for efficiency and sustainable progress for competitiveness, successful cluster brings efficiency and sustain progress for better competitive strength [21].

In line with the definition of an industrial cluster put forward by [22] as a group of companies that are interconnected because of togetherness and complementarity and are geographically close to related institutions in a specific field, the existing smoked fish Small and Medium Industries (IKM) on the island of Ambon is considered to have a collaborative cooperative relationship and create synergies which is to increase competitiveness. This can also be seen from the active participation of all stakeholders, namely the core industry, related industries, and supporting industries in the cluster. So, it can be said that the synergy of all partner activities (companies, universities, governments and research centers) in the cluster can determine the social and

economic development of a region to be more stable and competitive, both at the regional, national and international levels [23].

By analysing the participation of stakeholders involved in the smoked fish industry and based on the Porter's Diamond Model, a map or a design of a cluster model of the smoked fish industry on the island of Ambon can be made and can be used as a reference for other areas that are geographically similar to the island of Ambon as an archipelago. The creation of the "new industrial area" is inseparable from the existence of globalization which has enormous impacts and challenges for developing countries in the world [21-22]. The emergence of new challenges in the form of new industrial areas is more aimed at increasing competitiveness and as well as maintaining and developing economic activities sourced from local resources owned by each region [26-28]. This makes the form of cluster management and development in each region different and tends to develop at the regional level based on existing economic realities [29-31].

In general, Michael Porter defines an industrial cluster as a geographic concentration with related entities in a specific field that is the goal of clustering. With this definition, an industrial cluster can include suppliers of raw materials and other inputs from upstream to downstream in the form of marketing to potential markets. Clusters also include government agencies, business associations, service/research providers, and other institutions that support the "added value" of the specific field which is being clustered [22].

[16] argue that the industry in a region/country excels not from its own success but is the success of the group with the interrelationships between companies and supporting institutions. A group of companies and institutions in an industry in an area is called an industrial cluster. In the industrial cluster, the companies involved are not only large and medium-sized companies, but also small companies. The existence of industrial clusters will stimulate the occurrence of new businesses, new jobs, new entrepreneurs who are able to rotate new loans. Based on the description above, it can be believed that the cluster approach is an effective approach for industrial development.

Clusters represent all added value from suppliers to final products including supporting services and infrastructure. The cluster concepts are based on three main concepts, namely:

1. The Concept of Economic Geography (Economic Geography Concept)
   This concept is based on the territorial characteristics and environmental functions of companies that focus on identifying the characteristics or location factors that influence the selection of industrial locations. As a result, when viewed from a macro perspective, the behaviour of each company is not explicitly modelled but can be seen from the behaviour of the company as a whole [32-33].
2. Organizational Concept
   This concept considers the behaviour of each company based on the company's internal and environmental factors [34-35]. According to Scott, what underlies the emergence and growth of a cluster is the transaction cost approach. While Harrison's concept is based more on social economic theory (Social Economic Theory).
3. Strategy Concept (Strategy Concept)
   The selection of a company's location is inseparable from the company's strategy. The internal condition of a companyl, territorial, and environmental conditions are considered at various levels. This concept is supported by [24] and [36]. Porter mentioned that companies can increase their competitiveness through the formation of clusters with the assumption that competitiveness depends on the ability to innovate and upgrade. Storper stated that companies can compete if they carry out a dynamic production system, which is always adjusting production techniques without increasing production costs.

4 Conclusion

The results of this study conclude that there are 78 smoked fish industries that make up 6 (six) groups of smoked fish industry agglomerations in the Ambon island region with the average distance between the point (industry) and the closest point is 0.208 km. A total of 78.79% or 78 points (industry) has a distance to their nearest industry less than the average distance. These results indicate that the comparison of the number of industries that tend to cluster is bigger than the number of industries that tend to be random. The results of the Average Nearest Neighbour analysis using ArcGis 10.5, found that the distribution of the fishery processing industry in the Ambon Island region has a ratio of 0.203416 with a Z-score of -15.008879 and a significance of 0.000. The ratio is within the parameters that indicate a spatial clustered pattern. This means that the distribution of smoked fish industry on Ambon Island has been identified as having the potential to develop into industrial clusters. This potential is demonstrated through phases in the life cycle of industrial clusters which are assessed based on aspects of agglomeration size, completeness of parties involved, forms of collaboration between parties, and marketing reach. The size of the agglomeration includes the number of Smoked Fish Small and Medium Industries (IKM) on the island of Ambon, each in cluster I as many as 21 industries, in cluster II as many as 16 industries, in cluster III as many as 15 industries, in cluster IV as many as 13 industries, in cluster V as many as 8 industries and in cluster VI as many as 5 industries. The completeness of the actors involved is indicated by the large number of industries and companies involved both vertically and horizontally. The smoked fish Small and Medium Industries (IKM) on the island of Ambon is considered to have a collaborative cooperative relationship and create synergies which is to increase competitiveness. The

marketing reach shows that 97% of smoked fish products are sold to meet local market demands and the remaining 3% are sold as souvenirs to another region. By analysing the participation of stakeholders involved in the smoked fish industry and based on the Porter's Diamond Model, a map or a design of a cluster model of the smoked fish industry on the island of Ambon can be made and can be used as a reference for other areas that are geographically similar to the island of Ambon as an archipelago.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 467-478 ISSN 1339-5629

SELECTING SUSTAINABILITY KEY PERFORMANCE INDICATORS FOR SMART LOGISTICS ASSESSMENT
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doi:10.22306/al.v9i4.350 *Received: 31 Oct. 2022; Revised: 18 Dec. 2022; Accepted: 28 Dec. 2022*

SELECTING SUSTAINABILITY KEY PERFORMANCE INDICATORS FOR SMART LOGISTICS ASSESSMENT

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Keywords: smart logistics, sustainability, key performance indicators, industrial enterprise, supply chain.
Abstract: The application of smart technologies and applications is becoming increasingly common in the logistics processes of companies and supply chains. However, standard logistics indicators are still used to evaluate their performance, which contradicts the sustainable development strategy of many industrial enterprises and their supply chains. Thus, the article aims to design a methodology for selecting sustainability key performance indicators (SKPIs) suitable for assessing smart logistics and its technologies and applications. The research relies on cluster analysis of the SKPIs recommended in the relevant literature, frequency analysis of indicators used in practice and their comparison. The cluster analysis showed that the primary attention in the references is given to sustainability's economic and environmental dimensions. Most frequently, the authors highlighted the importance of the following indicators: production-related costs and investments, planning performance and quality, customer satisfaction, energy efficiency, waste intensity and treatment, emissions, and resource efficiency. On the contrary, the frequency analysis corroborated that leading industrial enterprises paid more-or-less balanced attention to all areas of sustainability, but at the company level. The article's primary result constitutes a methodology comprising six steps, respecting the results of the analyses carried out: (1) Sustainability objectives definition; (2) Establishing SKPIs cluster pool; (3) Definition of criteria for selecting SKPIs clusters; (4) Selection of SKPIs clusters; (5) Definition of SKPIs and their parameters; and (6) Development of SKPIs hierarchical structure.

1 Introduction

One of the key trends in contemporary logistics is the introduction of new technologies to improve the logistics process efficiency. These technologies have come to be known as smart technologies or technologies of the fourth industrial revolution (Industry 4.0). Thus, a new concept known as smart logistics or Logistics 4.0 has emerged. However, in practice, the implementation and operation of smart logistics technologies and applications are evaluated only in terms of standard logistics performance indicators. The given indicators focus on evaluating logistics processes' productivity, economics, quality, and lead times. However, that does not correspond to the current requirements for the sustainability of the business and, thus, logistics. Yet, sustainability is nowadays considered one of the primary strategies for increasing the value of businesses, as well as entire supply chains [1].

Sustainability is a long-term approach to business [2]. The sustainability strategy relies on balancing the three pillars of sustainability (triple bottom line approach): economic, environmental, and social [3,4]. If smart logistics technologies and applications are to deliver

sustainable value, their performance must be measured by a system of sustainable key performance indicators (SKPIs). Although the scientific and professional literature describes an extensive set of various SKPIs, their selection for evaluating smart logistics, their technologies and applications still constitute a significant research gap. The literature review (see Chapter 2.2) proved that there are very few studies on SKPs for smart logistics. Similarly, there are only some studies on the methodology used to select the most suitable SKPIs, none addressing smart logistics.

Therefore, the article aims to propose a methodology for selecting SKPIs suitable for assessing the sustainability performance of smart logistics and its technologies and applications. To achieve the stated objective, the following two research questions were defined:

1. Which SKPIs can be applied to assess the sustainability performance of smart logistics and its technologies and applications?
2. How can the appropriate SKPIs be selected to assess the sustainability performance of smart logistics and its technologies and applications?

The following approaches were used to address the research questions and achieve the research objective:

1. Cluster analysis of SKPIs obtained from explanatory literature review on SKIPs for smart logistics (see Chapter 3.1). The aim was to identify the SKIPs recommended by the scientific community for evaluating smart logistics and its technologies and perform their classification and frequency analysis.
2. Frequency analysis concerning the employment of SKPIs recommended by the United Nations Conference on Trade and Development (UNCTAD) in practice (see Chapter 3.2). UNCTAD has proposed a set of SKPIs suitable for managing sustainability at the company level. This analysis aimed to identify the groups of SKPIs that are most frequently used in business practice, as the implementation of smart logistics technologies and applications should contribute to their improvement.
3. A comparison of the performed analysis results (see Chapter 3.3) aiming to determine similarities, differences, and interrelationships between the identified SKPIs clusters.
4. Synthesis of acquired knowledge and proposal of the methodology for selecting SKPIs suitable for assessing the sustainability of smart logistics (see Chapter 4) to develop a procedure for evaluating the sustainable performance of smart logistics technologies and applications at different managerial levels of a company or supply chain.

The article presents a new, previously undeveloped methodology for assessing the sustainability performance of smart logistics and its technologies and applications. The innovative elements of the proposed methodology include in particular:

- Comprehensive approach. The methodology can be applied independently at different management levels: supply chain, enterprise, logistics process and smart logistics technology and application.
- Combination of standardised and tailor-made approaches. On the one hand, the methodology outlines a standardised set of SKPIs for assessing s company or supply chain. On the other hand, it allows comparing the implementation of smart technologies and applications within various logistics processes of a company or supply chain while respecting its specific needs.
- Feedback-based SKPIs selection process. The methodology has been developed as an iterative process enabling backtracking to previously adopted and re-evaluated procedures.
- Multi-source based SKPIs selection process. The methodology offers a combination of clearly defined sources for establishing the SKPIs cluster pool.

The study results are intended for managers requiring measuring, evaluating and improving the sustainability performance of smart logistics and its technologies and applications at different levels of management: supply chain, company, logistics department or processes.

The remaining parts are organised as follows. Chapter 2 reviews the literature on smart logistics and sustainability key performance indicators; Chapter 3 presents cluster analysis of SKPIs obtained from the relevant literature review, frequency analysis concerning the application of SKPIs recommended by UNCTAD in practice and their comparative analysis; Chapter 4 describes and discusses the primary article result, i. e., the proposed methodology for selecting SKPIs for smart logistics sustainability assessment; and, finally, Chapter 5 summarises the results.

2 Literature review

Considering the article's objective to be fulfilled, the relevant literature on smart logistics and sustainability key performance indicators was reviewed.

2.1 Smart logistics

In the complex logistics and supply chain management environment, the widespread application of information technologies (IT) has been inevitable in recent decades. The boundary between the digital world and the physical world, often referred to as Operational Technology (OT), is becoming increasingly blurred due to the growing interest in the practice and research on digitalisation in the industry (i. e., "Industry 4.0") on the one side, and the decreasing costs of computing power on the other [5]. Non-traditional approaches, such as logistics assets or load carriers, are becoming network-capable, shaping the concept of the Internet of Things (IoT) and the principle of

interconnection. Augmenting these "things" with sensors and actuators allows sensing and manipulating the physical world and creating Cyber-Physical Systems that follow the principles of autonomation and decentralised control [6].

Fulfilling these fundamental principles of Industry 4.0 [7] in Smart logistics applications ensures an impact on the visibility, reliability, and agility of logistics processes, ultimately affecting the logistics objectives [8]. Numerous potential positive effects are attributed to the application of these technologies and technological concepts in logistics; for example, enhanced process stability [9], reduced production delays [10], transportation costs [11], stock levels [12], and even reduction of environmental impacts, such as Greenhouse Gas emissions [11]. In sum, the perceived potentials of digitalisation in logistics can be expected to affect financial, environmental, and social indicators, which still need to be scientifically evaluated [13].

2.2 Sustainability key performance indicators

There are many systems and models for assessing logistics and supply chain performance. A review of the available topic-related literature is provided, for example, by Oubrahim et al. [14]. Hierarchical- and dimension-based performance appraisal systems are suitable for assessing sustainable performance at different levels of managerial decision-making. To link a company or supply chain strategy with actual performance, it is necessary to develop objectives and define an applicable set of key performance indicators (KPIs) describing the company or supply chain performance [15]. KPIs represent a set of metrics focused on the types of company or supply chain performance that are most relevant to the effectiveness of the current and future company or supply chain design [16]. KPIs provide quantitative or qualitative feedback that should translate into the results of a company or supply chain strategy [17]. SKPIs measure progress towards achieving a sustainable company or supply chain strategy in terms of environmental, social and economic impacts. Gebhardt et al. [18] demonstrated that implementing SKPIs in the company or supply chain in-house management system improves sustainability performance. According to Olabi et al. [19], indicators reflecting the sustainable development goals defined by the United Nations should be chosen to evaluate technological improvements.

SKPIs should be defined at all decision-making levels, such as supply chain, company, department or process [20]. A considerable number of studies recommend suitable SKPIs for these decision-making levels that are related to logistics processes. For example, Neri et al. [21] proposed a balanced set of 33 SKPIs (Triple bottom line) to measure the sustainability performance of industrial supply chains based on the balanced scorecard approach. Contini and Peruzzini [22] provided a comprehensive overview of company SKPIs based on a systematic literature review. They identified a set of 117 SKPIs that allow measuring the general corporate sustainability performance according to the triple bottom line approach in manufacturing companies. On the contrary, Hristov and Chirico [23] recommended the 14 most appropriate SKPIs for the company level based on a literature review and a survey conducted among Italian managers. Similarly, Swarnakar et al. [24] proposed a list of 18 SKPIs to assess a manufacturing company's sustainability performance. Bouchery et al. [25] designed a standard set of SKPIs for distribution processes based on 17 transportation and warehousing SKPIs. Torabizadeh et al. [26] put forward a list of 33 SKPIs for a sustainable warehouse management system. Kursini et al. [27] identified a list of 30 SKPIs for a sustainable warehouse in the leather manufacturing industry.

The literature review has demonstrated that very few studies focused on SKPs for smart logistics [28-32]. Their detailed analysis is included in Chapter 3.1. Similarly, only some studies address the selection methodology of the most suitable SKPIs, none focusing on smart logistics. Tyndus and Fernando [33] developed a reference model for implementing SKPIs at the supply chain level. Keeble et al. [34] proposed models for determining SKPIs at the company and project levels. Kibira et al. [35] designed a procedure for manufacturers to select KPIs for measuring, monitoring, and improving the environmental aspects of manufacturing processes.

3 Data analysis

3.1 Cluster analysis of SKPIs obtained from the relevant literature review

A review of the relevant literature on SKIPs for smart logistics was conducted to generate a list of possible SKPIs recommended by the scientific community. The review involved using a combination of the keywords listed in the upper part of Table 1 to formulate a search query for the SCOPUS database. The search string was further extended to ensure high-quality results so that only journal articles ("ar"), conference proceedings ("cp") and book chapters ("bc"), as well as in thematically relevant fields of research, were included. The search results were further reviewed, and articles focusing on sustainability and digitalisation were selected; on the other hand, papers solely focusing on applying the Global Reporting Initiative Standards were excluded.

SCOPUS constituted the only database source due to its high relevance for scientific publications in industrial engineering and management sciences [36]. Moreover, other research results have suggested that the information differs only minimally when extending the search to other databases, such as the Web of Science [37].

Considering the high number of SKPIs identified during the initial manual database screening, the syntactic and semantic aggregation to clusters was necessary. The aggregation was accomplished in several steps, including

automated clustering, followed by several manual loops and discussion rounds on the clusters.

Table 1 SCOPUS-based search string formulation

Search string		**Keyword I** AND	**Keyword II** AND	**Keyword III** AND	**Keyword III**
TITLE-ABS-KEY	**Keyword**	sustainability	indicator	Industr* 4.0	logistic*
	Synonyms	sustainable	reporting	digitali*ation	manufacturing
			index	digiti*ation	production
				smart logistics	
LIMIT-TO	**Options**	**LIMIT**	**SUBJAREA**		
		DOCTYPE, “ar”	SUBJAREA , “ECON”		
		DOCTYPE, “cp”	SUBJAREA , “BUSI”		
		DOCTYPE, “ch”	SUBJAREA , “ENGI”		

Subsequently, the identified papers were analysed, and all SKPIs were extracted and gathered in a standard Excel spreadsheet to be used as a database. If the article contained multiple mentions, appropriate references were also made in the database. By doing so, the relevance of the SKPI was taken into account. A summary of the literature analysed is presented in Table 2.

Table 2 List of identified references

Reference	**Methodology**	**Focus**
Kayikci, 2018	Delphi method (4 FMCG, 2 Transport), literature review and expert opinions	FMCG and Transport
Felsberger and Reiner, 2020	KPI selection: focus group interviews	How to measure the I4.0 impact
Takhar and Liyanage, 2020	Research and literature review, literature review on reporting requirements	Sustainability and circular economy data reporting using I4.0 technologies
Gunduz *et al.*, 2021	Literature review and QFD-methods (Quality Function Deployment)	Assessing the maturity level for supply chain smartness and sustainability
Nantee and Sureeyatanapas, 2021	Expert interviews, literature review on sustainability indicators	Logistics 4.0 impact on corporate sustainability performance

For the automatic syntactic clustering in the first step, the SKPI list was migrated from Excel to the PostgreSQL database. KPIs similarity analysis was performed using the *word_similarity(text, text)* function, which returns “a number that indicates the greatest similarity between the set of trigrams in the first string and any continuous extent of an ordered set of trigrams in the second string” [38]. The result is an $n \times n$ matrix filled with similarity values $s_{i,j}$ between $SKPI_i$ and $SKPI_j$ $(0 \leq i,j < n)$ for all SKPIs. The higher $s_{i,j}$ is, the higher the syntactic similarity of the two words on indices i and j, defined by the trigram matching method. Consecutively, the matrix was uploaded into Python via a .csv file and used to cluster the SKPIs with the *AgglomerativeClustering* class provided by the scikit-learn project [39]. The code applied for the clustering can be found online [40].

This way, SKPIs with the same or similar wording, i. e., syntactically similar SKPIs, were clustered. Subsequently, manual clustering was performed for semantic analysis, and new clusters were introduced to link individual SKPIs in a thematic context. After adapting the database to use only quantitatively measurable SKPIs, the research team evaluated the clusters in several discussion rounds so that they could have been to one of the commonly applied sustainability pillars – economic, environmental, and social. Table 3 displays the final clusters, their distribution to the three pillars, and the frequency analysis. The clusters are ranked in descending order of frequency of their occurrence in sustainability pillars.

Table 3 Cluster analysis outputs

Sustainability		Occurrence in literature sources					∑	
Area	**SKPI cluster**	[28]	[29]	[30]	[31]	[32]	**pcs**	**%**
Economic	Production-related costs and investments	1	1	1	1	1	5	100
	Performance and quality of planning	1	1	1	1	1	5	100
	Customer satisfaction	1	1	0	1	1	4	80
	Profit and economic success	0	1	0	1	1	3	60
	Product quality	0	1	0	0	1	2	40
	Sustainable costs and investments	0	0	1	0	0	1	20
	Business ethics	0	0	0	1	0	1	20
	Marketing	0	1	0	0	0	1	20
	System reliability	0	1	0	0	0	1	20
Environmental	Energy efficiency	1	1	1	1	1	5	100
	Waste intensity and treatment	1	1	1	1	1	5	100
	Emissions	1	1	0	1	1	4	80
	Resource efficiency	1	1	0	1	1	4	80
	Water	0	0	1	0	0	1	20
	Green product	0	0	1	0	0	1	20
	Land use	1	0	0	0	0	1	20
Social	Occupational health and safety	1	1	0	1	0	3	60
	Diversity and equal opportunities	0	1	1	0	0	2	40
	Local communities	0	0	1	0	0	1	20
	Employment	0	1	0	0	0	1	20

3.2 Frequency analysis of the use of the UNCTAD-recommended SKPIs in practice

This approach of identifying SKPIs suitable for assessing the sustainability of smart logistics and its technologies and applications was based on the Guidance on Core Indicators for Entity Reporting on Contribution towards Implementation of the Sustainability Development Goals [41]. The Guidance was developed by United Nations Conference on Trade and Development (UNCTAD) and designed to assist business entities in providing baseline information on SKPIs consistently and comparably to meet the common needs of different stakeholders of the SDG agenda.

The Guidance classifies SKPIs into four main areas:

1. Economic – four SKPIs clusters and eight specific SKPIs,
2. Environmental – five clusters and eleven SKPIs,
3. Social – four clusters and seven SKPIs,
4. Institutional – two clusters and seven SKPIs.

This classification has been transformed into three standard sustainability pillars. The transformation relies on merging the economic and institutional clusters into the economic pillar.

The content analysis of sustainability reports of leading European industrial companies was performed to assess the preferences of SKPI clusters in corporate practice. A list of the 20 largest European companies by 2020 revenues was used to select the industrial entities. The list was drawn from Fortune 500 ranking database [42]. The following criteria were applied to refine the list of companies:

1. Industrial focus,
2. Existing sustainability report,
3. Existing comprehensive SKPIs system.

The final research sample included 11 industrial companies (see Table 4). SKPIs differ in terminology and measures across industrial enterprises. Thus, the substantive content of the reported SKPIs was essential for their assignment to the UNCTAD classification. The frequency analysis result is presented in Table 5, showing the clusters in descending order according to their occurrence frequency in the sustainability pillars. The environmental pillar, a core component of all the sustainability reports reviewed, displays the most consistent results. The frequency analysis of economic KPIs is influenced by companies referring to standard financial statements (not included in sustainability reports) while reporting.

Table 4 Research sample

No.	Company (Country)	Revenue in 2020 (in milliard USD)	Industry	Source
1.	Royal Dutch Shell (Netherlands)	352.11	Oil and gas	[43]
2.	Volkswagen (Germany)	282.76	Automotive	[44]
3.	Glencore (Switzerland)	215.11	Natural resources	[45]
4.	Daimler AG (Germany)	193.35	Automotive	[46]
5.	Total (France)	176.25	Oil and gas	[47]
6.	Gazprom (Russia)	118.01	Oil and gas	[48]
7.	BMW Group (Germany)	116.64	Automotive	[49]
8.	Lukoil (Russia)	114.62	Oil and gas	[50]
9.	Siemens (Germany)	97.94	Technology	[51]
10.	Nestle (Switzerland)	92.11	Food and beverage	[52]
11.	Enel Groupe (Italy)	89.91	Energy	[53]

Table 5 Frequency analysis of the UNCTAD-recommended SKPIs clusters

Sustainability		Occurrence in sustainability reports											∑	
Area	KPI cluster	Shell	VW	Glencore	Daimler	Total	Gazprom	BMW	Lukoil	Siemens	Nestle	Enel	pcs	%
Economic	Revenue and/or (net) value added	1	0	1	1	1	1	1	1	1	1	1	10	90,9
	New investment/expenditures	1	1	1	1	0	1	1	1	1	0	1	9	81,8
	Corporate governance disclosure	1	0	1	1	1	1	1	1	1	0	1	9	81,8
	Payments to the government	1	0	1	1	0	1	1	1	0	0	1	7	63,6
	Local supplier/purchasing programmes	1	0	1	0	0	1	0	0	0	0	1	4	36,4
	Anti-corruption practices	0	0	1	0	0	1	0	0	0	0	0	2	18,2
Environme	Sustainable use of water	1	1	1	1	1	1	1	1	1	1	1	11	100
	Waste management	1	1	1	1	1	1	1	1	1	1	1	11	100
	Greenhouse gas emissions	1	1	1	1	1	1	1	1	1	1	1	11	100
	Ozone-depleting substances	1	1	1	1	1	1	1	1	1	1	1	11	100
	Energy consumption	1	0	0	0	0	1	0	0	1	1	1	5	45,5
Social	Gender equality	1	1	0	1	1	1	1	1	1	1	1	10	90,9
	Human capital	1	1	1	0	1	1	1	1	1	1	1	10	90,9
	Employee health and safety	1	1	1	1	1	1	1	1	0	0	1	9	81,8
	Coverage by collective agreements	0	0	1	0	1	1	1	1	0	0	0	5	45,5

3.3 Comparative analysis of the results obtained

Having identified two sets of SKPIs clusters, the next step involved examining the relationships (differences and similarities) in the obtained sets – the set of SKPIs clusters identified in the literature, hereinafter referred to as Literature set, and the set of SKPIs defined by UNCTAD (UNCTAD, 2019), referred to as UNCTAD set.

The clusters identified in the Literature set were matched with those defined in the UNCTAD set as part of the comparison of the two sets. The matching was intended to identify the clusters missing in the newly defined Literature set compared to the generally accepted UNCTAD set and vice versa. The final matching is presented in Figure 1.

The two sets reveal only a few differences, suggesting, on the one hand, a shared comprehension of the SKPIs in the literature and practice. However, on the other hand, the results reveal a lack of focus in the generic SKPIs sets, mainly the focus on the impact of digitalisation on sustainability [54,55]. The key differences can be summarised in two topics, addressed in more detail in the Literature set – production-related issues and the impact of digitisation. Thus, the newly defined set proposes SKPIs relevant to operational processes in industrial companies, such as the introduction of "system reliability", "process stability", "throughput", as well as "resource efficiency", allowing a more accurate assessment of production processes and indicating possible effects of specific improvement measures. Furthermore, the literature review has identified SKPIs with a high probability of being influenced by digitisation initiatives, such as "performance and quality of planning" and "customer satisfaction"; they constitute crucial factors for adopting smart logistics concepts.

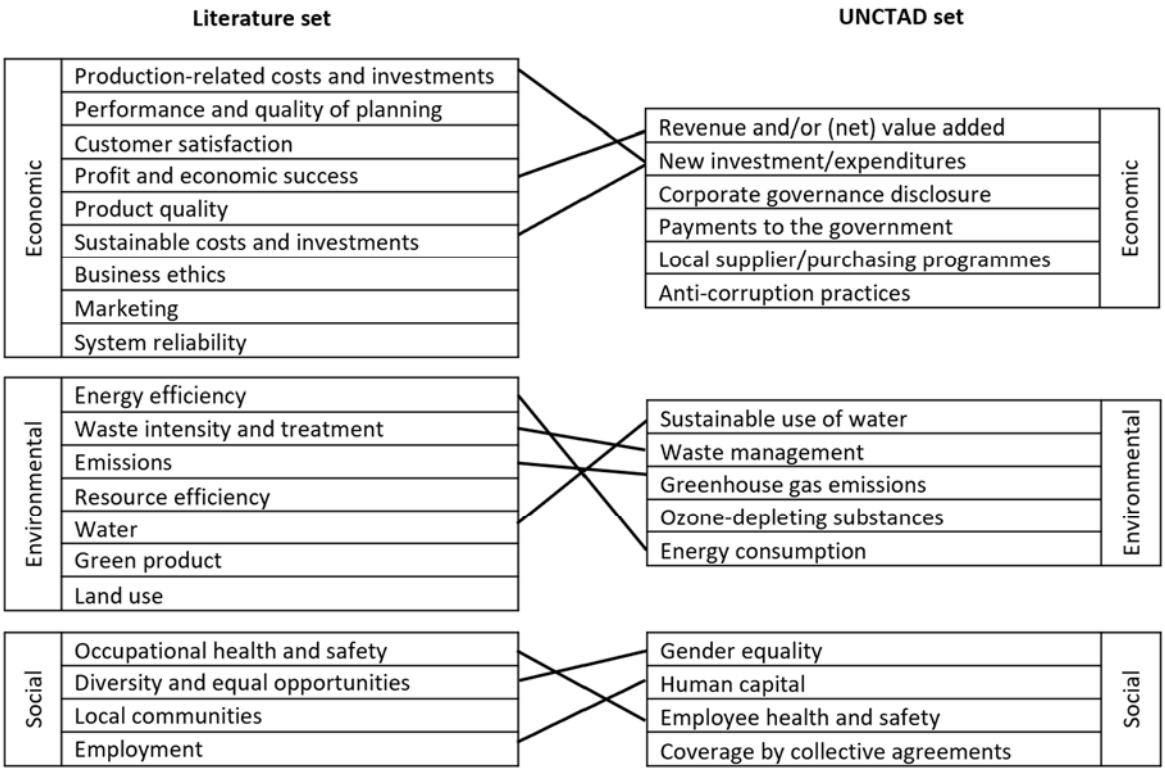

Figure 1 Matching the clusters from the literature to clusters from UNCTAD

4 Result and discussion

This chapter describes and discusses the main result of the article, namely the new SKPIs selection methodology for assessing the sustainability of smart logistics.

The professional community has not reached a consensus on whether to propose a global standardised set of SKPIs allowing comparisons between evaluated entities or processes or a case-by-case set of SKPIs tailored to a specific entity or process [25]. The proposed methodology attempts to combine both approaches and exploit their advantages. We propose developing a standardised set of SKPIs specific to the company or supply chain being evaluated. Although such an approach does not allow benchmarking with other companies or supply chains, it enables comparisons between the implementation of smart technologies and applications within various logistics processes of a company or supply chain while respecting its specific needs. If certain standard indicators are not relevant for particular smart technologies or applications, they are not included in the assessment.

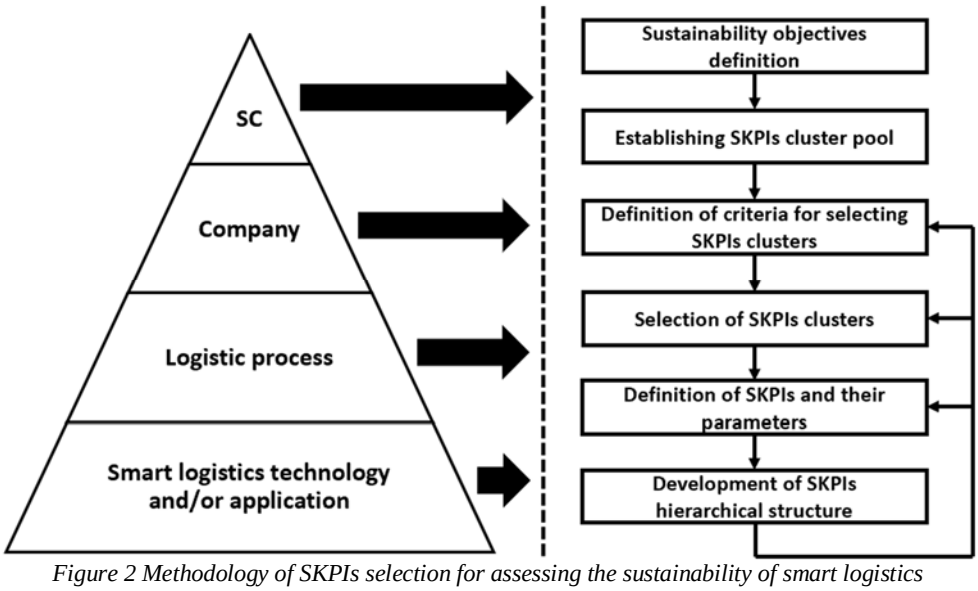

Figure 2 Methodology of SKPIs selection for assessing the sustainability of smart logistics

The methodology can be applied separately at different management levels (see Figure 2): supply chain, enterprise, logistics process and smart logistics technology and application. However, the sustainable performance of smart logistics should preferably be monitored and assessed at all levels. The sustainable performance of implemented smart logistics technologies and applications shall be assessed at lower management levels. Subsequently, this translates into overall sustainable performance at higher management levels.

The methodology relies on six steps shown in Figure 2 and is described in detail in the next section of the chapter.

4.1 Sustainability objectives definition

The SKPIs must be based on the sustainability strategy of the company and the supply chain, especially their sustainability objectives. Thus, the first step of the proposed methodology is the definition of sustainable objectives; the implementation of smart logistics technologies and applications should support their achievement. These objectives can represent a normative standard for a company or supply chain and apply to all stakeholders [35]. Thus, the final set of SKPIs shall be a balanced set reflecting the concerns of all stakeholders.

4.2 Establishing SKPIs cluster pool

Next, it is necessary to identify potentially suitable clusters for each sustainable goal, i. e., to create a sufficiently large SKPIs cluster pool. The following sources can be used:

a) SKPIs clusters that have already been defined in the company or supply chain as a result of other business processes;
b) SKPIs clusters from the literature review. To do so, one may apply the cluster analysis results from Chapter 3.1. The frequency analysis also allows the scientific community to assess the relevance of individual clusters;
c) SKPIs clusters recommended by corporate practice. In this case, a respected source is the Guidance on Core Indicators for Entity Reporting on Contribution towards Implementation of the Sustainable Development Goals developed by UNCTAD. The clusters contained in the Guidance are presented in Chapter 3.2, including a frequency analysis of their application by European industry leaders;
d) Design of own SKPIs clusters not included in the resources mentioned above.

The sources listed may overlap, see Figure 3, with dots representing SKPIs clusters. For example, a company or a supply chain may already use SKPIs clusters recommended by the scientific community and/or business practice.

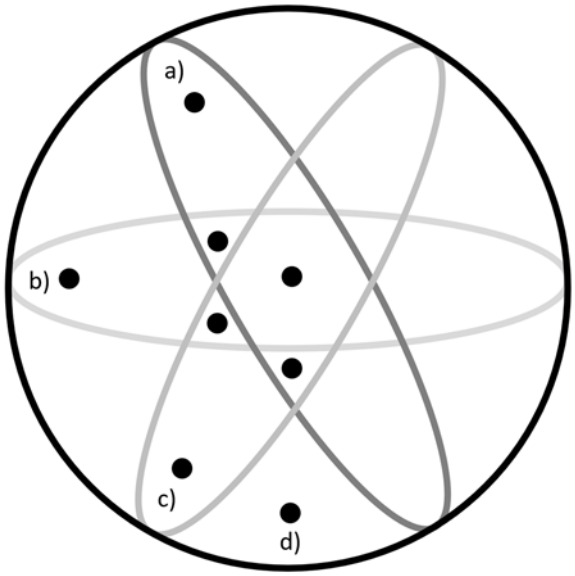

Figure 3 Sources for SKPIs cluster pool and their overlap

4.3 Definition of criteria for selecting SKPIs clusters

The next step in developing a functional and effective SKPIs system is determining the criteria for selecting suitable SKPIs clusters. A company or supply chain's main criteria should include:

1. Relevance to sustainable objectives. The SKPIs clusters should most closely reflect the achievement of the defined sustainability objectives.
2. Relevance to smart logistics. The SKPIs clusters should most closely mirror the change in sustainable performance associated with implementing smart logistics technologies and applications.

4.4 Selection of SKPIs clusters

This step involves applying the defined criteria for shortlisting the SKPIs clusters. As a rule, it shall include a qualitative assessment of whether or not the SKPIs clusters from the pool meet the defined criteria. Appropriate multi-criteria decision-making methods can be used to increase the assessment's objectivity.

4.5 Definition of SKPIs and their parameters

If suitable SKPIs clusters have been selected, the next step is to define one or more SKPIs for each of them. In defining them, one should remember that the final set of SKPIs must be manageable [25]. Therefore, it is better to choose a smaller number of SKPIs. To this end, it may be preferable first to define a broader set of possible SKPIs and, subsequently, identify those critical to the SKPI clusters.

SKPIs can be quantitative or qualitative. The best approach involves a combination of both methods [20]. In terms of expression, absolute or relative SKPIs can be used. Absolute SKPIs are more suitable for their gradual

aggregation to higher management levels and in-house benchmarking. The chosen SKPIs should be straightforward and specific to avoid misunderstandings and allow comparison over time.

A clearly defined benchmark must be assigned to each SKPIs. When a new measure is necessary, the company or supply chain should consider appropriate measurement methods, costs, and time [35]. To improve the sustainable performance of a business or supply chain, it is also advisable to set a target value for each SKPIs.

4.6 Development of SKPIs hierarchical structure

The procedure should result in a reasonably simple, functional, and efficient SKPIs system. Figure 4 illustrates the recommended hierarchical structure of sustainable pillars, clusters, SKPIs, measures and targets. Developing such a system usually requires retracing the previous steps and reassessing their content (see feedback in Figure 2). For implementing the system designed in such a way, applying the methodology for aggregated sustainability performance assessment of an industrial corporation developed by Wicher et al. [56] is recommended.

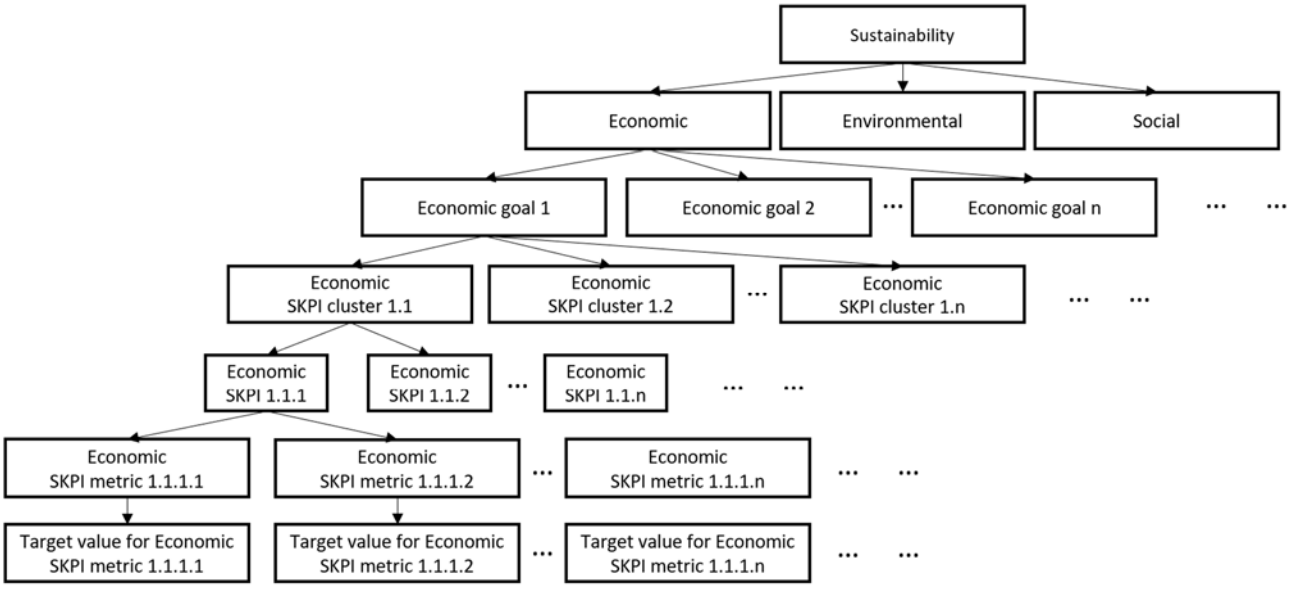

Figure 4 General hierarchical structure of SKPIs

5 Conclusion

This paper aimed to propose a methodology for selecting SKPIs suitable for assessing the sustainability performance of smart logistics and its technologies and applications. To accomplish the objective, two research questions have been addressed:

1. Which SKPIs can be applied to assess the sustainability performance of smart logistics and its technologies and applications? To do so, decision-makers can draw on a variety of sources. The proposal suggests combining SKPIs already in place in the company or supply chain with indicators recommended by the scientific community and business practice. Therefore, two analyses were conducted: a cluster analysis of SKPIs obtained through a review of the relevant literature and a frequency analysis of the use of the UNCTAD-recommended SKPIs in practice. Analyses have demonstrated that the primary focus should concentrate on investments and revenues in the field of Economy, emissions and waste management in the Environment, and occupational health and safety in the Social area.
2. How to select the appropriate SKPIs to assess the sustainability performance of smart logistics and its technologies and applications? While seeking an answer to this question, a SKPIs selection methodology for assessing the sustainability of smart logistics was proposed, involving defining sustainability objectives, creating SKPIs cluster pool, defining selection criteria applicable to SKPIs clusters, selecting SKPIs clusters, defining SKPIs and their parameters, and creating a hierarchical structure of SKPIs. The methodology can be applied separately at different management levels: supply chain, enterprise, logistics process and smart logistics technology and application.

While conducting research, we have revealed a distinct lack of a clear definition of smart logistics technologies and applications at different levels of the process, enterprise and supply chain management, both in the relevant literature and corporate practice. This ambiguity significantly complicates any assessment of sustainability performance in deploying the technologies. Therefore, the first objective of our further research is to propose an explanatory model for defining smart logistics technologies and applications at all management levels. The next step of any future research shall involve applying the established methodology and explanatory model as a baseline for developing a conceptual model to assess the

sustainable performance of smart logistics in supply chains, balancing the economic, environmental and social performance of logistics processes.

Acknowledgement
Our research was supported by the Czech Ministry of Education, Youth and Sports and the Austrian Federal Ministry of Education, Science and Research, project No. 8J21AT018, Conceptual Model for Comprehensive Sustainability Performance Assessment of Smart Logistics in Supply Chains. Furthermore, the research was supported by the specific University research of the Ministry of Education, Youth and Sports of the Czech Republic at VŠB – Technical University of Ostrava, project No. SP2022/78.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 479-485 ISSN 1339-5629

doi:10.22306/al.v9i4.355 *Received: 14 Nov. 2022; Revised: 07 Dec. 2022; Accepted: 27 Dec. 2022*

THE RELATIONSHIP OF INNOVATION AND THE PERFORMANCE OF BUSINESS LOGISTICS IN THE EU

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Keywords: innovation, business logistics performance, correlation analysis, cluster analysis.
Abstract: At present, innovations have a significant impact on the success of the company on the market, and in the case of their correct implementation, they represent a competitive advantage for the company, which significantly differentiates it from the competition. At the same time, we can perceive them as an essential part of business, as the market, consumers and their preferences change dynamically, and through innovations the company can respond more flexibly to these changes and thus gain an advantage over its competition. The paper is dealing with the issue of innovation and business logistics performance in the EU. To examine the relationship between innovation and business logistics performance, we used data on the Innovation Index and the Logistics Performance Index in individual EU countries. The correlation analysis was applied to assess the closeness of the statistical dependence among the investigated variables, and subsequently we applied cluster analysis to decompose the basic set of investigated objects into several relatively homogeneous subsets - clusters. The results confirm the dependence between innovation and business logistics performance in EU countries. Regarding the results of the analysis, we can state that countries with the greatest business logistics and innovation performance tend to form geographically close clusters, and this decreases with increasing geographical distance from more efficient countries.

1 Introduction

Nowadays, innovations are becoming an important success factor, the correct implementation of which can move the company ahead of the competition, increase its competitiveness, respond more flexibly to constantly changing customer requirements and strengthen its position on the market. Innovations represent a means by which it is possible to handle ever more demanding customer requirements, increasing competitive pressure, rapid technological development, and globalization of business [1-3].

Innovations in technologies continue to drive massive changes in logistics and supply chain management, making today perhaps the most exciting time in logistics or supply chain phenomena. Technological innovations lead to new ways of doing business, as well as entirely new business models. Nowadays, the number of technologies affecting logistics and supply chain management is considerable [4].

Logistics ensures that the given objects, such as raw materials, semi-finished products, parts, subcontracts, products, etc., are transported in the specified time, quantity, and quality to the specified place, while observing the required conditions and minimum costs. Logistics includes the processes of operational handling, transport, storage, and their management. Logistics is an area where significant savings can be achieved, it has an impact on the fulfillment of customer requirements and on the flexibility of production.

By Kováč [5] the main requirements for logistics innovations as stated by are:

- Minimization of material flows. The material flow does not add any value for the customer, so it must be minimized.
- Continuity of material flows. It is related to the requirement of production cycle minimization and shortening
- Optimization in a global environment. New solutions for the global market of component suppliers and customers of final products.
- Use of computer management and electronic commerce technologies.
- New organization of supplier relations based on partnership and network organization.

The expansion of trade and services liberalization has forced companies to consider global market demand in their competitive strategic planning. Therefore, business processes had to become continuous, and innovations for them represent the promise of potential growth, development, and competitive advantages in the market. Business logistics has been considered as the most important area that needs to be innovated, because they

represented an effective means of improving performance [6-10].

As reported by Jaafar et al. [6], innovation as a term was ignored in logistics research for a long time and was mainly associated with the general product and its innovations or focused on high-tech innovation. By Flint et al. [11,12], innovation represents an important factor for the logistics services and increasing competitive advantage. Flint et al. [12] in accordance with the innovation theory of Schumpeter [13], who defined innovation as the implementation of new combinations of product, process and organizational innovations that would provide new access to supplier or consumer markets, emphasize that innovation is not limited only to technological breakthroughs or products themselves, but the concept of innovation can occur within services, processes, or any social system. By their theory, innovation also includes the conscious application of information, imagination, and initiative in exploiting greater or different value from resources and includes all processes by which new ideas are generated and transformed into useful products but also services. Based on the above, Flint et al. [12] defined the term "logistics innovation" as any service related to logistics that is considered new and useful for customers so innovation represents any internal and external operations to increase operational efficiency.

The evaluation of innovativeness is carried out in terms of the frequency of introduction of new processes related to logistics and the ability to make them more efficient.. Panayides and Lun [14] in the evaluation of innovativeness in logistics concluded that innovations increase the performance of supply chains. Innovations in logistics represent the combined development of information and related technologies with new logistics and marketing practices to increase logistics performance [15]. As stated by Straka et al. [16] or Mansfield et al. [17], innovativeness and its impact on performance and economic growth has long been a subject of interest of economists. Based on the above, the aim of this paper is to identify the relationship between innovation and business logistics performance in the EU.

2 Methodology

The paper's methodology is based on data from The WORLD Bank [18], which evaluates the Logistics Performance Index, and The Global Economy [19], which provides data on the Global innovation index.

The Logistics Performance Index is an interactive benchmarking tool created to identify business logistics opportunities and challenges to increase its performance. The logistics performance index is based on a global quantitative and qualitative survey, and it is evaluated in 160 countries of the world to share business experience in the global business-logistics environment. The logistics Performance Index captures the logistics elements of individual countries from the point of view of:

- Customs,
- Infrastructure,
- International shipments,
- Logistics quality and competence,
- Tracking and tracing,
- Timeliness.

The Global Innovation Index monitors global innovation trends in individual countries of the world, which bring innovative effects of economic growth. The data obtained from these two basic sources represent the secondary inputs of this research and they can be subsequently processed by the SPPSS Statistic software from 27 countries of the European Union - EU 27.

Based on the literature review, we established the hypothesis H1 "We assume a statistically significant dependence between innovations and the logistics performance in the EU."

The correlation analysis was used to determine the relationship between these two monitored factors. The correlation coefficient defines the strength of the relationship between innovations and the performance of business logistics as well as its individual elements. The strength of the correlation coefficient relationship is interpreted according to Hanák [20] as follows - correlation coefficient values of 0.8 to 1 (-0.8 to -1) are particularly strong, so there is a very strong interdependence among the variables. Values from 0.4 to 0.8 (-0.4 to -0.8) are moderately strong, and from 0 to 0.4 (-0.4 to 0) are weak. These values represent findings how the change in one variable affects another variable. Linear correlation dependence means that if one variable grows, then another one also grows, which in our case represents that if the share of innovations grows, the performance of business logistics grows linearly with them.

We used cluster analysis to segment the EU countries from the point of view of the relationship between innovations and business logistics performance and its elements. We divided the EU countries into groups with the greatest similarity within the group and with the greatest possible difference among individual groups by the cluster analysis [21].

Subsequently, based on the findings, we will create conclusions about the solved issue through the inductive-deductive method.

3 Result and discussion

Based on the obtained data of the Logistics Performance Index and its elements, as well as the Global Innovation Index, we calculated the correlation coefficient characterizing the relationship of these variables, see Table 1. As the values of the correlation coefficients of individual variables show, the relationship of logistics performance with innovations shows medium to medium-strong dependence among the investigated variables. A very strong interdependence was shown only between Customs and innovations. This is probably because the Schengen

area is among the EU countries. The members of the Schengen area are mainly the states of the European Union. Within it, persons and goods can freely cross borders at any point of the contracting states without border control [22]. This fact significantly affects logistics and its performance. The other investigated variables have a moderately strong dependence with innovations, which also points to the dependence of logistics performance on innovations in connection with infrastructure (0.78), with Logistics quality and competence (0.72), with Tracking and tracing (0.70), with Timeliness (0.60) and with international shipments (0.51), each in different intensity. Based on the mentioned results, we can conclude that the dependence between innovations and the logistics performance in the EU is statistically significant and hypothesis H1 is accepted.

The results confirm the theory of Flint et al. [11,12], who claim that innovation is an important factor for providing logistics services and increasing competitive advantage. As Panayides and Lun [14] present, innovation increases the performance of supply chains.

Table 1 Data and the relationship of innovation and the performance of logistics in the EU

Country	Logistics Performance Index*							Global innovation index*
	Total	Customs	Infrastructure	International shipments	Logistics quality and competence	Tracking and tracing	Timeliness	
Germany	4.20	4.09	4.37	3.86	4.31	4.24	4.39	58.00
Sweden	4.05	4.05	4.24	3.92	3.98	3.88	4.28	63.10
Belgium	4.04	3.66	3.98	3.99	4.13	4.05	4.41	50.05
Austria	4.03	3.71	4.18	3.88	4.08	4.09	4.25	51.30
Netherlands	4.02	3.92	4.21	3.68	4.09	4.02	4.25	63.30
Denmark	3.99	3.92	3.96	3.53	4.01	4.18	4.41	58.40
Finland	3.97	3.82	4.00	3.56	3.89	4.32	4.28	59.60
France	3.84	3.59	4.00	3.55	3.84	4.00	4.15	54.40
Spain	3.83	3.62	3.84	3.83	3.80	3.83	4.06	48.70
Italy	3.74	3.47	3.85	3.51	3.66	3.85	4.13	46.30
Czech Republic	3.68	3.29	3.46	3.75	3.72	3.70	4.13	48.70
Portugal	3.64	3.17	3.25	3.83	3.71	3.72	4.13	45.70
Luxembourg	3.63	3.53	3.63	3.37	3.76	3.61	3.90	54.50
Poland	3.54	3.25	3.21	3.68	3.58	3.51	3.95	41.70
Ireland	3.51	3.36	3.29	3.42	3.60	3.62	3.76	57.20
Hungary	3.42	3.35	3.27	3.22	3.21	3.67	3.79	44.90
Slovenia	3.31	3.42	3.26	3.19	3.05	3.27	3.70	46.90
Estonia	3.31	3.32	3.10	3.26	3.15	3.21	3.80	50.50
Greece	3.20	2.84	3.17	3.30	3.06	3.18	3.66	38.90
Romania	3.12	2.58	2.91	3.18	3.07	3.26	3.68	37.60
Croatia	3.10	2.98	3.01	2.93	3.10	3.01	3.59	40.70
Bulgaria	3.03	2.94	2.76	3.23	2.88	3.02	3.31	37.60
Slovak Republic	3.03	2.79	3.00	3.10	3.14	2.99	3.14	42.90
Lithuania	3.02	2.85	2.73	2.79	2.96	3.12	3.65	41.20
Malta	2.81	2.70	2.90	2.70	2.80	2.80	3.01	50.30
Latvia	2.81	2.80	2.98	2.74	2.69	2.79	2.88	43.20
Cyprus	3.15	3.05	2.89	3.15	3.00	3.15	3.62	47.80
Correlation index	0.73	0.83	0.78	0.51	0.72	0.70	0.60	1

*Data are for the last recorded year of logistics performance - 2018

Subsequently, we processed a cluster analysis for the division of EU countries into groups with the greatest similarity from the point of view of the performance of business logistics and innovations, and at the same time with the greatest possible difference among the single groups, see Figure 1.

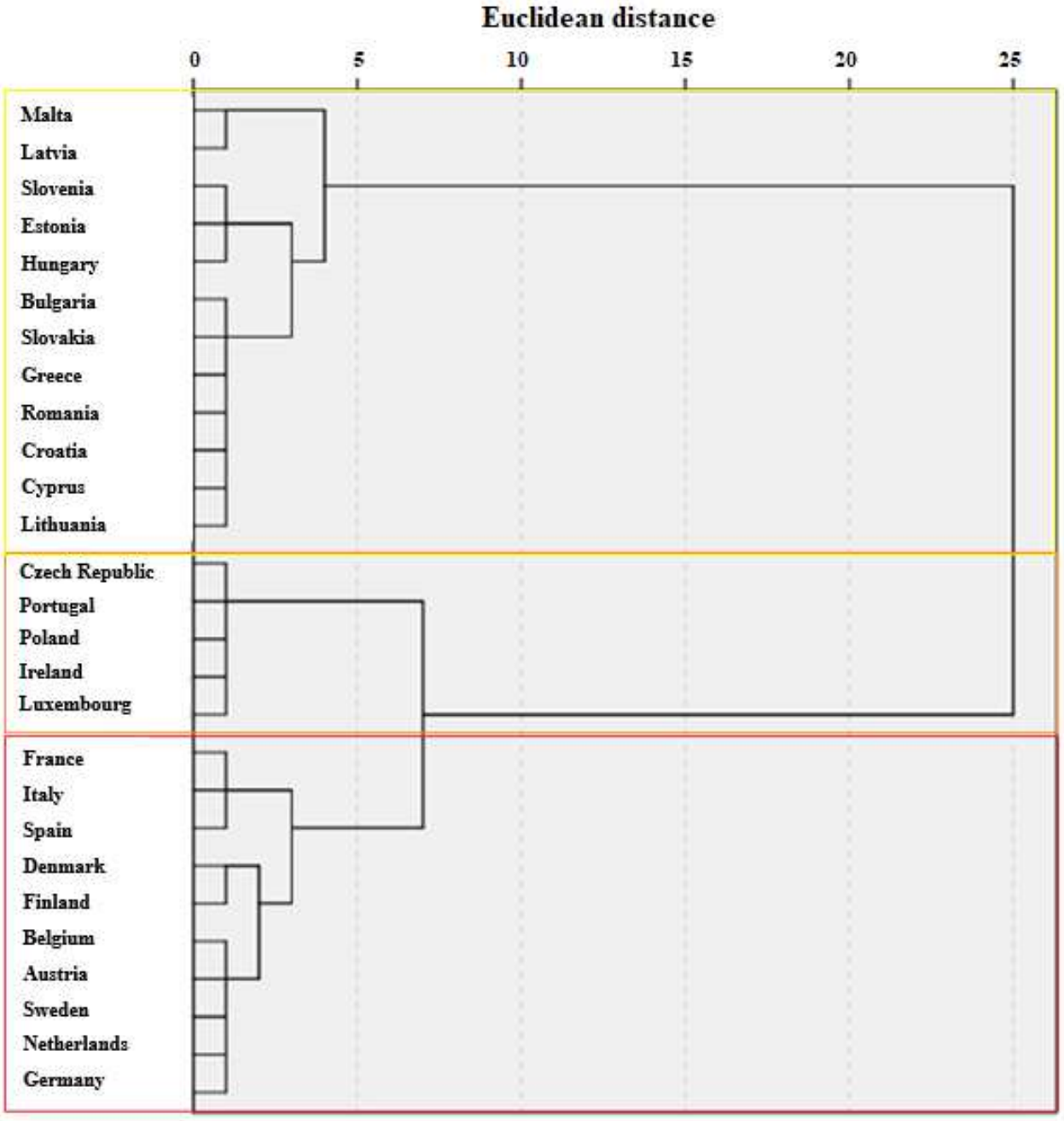

Figure 1 Cluster analysis of the relationship of innovation and the performance of logistics in the EU

We identified the greatest distance, which represents the greatest difference between the studied groups and the greatest similarity within the groups, at the Euclidean distance of 5, from which we subsequently identified three clusters:

The first cluster - characterized by the greatest performance of logistics and innovation - Germany, Sweden, Belgium, Austria, Netherlands, Denmark, Finland, France, Spain, Italy.

The second cluster - characterized by average logistics and innovation performance - Czech Republic, Portugal, Luxembourg, Poland, Ireland.

The third cluster – characterized by low logistics and innovation performance – Hungary, Slovenia, Estonia, Greece, Romania, Croatia, Bulgaria, Slovakia, Lithuania, Malta, Latvia, Cyprus.

Finally, we illustrated the stated findings in Figure 2, which represents a map of countries from the point of view of logistics performance and innovation in the EU.

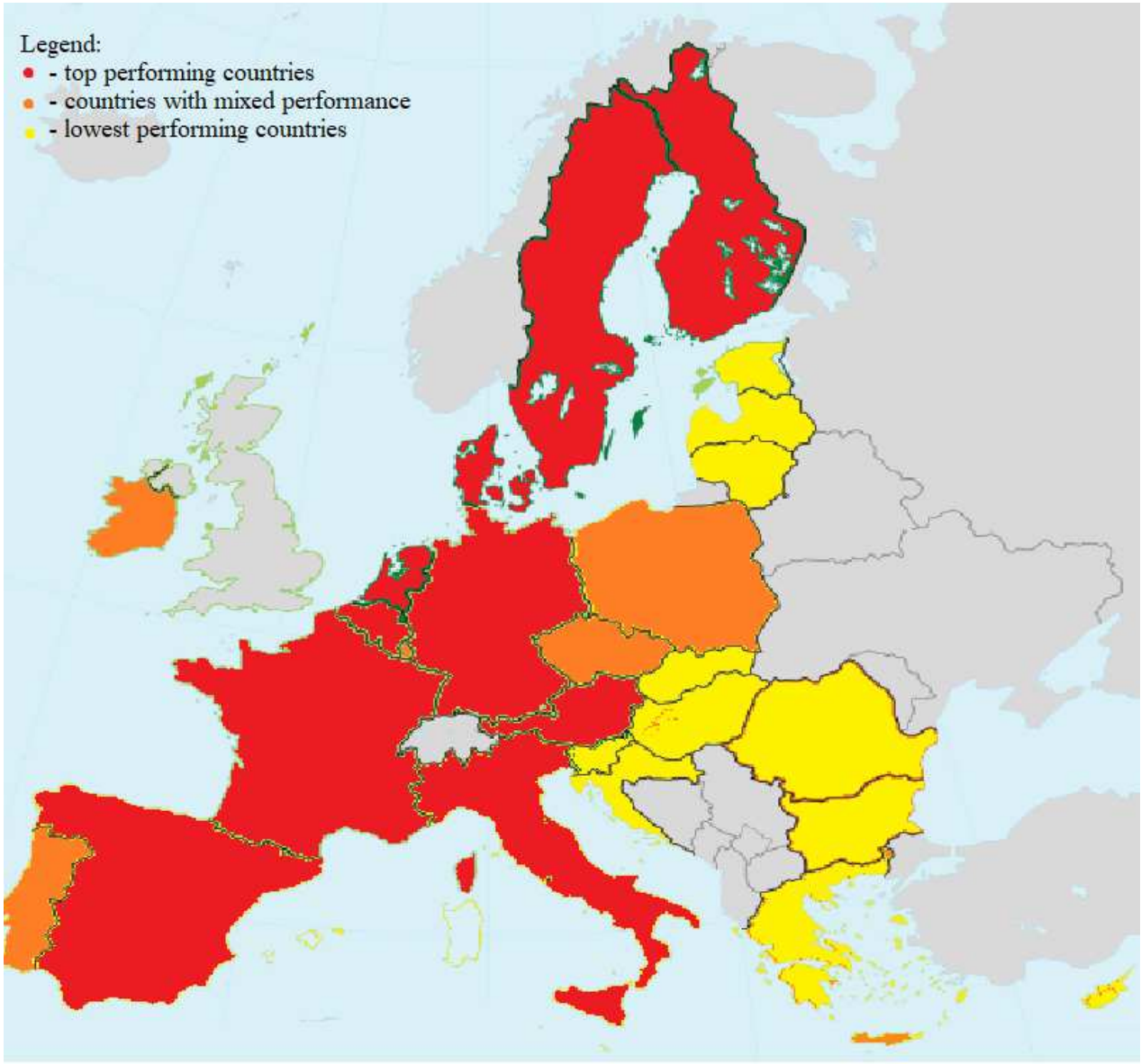

Figure 2 Map of countries from the point of view of logistics performance and innovation in the EU

Based on the performed analyses, we can conclude that the countries with the greatest performance in business logistics and innovation tend to form geographically close groups. Subsequently, as we can see from the graphic analysis, the performance of business logistics and innovation decreases with increasing geographical distance from more efficient countries in the researched area, i.e. countries with higher performance in business logistics and innovation. This fact was confirmed by several studies focusing on the relationship among innovations and other factors such as ecological innovations or sustainable development [23,24].

4 Conclusions

Innovations have become an important factor affecting the success of the company on the market, and in the case of their correct implementation, they are an important factor for the company bringing success on the market in the competitive fight. At the same time, innovations are a tool that enables managing not only growing competitive pressure, rapid technological development, and globalization of business. Innovations in technology are mainly the driving force behind significant changes, which are subsequently also manifested in the field of logistics and supply chain management. For this reason, we can talk

about a time when the field of logistics is experiencing significant changes bringing a lot of news. However, innovation performance and logistics performance are not at the same level in individual countries, and different factors affect this performance.

In the paper we examine the relationship between innovation and logistics performance in the EU. We investigated this relationship through correlation analysis, which confirmed a moderately strong dependence between the investigated variables. From the point of view of the individual performance parameters of logistics and innovation, a great dependence was confirmed between innovation and customs. As stated in the paper, we assume that this high dependence among the investigated variables was mainly caused by the fact related to the Schengen area, which ensures the free movement of goods within most European countries. Other parameters of logistics performance show moderate dependence on innovations. As part of the cluster analysis, we examined groupings of EU countries from the point of view of the investigated relationship between innovation and logistics performance. Based on the findings of the cluster analysis, we conclude that the relationship between innovation and business logistics performance has been confirmed. Countries with the greatest logistics and innovation performance tend to form geographically close clusters. The performance of business logistics and innovation decreases with increasing geographical distance from more efficient countries.

Acknowledgement
The authors would like to thank 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 1/0475/22 “Environmental Consumer and Environmental Citizen”, grant number 1/0495/22, “Sustainability of Value Supply Chains and its Impact on the Competitiveness of Companies in the Forest and Forest-Based Sectors" and grant number 1/0494/22 “Comparative Advantages of the Wood Based Sector under the Growing Influence of the Green Economy Principles”.

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Review process
Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 4 Pages: 487-499 ISSN 1339-5629

doi:10.22306/al.v9i4.356 *Received: 17 Nov. 2022; Revised: 10 Dec. 2022; Accepted: 29 Dec. 2022*

SUSTAINABLE SUPPLY CHAIN MANAGEMENT IN THE MEAT INDUSTRY IN POLAND

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Keywords: sustainable, supply chain, management.
Abstract: Every type of business is closely related to the flow processes of various types of goods. The flow process begins at the source of raw materials until it reaches the final customer. A corollary to the newly emerging challenges of both social and environmental management of increasingly complex supply chains is the issue of sustainable supply chain management. The meat industry, along with its entire supply chain, is subject to cyclical crises, with different foundations and negative effects on individual links. One of the reasons for the crises in the meat industry is the management of supply chains based primarily on economic objectives to the exclusion of social and environmental aspects. The purpose of the article is to assess the level of sustainable supply chain management in the meat industry. The research problem is to determine the involvement of meat industry companies in the various dimensions of sustainability: economic, social and environmental. Therefore, a special online survey questionnaire was created, where potential respondents representing 93 meat companies were identified and purposely selected. After receiving and verifying the completed questionnaires, 85 completely completed questionnaires were qualified for further analysis and a coding process was carried out using Excel software, then the data was imported into Statistica statistical software, where the main statistical analyses were carried out.

1 Introduction

In the rapid growth of the global economy is giving rise to increasingly complex yet uncertain supply chains, both domestic and international. Until recently, companies dealt with this by introducing various supply chain management, risk management techniques to a more or less advanced degree. For several years now, companies have been facing the new challenge of sustainability.

Over the years, the issue of sustainability has become a priority thus its essence has begun to play an increasingly important role in the agendas of international communities. The starting point was the creation of the Brundtland Report in 1987 entitled, "Our Common Future," which, among other things, defined sustainable development as one that meets the current needs of society while not compromising future generations to meet their needs. Subsequently, the issue of sustainable development was repeatedly analysed at many international conferences with the final result being recommendations for the development of national strategies that take into account the economic social and environmental aspects of sustainable development. Since then, public interest in the issue of sustainability has continued to grow.

Companies previously focused solely on economic profit and ignoring environmental and social aspects had to implement pro-social and pro-environmental measures to become leaders in their industry. Companies involved in the supply chain decided to modernize it to satisfy all three aspects of sustainability. However, in the case of the food supply chain, things were a bit more complicated because assumptions did not make it easy to achieve the goal.

In the 21st century, the awareness of the potential consumer is increasing, in addition, an upward trend of interest in the eco-friendly sphere has been noted. Researchers say that it is more and more common to analyse various characteristics of a product before buying it. Relating this to the meat industry in Poland, the customer analyses a number of important issues before buying, such as:

- The origin of the product (opinion of the butcher or processing plant).
- The origin of the livestock from which the product was made (domestic/imported) (organic farming/non-organic farming).
- The type of packaging the product comes in (eco-friendly or not).

Companies wishing to fit into the highest standards imposed by consumers must manage their supply chain in a sustainable manner, which means affecting all three aspects equally. Important measures taken by companies include the selection of sustainable contractors, the implementation of environmentally friendly production processes and greater focus on the needs of employees.

Companies in the meat industry face a tough challenge, because in addition to the many requirements imposed by consumers on the quality of products, they are exposed as an industry to cyclical crises caused by threats of various origins. Pointing out as examples from recent years will be the swine flu pandemic year 2009-2010, the COVID-19 pandemic from 2020, African swine fever (ASF)-the first outbreaks in 2014, followed by the return of the disease in 2021, Avian Influenza outbreaks in 2021. Each of these

phenomena causes a crisis, which affects supply chain management in the form of a reduction in the amount of livestock on the market, halting or reducing supplies, processing, sales.

To achieve a practical result, companies must combine supply chain and sustainability knowledge along with social responsibility. Taking responsibility for all processes in the transition of a product starting from the raising of the slaughtered livestock to the delivery of the final product to store shelves taking into account the waste generated during production is the essence of sustainable supply chain management in the meat industry. Recent years have shown that even the largest meat processing plants or slaughterhouses can face a crisis caused by a lack of awareness of social and environmental risks, despite a mature approach to social responsibility.

Therefore, the topic is extremely important in terms of determining the theoretical basis for studying the level of sustainability of supply chain management in the meat industry. And in practical terms, to formulate solutions to stabilize the meat industry on this level by implementing sustainable supply chain management based mainly on close cooperation.

The purpose of the article is to assess the level of sustainable supply chain management in the meat industry. The research problem is to determine the involvement of meat industry companies in the various dimensions of sustainability: economic, social and environmental.

The gist of the article rises as talk of responsible production and consumption is in The-Sustainable-Development-Goals-Report-2022 prepared by the United Nations Department of Economic and Social Affairs Statistics Division in 2022. The slogan promoting the report was the words of António Guterres (Secretary-General, United Nations), "*We must rise higher to rescue the Sustainable Development Goals - and stay true to our promise of a world of peace, dignity and prosperity on a healthy planet.*" More specifically, the 12th goal of this report is dedicated to production and consumption. Delving deeper into the content, we find disturbing information about the scale of the problem, which is briefly described as: , "*Unsustainable patterns of consumption and production are root causes of the triple planetary crises of climate change, biodiversity loss and pollution. These crises, and related environmental degradation, threaten human well-being and achievement of the SDGs.*" [1]. Information on how to deal with this problem is also included: , "*Transforming our relationship with nature is key to a sustainable future. As the world develops strategies for sustainable recovery from the pandemic, governments and all citizens should seize the opportunity to work together to improve resource efficiency, reduce waste and pollution, and shape a new circular economy.* " [1]. The UN policy emphatically underscores the magnitude of the problem facing the world in this time of crisis, and this article can be the basis for research and analysis in every sector of the food economy for actual analysis for 2023.

1.1 Sustainable supply chain management (SSCM)

The issue of sustainability is a rapidly growing area of research that represents the interests of business, science and associations. It is defined and interpreted in various ways and contexts. The concept is increasingly pointing the way forward for business, and more companies are incorporating social and environmental criteria into their operations. Sustainable supply chain management (SSCM) has grown significantly and has become a subject of increased concern due to environmental resource limitations, a global population explosion, the corruption of logistics production and consumption activities, and waste and pollution increases [2]. Sustainable supply chain management (SSCM) has received much attention in the decade ending in 2020 due to an increased awareness of climate change and environmental and social issues across the globe. The current trend of disaggregating global supply chains increases the need to expand sustainability efforts beyond firm boundaries [3]. At the same time, this creates a significant regulatory problem. In recent years, pressure has increased on private sectors to take responsibility for social and environmental issues. [4] SSCM requires firms across a supply chain to report not only on profits but also on environmental and social performance [5]. To achieve the objectives of SSCM, firms should set long-term goals on sustainability, be transparent in their reporting, develop a culture of sustainability and manage supply chain risks appropriately [6]. Sustainability refers to the integration of environmental, economic and social goals to meet current needs without compromising the needs of future generations [7,8]. Sustainable supply chain management can also be defined as optimizing a company's processes and operations with low-impact environmental protection and increasing social benefits through their corporate social responsibility [9]. Sustainable supply chain management (SSCM) integrates economic, social and environmental supply chain objectives to improve long-term performance by assessing and monitoring business performance against social, environmental and economic dimensions [10]. Adoption and implementation of SSCM provide many benefits to the firms this include reduction in cost of product, better customer–supplier relationship, achieving circular economy etc. [11].

Social sustainability encompasses the concepts of equality, empowerment, accessibility, participation, identity culture and institutional stability. The concept suggests that people matter because development is about people. Essentially, sustainable social development means a system of social organization that alleviates poverty. Examples of social sustainability include ensuring fair policies, ethical practices, equal opportunities, diversity [12-14].

The concept of environmental sustainability refers to the natural environment and how it remains productive and resilient to support human life. Environmental sustainability involves the ecosystem integrity and carrying capacity of the natural environment. It requires natural capital used sustainably as a source of economic inputs and as a sink for waste. When a supply chain is environmentally sustainable, it is known as a green supply chain. Examples of an environmentally sustainable supply chain include the treatment of waste, recycling, environmental education and training, green purchasing, green manufacturing, and green design [15]. Reducing the environmental impact of business activities taking into account all links in the supply chain, taking into account the interconnections and interactions between them and the natural environment, is becoming an increasingly important challenge. Such a comprehensive approach enables effective environmental action, while increasing opportunities for eco-innovative solutions. [16,17] Issues related to green supply chain management in Poland are considered within the framework of various directions and currents of organization and management theory [18,19].

Scientists say that due to population growth, human needs such as food, clothing, housing are increasing, but the means and resources available in the world cannot be increased to meet the demands always. Economic sustainability therefore requires that decisions be made in the most equitable and financially viable and possible way, taking into account other aspects of sustainability. Examples of economic sustainability include cost reduction, on-time delivery, reliability, and quality [20].

Sustainability is a long-term focused approach to business. It represents the creation of such systems and processes that are able to endure into long time work. Given that businesses have their economic nature but operate within certain environments and social systems, the study of sustainability is not limited to the environmental issues [21]. The three key dimensions in which sustainability needs to be studied are economic, ecological but also social [22].

Sustainable supply chain management is a fundamental aspect of the construction of competitive advantage in global markets as it aims to optimize the consumption of resources by applying the principles and practices of the circular economy, operating under moral principles that guide the actors in the chain in what and how to sustain value and reciprocity relations [23]. The integration of sustainability practices at inter and intra level of an organization's supply chain is positively linked to its environmental and social performance [24]. A lack of sustainability integration can affect the overall sustainability performance of the supply chain. Sustainable development is now not only a necessity but also emerged as a potential game-changer for organizations. Increasing numbers of companies are now committing to the cause of sustainability in their supply chain [25]. Global competition is putting more pressure on the government authorities, for the implementation of environmental regulations that stimulate greater sustainability in manufacturing companies through the best practices of supply chains [26]. With such policies, producers must optimize their systems and focus the efforts on fostering bio-economy, as well as ecofriendly goods and markets to increase the environmental performance as demand for environment low-impact products grows [27]. Kulchitaphong et al., [28] have conducted research that allows entrepreneurs to define strategies and goals to create mechanisms and actions to achieve customer needs, satisfy customers, build trust, accumulate loyalty, and lead to sustainable consumption in the end.

1.2 Characteristics of the supply chain in the meat industry in Poland

In order to properly characterize the meat supply chain in Poland, general data on meat production and consumption in Poland are presented and discussed at the outset Table 1 and Table 2 . They are intended to illustrate the scale of market demand for meat products and the production capacity of plants in recent years. Next, the definition of the food supply chain was refreshed, after which the food supply chain in Poland was discussed and illustrated in detail.

Table 1 Slaughter livestock production in Poland for 2020-2021

DESCRIPTION	MEASUREMENT	SUPPLIES				
		2015	2019	2020	2021	DIFF
Meat total	thousands of tons	3652	4043	4194	4348	119.1
Raw meat from slaughter animals	thousands of tons	2077	2296	2413	2543	122.4
Poultry	thousands of tons	1575	1747	1782	1805	114.6
Canned goods, cold cuts, poultry sausage products	thousands of tons	176	128	136	105	59.7
Meat and offal preparations from slaughtered animals (canned meat, cold cuts, sausage products and other preparations)	thousands of tons	897	862	803	837	93.3

Source: CSO data source

Table 1 shows an overall significant increase in total meat in 2021 compared to 2015-a difference of 19.1%. Discussing the tables in detail, an upward trend can be seen for raw meat from slaughter animals 22.4%, poultry 14.6%.

In contrast to raw meat- processed meat and offal from slaughter animals recorded a decrease of 6.7%. In contrast, shipments of canned meat, cured meats and poultry sausage products recorded a huge decline of as much as 40.3% compared to 2015.

Analyzing the results of Table 1, it can be said that over the years, canned goods, cold cuts, poultry sausage products and Meat and offal preparations from slaughtered animals had an overall downward trend. However, there appears some deviation of the downward trend over 2019/2020/2021 even it can be said that it was at times upward over these years. A factor that may have caused this was the outbreak of Pandemic COVID-19 and its aftermath across the country. The public, wanting to secure in the knowledge of how long this condition could last, increased their interest in products with longer shelf life when shopping, which was anyway hampered during the lockdown. Many local butcher shops were able to interrupt their operations, which further motivated consumers to increase their interest in ready-made products from store shelves.

Table 2 Per capita consumption of meat consumer goods in Poland 2015-2021

DESCRIPTION	MEASUREMENT	2015	2019	2020	2021
Meat and offal (including intended for processing)	kg	75.0	75.9	77.6	77.5
including meat	kg	70.9	71.4	72.9	73.8
Edible animal fats	kg	5.8	6.0	6.0	6.9

Source: CSO data source

The Table 2 indicates the meat consumption per capita for 2015-2021 in Poland . Considering the data in the table, we see an overall upward trend in meat and offal consumption of 2.5kg. Specifically, meat consumption increases by 2.9kg per capita in Poland, while consumption of animal edible fats increases by 1.1kg relative to 2015.

Food products typically pose additional challenges to logistics and transportation due to their perishability, limited storage capacity, security and traceability requirements [29,30]. Modern food supply chains are increasingly complex and contain multi-level stakeholder relationships that compete to stay in the chain and serve customers [31]. Food supply chains around the world, involve a large number of stakeholders, and the average distance food travels from the producer to the end consumer has increased dramatically over the past two decades [32]. The food supply chain (FSC) is a network of activities aimed at providing food for the public and maintaining food security [33]. As in other supply chain scenarios, different actors interact with each other at different stages of the FSC, such as production, processing, distribution and consumption. The actors in the food chain form an ordered set of actor groups dealing with specific areas indicated in Figure 1. Here we can distinguish between, producers (farmers, growers), food processors, transport and storage operators and retailers. In a broader aspect, the ordered groups can include the group of consumers located just behind the traders. Organizations producing equipment for other groups such as packaging, cleaning products, ingredients and additives should not be overlooked either [34].

Figure 1 Diagram of the food supply chain [35]

The Figure 2 below provides an overview of the meat industry supply chain in Poland. It is referenced for each type of slaughter livestock including: beef pork or poultry. It is intended to characterize the different groups of the chain in an orderly sequence.

Figure 2 Simplified Meat Supply Chain in Poland [36]

The first link in the supply chain of any type of slaughter livestock is the producers. This is the most numerous group of all in the meat industry supply chain in Poland. Livestock is purchased through purchasing points, middlemen, not forgetting, of course, the import of livestock. The ways in which butchers and other meat processing plants are supplied depend on their economic position in the market [37]. As can be deduced, the next link is middlemen, who, buying from individual producers-usually small ones-give them the opportunity to sell animals, buying at a discounted price while selling to butcher plants at a profit. In the current era of shortages in sales markets, meat plants are trying to use various sources of domestic and foreign supplies. There is also the aspect of contracting agreements here, the beneficiaries of which are farms with large production capacities that do not allow themselves to interrupt the supply of livestock to butcher plants. The next link is the butcheries and meat processing plants, which are involved in the slaughtering processing or production of meat products. After the production stage, they distribute their products through their own stores or wholesale market from where the products reach the retail market and then directly to the consumer group.

Unfortunately, pig producers are the weakest link in the supply chain. This is due to the fact that the supply chain for pork products is characterized by a high degree of fragmentation and, in addition, there is a lack of permanent links (including capital links) between breeders and slaughterhouses. A similar situation to that of pigs is also observed in the cattle sector. A slow process of livestock concentration is taking place, and this is mainly due to the specialization of farms in milk production. The number of cattle farms is decreasing and, at the same time, the cattle density per 100 hectares of farmland is increasing. Poland is part of the global trends of intensification and industrialization of livestock production, globalization and liberalization of meat trade. There are many small and medium-sized farms engaged in livestock breeding and rearing, although their number is slowly declining. Industrial animal husbandry is contributing to the liquidation of many small farms and the depopulation of rural areas [38]. The organizational characteristic of the market in Poland is the multiplicity of production entities, i.e. breeders. This results in a consequent fragmentation of the supply structure. As a result, processes that streamline supply and build up the raw material base for meat plants have become very important.

The last group is a very demanding group and imposes new trends on the meat industry, which has existed in Poland for a long time. The change in consumer perception of the very process of raising, producing, processing or selling meat dramatically affects their final choice of product from the store shelf. Here we have an increased interest in sustainability especially in environmental and social aspects by the consumer group. More and more details about the company offering the product - its supply chain, production or processing process, labour policy are of interest to consumers before making a choice. Therefore, it is important for companies wishing to be competitive in the market to adhere to sustainable supply chain standards in all three environmental, social and economic aspects. While increasingly more companies are disclosing sustainability information, corporate reports may be overly optimistic about companies' actual practices, especially when it comes to ensuring the sustainability of the entire supply chain, where unsustainable practices can be hidden [39].

2 Methodology

The main objective of the conducted research was to identify key areas related to the implementation of the concept of sustainable supply chains in companies operating in the meat industry. To achieve the adopted goal, a survey questionnaire was developed, consisting of nine questions covering two parts of the survey:

- a survey metric containing an introduction, which includes the purpose of the survey being conducted, how the data obtained will be used, and assurances of the anonymity of the feedback received. In addition, the part included questions about the size of the company, the duration of its operations and the definition of its business profile,
- the research part of the questionnaire, which included questions on: the importance of the determinants of LAC in the practical implementation of the concept, the use of business, environmental and social elements affecting the level of sustainable supply chain management, and the

identification of the main impediments affecting the introduction of the concept.

The research population consisted of enterprises of the meat industry, which number about 1,250 in Poland, based on data from the Central Statistical Office and IERiGŻ-PIB.

The research was carried out between February and September 2022, it took the form of a survey prepared online where potential respondents representing 93 meat industry enterprises were identified and purposively selected and asked by phone or email to complete the survey. The possibilities of collecting data for the purposes of this study are limited which meant that the research sample size could not be considered representative.

After receiving and verifying the completed questionnaires, 85 completely filled out questionnaires were qualified for further analysis and the coding process was carried out, using Excel software, then the data was imported into Statistica statistical software, where the main statistical analyses were carried out.

The responses obtained constituted the primary data, which were subjected to further analyses, both quantitative and qualitative in nature. For quantitative analyses, an Excel spreadsheet was used. On the other hand, since the questions in the survey questionnaire took the form of questions using a 5-point Likert scale, appropriate statistical methods were used to conduct the analyses, in this case analysis of the r-Pearson correlation coefficient, which is used to test whether there are significant statistical relationships between two variables. The r-Pearson score can take values between -1 and 1, where values of -1 or 1 indicate a perfect correlation between the variables under study, and a score of 0 indicates the absence of a correlation. In addition, it is assumed that values in the ranges:

0 - 0.3 - indicate weak correlation,
0.3 - 0.5 - denote moderate correlation,
0.5 - 0.7 - denote strong correlation,
0.7 - 1 - denote very strong correlation

The choice of this coefficient was dictated by the fact that it is perceived as the strongest and strongest coefficient, the results of which have the highest reliability.

3 Result and discussion

Analyzing meat industry research subjects, the following questions were asked and data was obtained for further consideration:

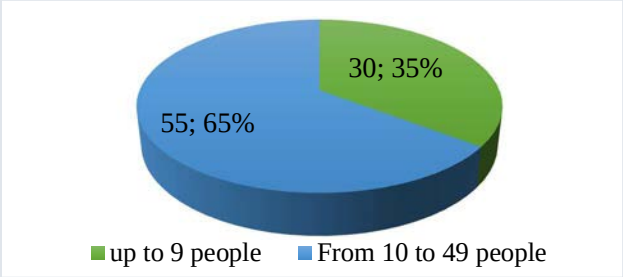

Figure 3 Number of employees working for the company
Source: Own compilation based on survey.

In the survey, 65% of the enterprises were small businesses, employing between 10 and 49 people, with the remaining group being micro-enterprises (Figure 3). The survey also had possible answers of 49 to 249 people and 250 or more people, but they were not selected even once.

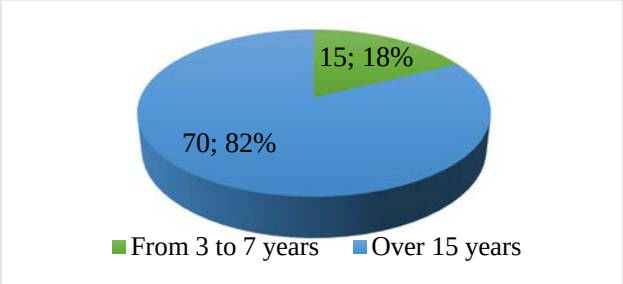

Figure 4 The period in which the company operates in the domestic market
Source: Own compilation based on survey.

More than ¾ of the surveyed enterprises have been in the market for more than 15 years, while the remaining 18% are young enterprises, operating in the market for no more than 7 years (Figure 4). In this case, too, there was a wider choice of answers: respondents could mark: less than 3 years or 8 to 15 years, however, such respondents could not be reached.

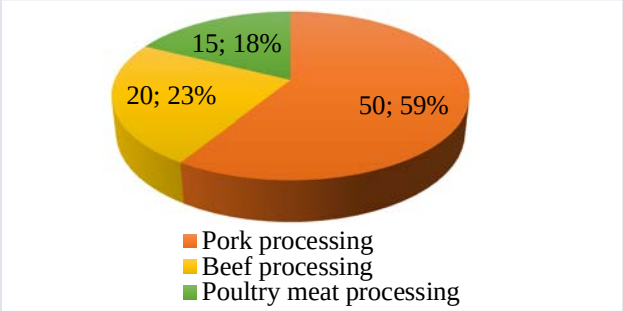

Figure 5 Type of meat industry of the company
Source: Own compilation based on survey.

Almost 60% of them represented pork processing, less than ¼ represented beef processing, and the remaining 17% were poultry meat processing enterprises (Figure 5).

The next question analyzed the determinants of supply chain management in meat companies.

Table 3 Indicate the importance of the following determinants of SCM in terms of their impact on the application of the concept in practice?

1 = Not important, 2 = Slighlty important, 3 = Neutral, 4 = Important, 5 = Very Important.		**average**	**median**	**St. Dev.**
a	Increased competition	4.59	5	0.49
b	The needs of the end customer	5.00	5	0.00
c	Process integration of supply chain processes	4.18	4	0.78
d	Cooperation of supply chain members	4.41	4	0.49
e	Cost reduction	4.12	5	1.23
f	Improve processes and improve productivity	4.82	5	0.38
g	Internal inter-functional cooperation	4.82	5	0.38

Source: Own compilation based on survey.

All of the companies that participated in the survey in the area of indicating the determinants of SCM indicated the needs of the end customer. Determinants in the form of process improvement and productivity improvement, as well as internal inter-functional cooperation came in second place. The lowest rated determinant was cost reduction and the process of integrating processes within the supply chain.

Table 4 How important are the following sustainability business elements used by you that influence the SCM?

1 = Not important, 2 = Slighlty important, 3 = Neutral, 4 = Important, 5 = Very Important.		**average**	**median**	**St. Dev.**
a	Collaboration in inventory and logistics management	4.65	5	0.48
b	Use of information technology to increase communication efficiency	3.94	4	1.16
c	Building long-term relationships based on established guidelines	4.65	5	0.48
d	Shared clear vision for supply chain management	4.65	5	0.48
e	Use of the concept of "Just in Time"/as a tool to increase competitiveness	4.82	5	0.38
f	Exchange of production information on an ongoing basis, For example, through sales and operations planning meetings	4.00	4	0.91
g	Joint introduction of benchmarking and performance indicators	4.24	4	0.73
h	Standardization of quality policies for both products and processes with established guidelines	4.82	5	0.38
i	Tailored product strategies, supply and distribution with supply chain strategy	4.82	5	0.38
j	Providing information on customer requirements and project plans	4.47	5	1.14
k	Using supply chain concepts in product, process and packaging design	4.24	4	0.73
l	Common procedures for obtaining feedback from customers who are involved in product development	4.65	5	0.48
ł	SC competitiveness	4.47	5	0.78

Source: Own compilation based on survey.

The most important business elements of sustainability used by the surveyed companies included those in the form of the use of the "JIT" concept as a tool to increase competitiveness, the standardization of quality policies, both for products and processes, and the alignment of product strategies. On the other hand, the lowest rated elements were the ongoing exchange of production information through sales and operations planning meetings, the joint introduction of benchmarking and performance indicators, and the use of supply chain concepts in product, process and packaging design.

Table 5 How important are the following environmental sustainability elements used by you affecting SCM?

1 = Not important, 2 = Slighlty important, 3 = Neutral, 4 = Important, 5 = Very Important.		**average**	**median**	**St. Dev.**
a	Environmentally friendly manufacturing processes	4.12	4	0.32
b	Measures to reduce waste	4.65	5	0.48
c	Commitment to emission-free manufacturing processes	4.65	5	0.48
d	Use of renewable energy sources in production	4.82	5	0.38
e	Sustainable waste processing	4.82	5	0.38
f	Selection of supply chain partners based on environmental guidelines	4.18	4	0.78
g	Employee involvement in environmental programs	3.94	4	1.16
h	Application of reverse logistics solutions in SC	4.18	4	0.78

Source: Own compilation based on survey.

On the other hand, among the most important environmental elements of sustainability, companies ranked the use of RES in production processes and sustainable waste processing. In contrast, employee involvement in environmental programs was rated very low.

Table 6 How important are the following social sustainability elements used by you affecting SCM?

1 = Not important, 2 = Slighlty important, 3 = Neutral, 4 = Important, 5 = Very Important.		**average**	**median**	**St. Dev.**
a	Application of the code of ethical conduct to employees and contractors	4.59	5	0.49
b	Applying fair employment policies to the local community	4.59	5	0.49
c	Provision of equipment to ensure hygiene and safety at work	4.82	5	0.38
d	Investments in public infrastructure facilities	4.18	4	0.78
e	Timely and lawful payment of taxes and fees due	4.82	5	0.38
f	Transparency of the income on which taxes are based	4.82	5	0.38
g	Application of ethical standards of business and commerce	4.82	5	0.38
h	Investment in poverty reduction programs	4.18	5	0.98
i	Participation in charitable actions of the local community	4.47	5	0.78
j	Participation in regional and supra-regional development initiatives	4.00	4	0.91
k	Participation of the company through the SC in environmental and/or public space activities	4.41	4	0.49

Source: Own compilation based on survey.

With regard to the social elements of sustainability, the highest ratings were given to the provision of equipment to ensure occupational health and safety, the timely and legal payment of taxes and fees due, the transparency of income on which taxes are based, and the application of business and trade ethical standards. The lowest rating was given to the company's participation in regional and supra-regional development initiatives.

Table 7 How important are the following impediments to the implementation of the SCM?

1 = Not important, 2 = Slighlty important, 3 = Neutral, 4 = Important, 5 = Very Important.		**average**	**median**	**St. dev.**
a	Lack of understanding of the goals and ideas of SCM among employees	4.41	4	0.49
b	Workers' resistance to the implementation of changes related to the SCM	4.24	4	0.73
c	Organizational structure that hinders information sharing	4.47	5	0.78
d	Problems with the quality of operations caused by members of the supply chain	4.47	5	0.78
e	Communication problems and confidential data	4.47	5	0.78
f	Laws and regulations hindering relationships within the SCM	4.24	4	0.73
g	Some members of the supply chain do not support the concept of SCM	4.47	5	0.78

Source: Own compilation based on survey.

Analyzing, on the other hand, the impediments that enterprises face in the way of realizing GCC, the most significant was considered to be the fact of having an organizational structure that makes it difficult to exchange information, the existence of problems with the quality of activities caused by individual members of the supply chain, communication and confidentiality of data, and the fact that some members of the supply chain do not support the concept of GCC. On the other hand, the least significant impediment was considered to be the resistance of employees to the implementation of changes related to GCC, and that current laws and regulations hinder GCC relationships.

Table 8 details the correlations between all the variables in the above tables and the number of employees, years of operation and type of enterprise. A detailed description has been created under the table, which interprets the results obtained.

Table 8 Correlations

	Number of employees	Years in business	Type of enterprise
[Increased competition]	0.132410	0.553283	-0.018227
[End customer needs]			
[Supply chain process integration]	0.166070	0.104090	0.560082
[Cooperation of supply chain members/links]	0.617914	0.387298	0.637947
[Cost reduction]	-0.229380	0.044237	0.196740
[Process improvement and productivity improvement].	0.626783	1.000000	-0.352966
[Internal inter-functional cooperation]	0.626783	1.000000	-0.352966
[Collaboration in inventory and logistics management].	1.000000	0.626783	0.394197
[Use of information technology to increase communication efficiency].	-0.037398	-0.023440	0.486490
[Building long-term relationships based on established guidelines].	1.000000	0.626783	0.394197
[Shared clear vision for supply chain management].	1.000000	0.626783	0.394197
[Use of "Just in Time"/as a tool to increase competitiveness].	0.626783	-0.214286	0.847117
[Sharing production information on an ongoing basis, such as through sales and operations planning meetings].	0.406921	0.510102	0.336090
[Joint introduction of benchmarking and performance indicators].	0.743925	0.783349	0.245774
[Standardization of quality policies for both products and proceow sz established guidelines].	0.626783	-0.214286	0.847117
[Tailored product strategies, delivery and distribution in line with supply chain strategy].	0.626783	1.000000	-0.352966
[Providing information on customer requirements and project plans].	0.626783	1.000000	-0.352966
[Using supply chain concepts in product, process and packaging design].	0.743925	0.783349	0.245774
[Common procedures for obtaining feedback from customers who are involved in product development].	1.000000	0.626783	0.394197
[S.C. competitiveness]	0.923823	0.877328	0.069365
[Environmentally friendly production processes]	0.269680	0.169031	0.278423
[Waste reduction activities]	1.000000	0.626783	0.394197
[Commitment to emission-free production processes].	1.000000	0.626783	0.394197
[Use of renewable energy sources in production].	0.626783	1.000000	-0.352966
[Sustainable waste processing].	0.626783	1.000000	-0.352966
[Selection of supply chain partners based on environmental guidelines].	0.166070	0.104090	0.560082
[Employee involvement in environmental programs].	-0.037398	-0.023440	0.486490
[Application of reverse logistics solutions in SC].	0.166070	0.104090	0.560082
[Application of a code of ethical conduct to employees and contractors].	0.132410	0.553283	-0.018227
[Use of fair employment policies of the local community].	0.132410	0.553283	-0.018227
[Providing equipment to ensure occupational health and safety].	0.626783	1.000000	-0.352966
[Investment in public infrastructure facilities].	0.166070	0.104090	0.560082
[Timely and lawful payment of taxes and fees due].	0.626783	1.000000	-0.352966
[Transparency of the revenue underlying the tax calculation].	0.626783	1.000000	-0.352966
[Application of ethical standards of business and commerce].	0.626783	1.000000	-0.352966
[Investment in poverty reduction programs]	0.132410	0.553283	-0.018227
[Participation in charitable actions of the local community].	0.923823	0.877328	0.069365
[Participation in regional and supra-regional development initiatives].	0.406921	0.510102	0.336090
[Company's participation through SC in environmental and/or public space activities].	0.617914	0.387298	0.637947
[Lack of understanding of the goals and ideas of SCM among employees].	0.617914	0.387298	0.637947
[Employee resistance to the implementation of changes related to SCM].	0.743925	0.783349	0.245774
[Organizational structure that hinders information sharing].	0.923823	0.280745	0.658971
[Problems with the quality of operations caused by members of the supply chain].	0.923823	0.280745	0.658971
[Communication problems and confidential data].	0.923823	0.280745	0.658971
[Laws and regulations hindering relationships under the SCM].	0.743925	0.149209	0.872497
[Some members of the supply chain do not support the concept of SCM].	0.923823	0.280745	0.658971

Source: Own compilation based on survey.

Interpreting the results of the correlation analyses carried out, first of all, it can be pointed out that there are a number of statistically significant correlations between the size of the company, age, and business profile and the selected areas of SCM and SSCM. Analyzing the importance of the determinants of SCM in terms of their influence on the application of the concept in practice, it can be concluded that there are statistically significant correlations between:

- between the size of the enterprise and the cooperation of supply chain members/cells (r=0.61), process improvement and productivity improvement (r=0.63), and internal inter-functional cooperation (r=0.63);
- between company age and increased competition (r=0.55), process improvement and productivity improvement (r=1.00), and internal inter-functional cooperation (r=1.00). With correlation values for the last two elements indicating very strong relationships;
- between business profile and supply chain process integration (r=0.56) and collaboration of supply chain members/cells (r=0.64).

In the area of business elements of sustainability, the correlation analyses conducted confirmed the existence of significantly statistical relationships between:

- company size and cooperation in inventory and logistics management (r=1.00), building long-term relationships based on established guidelines (r=1.00), sharing a clear vision for supply chain management (r=1.00), using the "Just in Time" concept as a tool to increase competitiveness (r=0.63), jointly introducing benchmarking and performance indicators (r=0.74), standardizing quality policies for both products and processes with established guidelines (r=0.63), alignment of product strategies, supply and distribution in line with supply chain strategy (r=0.63), sharing information on customer requirements and project plans (r=0.63), use of supply chain concepts in product, process and packaging design (r=0.74), joint procedures for obtaining feedback from customers who are involved in product development (r=1.00), and competitiveness of SC (r=0.92).
- age of the company vs. collaboration on inventory and logistics management (r=0.63), building long-term relationships based on established guidelines (r=0.63), sharing a clear vision of supply chain management (r=0.63), sharing production information on an ongoing basis, e.g. through sales and operations planning meetings (r=0.51), joint introduction of benchmarking and performance indicators (r=0.78), alignment of product strategies, supply and distribution in line with supply chain strategy (r=1.00), sharing information on customer requirements and project plans (r=1.00), use of supply chain concepts in product, process and packaging design (r=0.78), common procedures for obtaining feedback from customers who are involved in product development (r=0.63), and competitiveness of S.C. (r=0.88).
- between the business profile and the use of information technology to increase communication efficiency (r=0.49), the use of the "Just in Time" concept as a tool to increase competitiveness (r=0.85), the standardization of quality policies for both products and processes with established guidelines (r=0.85).

In the area of environmental elements of sustainability, correlation analyses conducted confirmed the existence of significantly statistical relationships between:

- company size and waste reduction efforts (r=1.00), commitment to emission-free production processes (r=1.00), use of renewable energy sources in production (r=0.63), and sustainable waste processing (r=0.63).
- between company age and waste reduction efforts (r=0.63), commitment to emission-free production processes (r=0.63), use of renewable energy sources in production (r=1.00), and sustainable waste processing (r=1.00).
- between business profile and the selection of supply chain partners based on environmental guidelines (r=0.56), employee involvement in environmental programs (r=0.49), and the use of reverse logistics solutions in SC (r=0.56).

In the area of social elements of sustainability, correlation analyses conducted confirmed the existence of significantly statistical relationships between:

- the size of the enterprise and the provision of equipment to ensure occupational health and safety (r=0.63), the timely and legal payment of taxes and fees due (r=0.63), the transparency of income on which taxes are based (r=0.63), the application of ethical standards of business and commerce (r=0.63), participation in charitable actions of the local community (r=0.92), and the participation of the enterprise through SC in activities for the environment and/or public space (r=0.62).
- the age of the enterprise and the application of a code of ethical conduct towards employees and contractors (r=0.55)), the application of fair employment policies to the local community (r=0.55), the provision of equipment to ensure occupational health and safety (r=1.00), the timely and legal payment of taxes and fees due (r=1, 00), transparency of income on which taxes are based (r=1.00), adherence to ethical standards of business and commerce (r=1.00), investment in poverty reduction programs (0.55)), participation in charitable actions of the local community (r=0.88), and participation in regional and supra-regional development initiatives (r=0.51).
- between the business profile and investment in public infrastructure facilities (r=0.56), and the company's participation through SC in environmental and/or public space activities (r=0.64).

On the other hand, with regard to impediments, the following significantly statistical relationships were identified between:

- company size and employees' lack of understanding of the goals and ideas of SCM (r=0.62), employees' resistance to SCM-related changes (r=0.74), organizational structure hindering information sharing (r=0.92), problems with the quality of activities caused by supply chain

members (r=0.92), communication problems and confidential data (r=0.92), laws and regulations hindering SCM relationships (r=0.74), and that some supply chain members do not support the concept of SCM (r=0.92).

- Between the age of the company and employees' resistance to implementing changes related to SCM (r=0.78),

- between the business profile and employees' lack of understanding of the goals and ideas of SCM (r=0.64), organizational structure hindering information sharing (r=0.66), problems with the quality of operations caused by supply chain members (r=0.66), communication problems and confidential data (r=0.66), laws and regulations hindering SCM relationships (r=0.87), and that some supply chain members do not support the SCM concept (r=0.66).

In conclusion, it can be said that there are significant statistical relationships between almost all aspects of SCM and size, years of operation and business profile. Only depending on the selected criterion (age, years and business profile) can the number of these correlations vary. In addition, it should be noted that the prevailing value of the identified correlations exceeds values of 0.6, which means that the correlations that occur are strong correlations. Therefore, it can be assumed that the formation of the SCM of enterprises significantly depends on the size, years of operation in the market and profile of the enterprises. It is also worth mentioning that only in the case of environmentally friendly production processes and end customer needs, no statistically significant correlations were shown. On the other hand, the greatest number of statistically significant correlations were shown in the area of impediments to the introduction of SCM - especially with regard to the size and business profile of enterprises.

4 Conclusions

Summarizing the research, it can be said that all the companies surveyed declared that the greatest influence on the application of supply chain management concepts in practice is the needs of the end customer. Slightly less influence, on the other hand, is attributed to internal inter-functional cooperation and process improvement and productivity improvement. In contrast, the least impact was attributed to cost reduction and the process of integrating supply chain processes. Thus, it can be acknowledged that all of the meat companies surveyed place a very high value on end-customer satisfaction through smart supply chain management.

The objectives of the article were achieved by assessing the level of sustainable supply chain management in the meat industry. The results of the study relating to sustainable supply chain management allow us to conclude that the surveyed companies indicated both very important and important elements in each business, environmental and social aspect, while nowhere were there answers of little or no importance.

Thus, the most important business elements of sustainable development were: use of the "JIT" concept, standardization of quality policy and alignment of product strategy. The lowest rated elements were the ongoing exchange of production information through planning, sales and operations meetings, and the use of information technology to increase communication efficiency.

The environmental elements of sustainability with the highest average were: use of RES and waste treatment in accordance with the principles of SD. The lowest rated elements were environmentally friendly production processes, employee involvement in environmental programs, and selection of supply chain partners based on environmental guidelines.

The surveyed group of meat companies declared that all the social SD elements indicated in the survey were important or very important. The highest rated elements were those related to the company's attitude to Polish law, in particular the timely payment of taxes and fees due and the transparency of income on which taxes are based. Also highly rated were the application of ethical standards of business and commerce and the provision of equipment to ensure hygiene and occupational safety.

Undoubtedly, companies in the meat industry pay very close attention to the satisfaction of the end customer. As well as paying attention to the overall external image of the company as perceived by third parties and individuals.

Meat companies also indicate that process improvement and productivity improvements do not significantly affect the application of supply chain management concepts in practice. Improved processes allow the use of newer technology, which would make the flow of goods and information faster, more resilient in the event of disruptions and make supply chain management easier and less exposed to potential undesirable risks or hazards.

Sustainable development presupposes such development that, while meeting the needs of today's societies, does not at the same time limit the development opportunities of future generations, so it is alarming that the meat companies surveyed do not want to develop information technology to increase the efficiency of communication. Fast and seamless communication between members of the supply chain or the company's internal departments themselves allows for the streamlining of many processes resulting in greater satisfaction of the final customer, thanks to the faster arrival of meat products in his hands.

Today's society pays a lot of attention to caring for the environment, so when choosing products from store shelves they are interested in the origin of meat products, the way they are processed and prepared. Therefore, when hearing that a meat company does not use environmentally friendly production processes they will be more discouraged from buying their products.

Based on the characteristics of the research population, suggestions for further research can be made. One

fundamental suggestion is to increase the scope of the research conducted, so that a larger group of enterprises will participate in the survey, and the resulting sample will be representative which would provide an overview of sustainable supply chain management in the meat industry nationwide.

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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 on the original and new, interesting, high-quality, theoretical, practical and application-oriented contributions to the field of science and research and pedagogy and education in 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**

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