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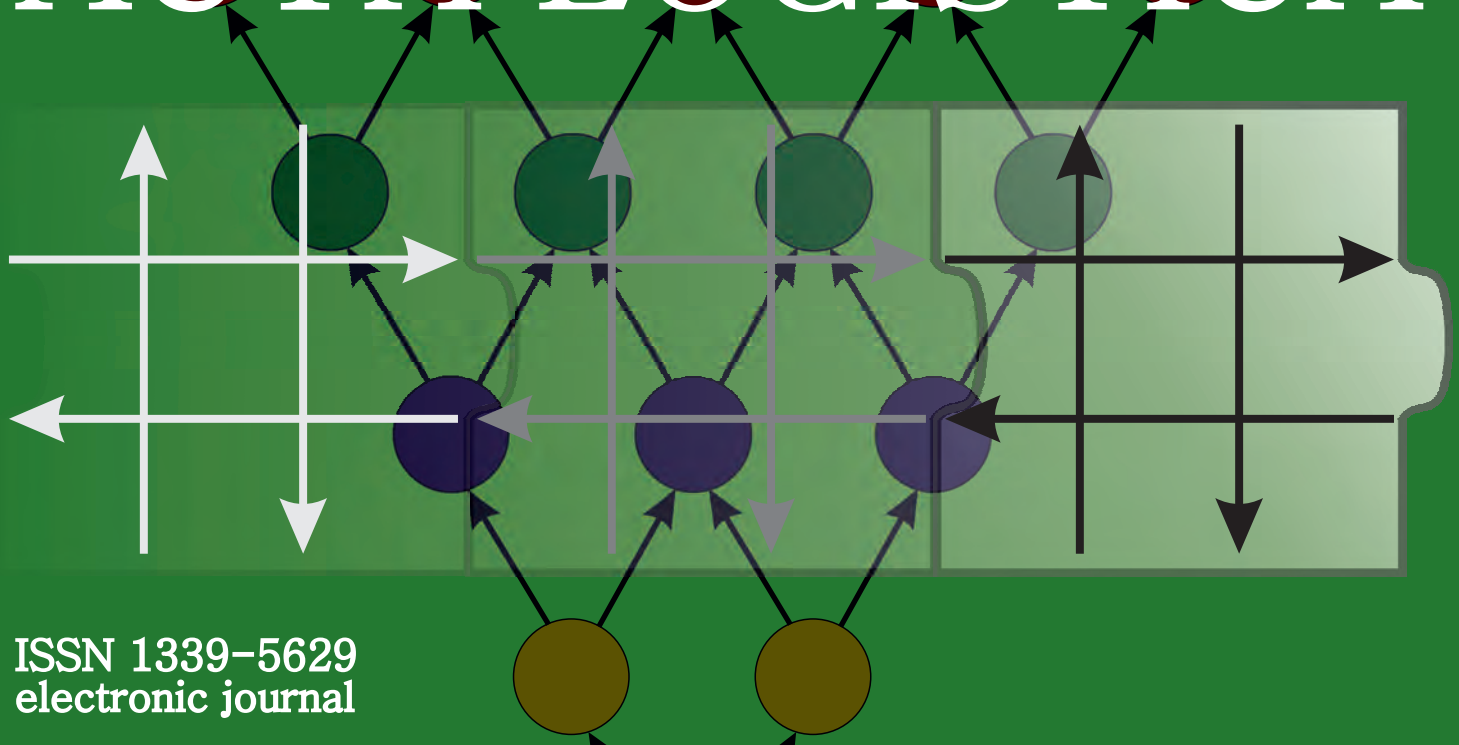

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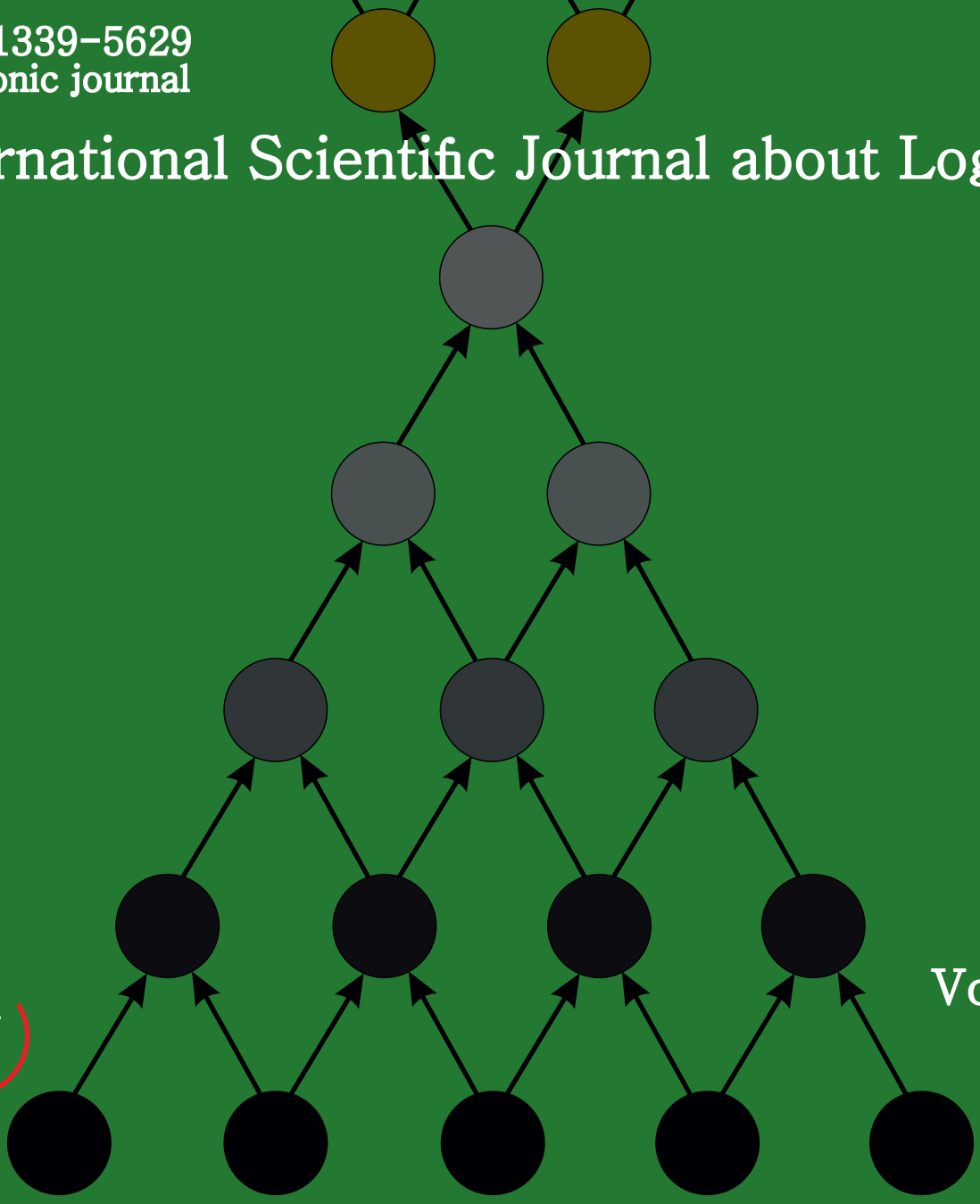

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TRADE OF RETURN PACKAGING IN THE PROCESS OF DELIVERY OF RAW MATERIALS ON THE EXAMPLE OF KICO-POLSKA SP. Z O.O.

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Keywords: return logistics, material delivery, packaging turnover, simulation of the logistics process
Abstract: An effective enterprise means correctly implemented processes. Today, logistics plays an important role in the company, and it influences the processes carried out in production companies, ensuring the implementation of its most important function - production. The article analyses the processes of trading in returnable packaging. The optimisation of these activities was carried out on the basis of a program for simulating logistics processes. The main purpose of the article is to identify the impact of the processes of material delivery and packaging turnover on the functioning of a production company. The article is based on a case study of a manufacturing company. In the discussed case, the FlexSim program was used to simulate logistic processes. The situation presented in the article allows to shorten the time and reduce costs that were necessary for the accepted materials to be made available for processing by introducing returnable packaging, adapted to be transferred directly to production. Suppliers providing them with materials will allow you to bypass the unnecessary process. Such activities also result in the circulation of returnable packaging.

1 Introduction

Comprehensive cooperation with suppliers is a very important aspect of management. Thanks to such cooperation, aimed at minimising costs and reducing the time necessary to carry out the processes, it is possible to achieve measurable benefits. To obtain such results, it is necessary to identify the sites where suboptimal activities are taking place that have a negative impact. The supply system, the element of which is the process of supplying materials, is a pillar that ensures the continuity of the production company. Depending on the characteristics of the materials and the conditions agreed with the suppliers, they are delivered in various packages. However, these processes are not always optimal. This introduces the need to carry out an additional repackaging process, which generates additional costs and increases the time needed to prepare materials for production. Their elimination and introduction of changes in this area require detailed analyses and simulations.

The continuity of effective work of a production company requires effective management of material flows. The necessary raw materials, elements or semi-finished products, most often purchased through trade, are most often delivered in containers. They are designed to ensure safety in transport, but not always their physical characteristics enable the most optimal storage. You may need to repack them. Unfortunately, this is an additional process that slows down the flow of materials. Repackaging can be solved by carrying out such a process directly at the manufacturers. However, the introduction of such a solution requires the implementation of returnable packaging turnover.

Companies want to eliminate such unfavourable processes as repackaging. For their analysis, programs allowing for their modelling and simulation are used. This allows for efficient decision making.

The main purpose of the article is to identify the impact of the processes of material delivery and packaging turnover on the functioning of a production company. The article was based on an analysis of the literature on the subject, a case study and the simulation method using the FlexSim program. The case study was based on a manufacturing company operating in the automotive industry.

Optimal supply chain management is very important to gain a competitive advantage. This is possible thanks to the effective cooperation of all partners in the supply chain. Connecting all its participants leads to a phenomenon in which the effective operation of the last link, and so to satisfy its needs, also has a positive effect on the others. All companies involved in the supply chain should show the greatest commitment because, in the event of ineffective operation of one of the links, this may disrupt the operation of the entire system, leading to financial and image losses and even loss of market position. The supply chain itself can be defined as "mining, production, trade and service companies cooperating in various areas and their clients, between which stream of products, information and financial resources flow" [1].

The concept of supply chain management began to appear in the literature on the subject only in the 1980s. In the literature on the subject, you can find a definition that it is "the process of planning, implementing and controlling the efficient and economically effective flow and storage of raw materials, work-in-progress inventories, finished products and related services, and relevant information from the place of origin to the place of consumption (including transport to and from the organisation inside and outside the organisation) in order to satisfy customers' requirements" [2]. Due to the close links between the entities in the chain, the relations between them become important. In order to achieve a competitive advantage, it is essential that all companies work together transparently to meet customer demand. Ewa Kulińska notes that "supply chain management is always burdened with some risk because in such a complex structure you can often come across events and phenomena bearing the hallmarks of randomness, which cannot be fully foreseen due to the unknown reasons for their occurrence." [3].

The material delivery process is part of the supply logistics, which is part of the entire logistics system of the company. Its mission is to organise the flow of materials, so it includes "activities related to the flow of materials from the warehouses where they were stored to the production hall, and more specifically to the first production station where these materials will be used." [4]. Effective planning is essential for the successful management of delivery processes, which should "be based primarily on enhancing cooperation. The cooperation reaches such a level that suppliers become team members, providing professional assistance in the development phase of new products and models." [5]

"The process of supply connects participants in the supply chain and ensures the desired quality created by suppliers in this chain. The quality of materials and services' entering' the system affects the quality of 'outgoing', and therefore customer satisfaction and the company's income" [2]. It is worth noting that "when choosing the right procurement strategy, it is necessary to analyse the position of the company and its freedom as well as the possibilities of operating on individual markets. Diverse operating options require different behaviours in terms of selecting a sourcing strategy." [6]

Analysing the literature, it can be concluded that supply logistics is responsible for enabling production continuity. The availability of the materials needed for production is necessary for the production to function. "The physical flow of products in the economy is often conditioned by the use of appropriate packaging" [7]. Depending on the contract with suppliers and the physical characteristics of the materials, they are delivered in various types of packaging. "Since the first organised by the business people, the choice of packaging was an important decision, affecting among other things, on the profitability of the company's activities." [8] "The role of packaging in the flow of materials and products along the supply chain is unquestionable. Commercial packaging, but also collective packaging, including pallets and various types of containers and containers, rotation packaging and used packaging (disposable or damaged as waste) fit into the area of interest of ecology and green supply chain" [9]. Due to the fact that their main task is to protect the load during transport and storage, they are not always optimal for making them available directly for production. One of their characteristic types is returnable packaging, which requires the packaging to be marketed. It is part of reverse logistics, which is described as "the application of a logistics concept to residues to thereby result in an economically and ecologically efficient residual flow, with simultaneous spatio-temporal transformation, including change in quantity and species." [10]. One of the elements that can be distinguished in reverse logistics is packaging turnover [11]. This is undoubtedly a reverse flow in the supply chain, where after delivering products to the supply chain partners, returnable packaging circulates between them.

Logistics tools give us many opportunities to improve logistics processes [13-14]. One of them are simulations of logistics and production processes, which are becoming more and more popular nowadays [15]. The development of technology gives the opportunity for the development of Industry 4.0. It is in line with this idea that the automation of production and logistics is created. This is possible thanks to new technological solutions, IT, knowledge and innovation, as well as the possibility of process simulation. The latter undoubtedly affect the success of the applied solutions and the possibility of their prior checking and adaptation to the organisation's capabilities prior to their physical implementation in the enterprise [16-19]. However, it should be noted that any development in this industry should be in line with sustainable development [20-22]. This is one of the ideas that should build a new form of industry operation - Industry 4.0.

2 Management of returnable packaging in KICO-Polska sp. z o. o.

The process of accepting materials, discussed later in the article, was presented on the basis of KICO-Polska Sp. z o.o. Established in 2005, the company is located in Świebodzin. It is a company that specialises in the production of articles that require assembly. Since 2015, it has been part of the KICO Kunststofftechnik GmbH group having four factories on two countries. Since then, he has also specialised in the plastics processing sector. For many years, the company has been responding to growing customer requirements and quality requirements, which allowed for establishing cooperation with many commercial vehicle manufacturers and system suppliers. The company operates in the automotive sector, which is one of the most developing industries. Effective operation in its scope requires not only constant investments in the latest technologies, but also the constant implementation of more and more optimised solutions in the field of logistics

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management. It is even more important when the company effectively implements one-day production schedules and uses the 'Just in time' philosophy. This means that production is only planned for the next day ahead. The efficient functioning of the supply system is therefore crucial to maintaining the continuity of production. Enterprises shall take comprehensive measures aimed at effective management of supply processes. After the production schedules are drawn up, KICO immediately reports its need to the suppliers. It is worth paying attention to the importance of communication in these processes. In the event of any communication disruptions, the delivery of materials may not proceed properly. Deliveries go to the supply warehouse. There, they are collected by the entrance logistics department. Each delivery is verified with the attached and required documentation. These processes include quantitative and qualitative control. Pallets with materials are sent to a designated zone, where they will be waiting for further development in a high-bay warehouse. Materials for the enterprise are usually delivered in metal containers (Figure 1) and in cardboard boxes secured with GITTERBOX packages (Figure 2).

Figure 1 Metal container for materials

Figure 2 GITTERBOX packaging securing large cardboard boxes with materials

The delivery of materials from the supply warehouse to the production hall, however, becomes problematic as the bulk containers in which they are delivered are not optimal to be located directly in the production hall. They are large and unwieldy, which makes it difficult for employees to further process materials. The KICO- Polska Sp. z o.o. company therefore uses the processes of repackaging the delivered materials into smaller plastic containers. Currently, RL-KLT 3215 (Fig. 3) / RL-KLT 4315 / RL-KLT 4329 / RL-KLT 6429 packages are used in the internal circulation. Later in the article they will be called "returnable packages" due to their circulation in the chain supply.

Figure 3 Container RL-KLT 3215 with dimensions of 297x198x147.5 mm

3 Methodology and results

A repackaging area is a place that generates a suboptimal repackaging process that slows down the flow of materials. The solution introduced by the company is repackaging at one of the three main suppliers. To analyse the effectiveness of the new system, it is necessary to perform simulations before and after the planned changes. In the discussed case, the repackaging process before and after its change was presented using FlexSim. The solution is new tools adapted to many areas of transport, including those that reduce the negative impact on the environment [12].

3.1 Simulation of the current process of product delivery and repackaging into appropriate returnable packaging – before the changes

Determining the initial data is necessary to perform the simulation. The repackaging zone works in a three-shift system and leaves it daily on average from 1,500 - 2,300 containers with repackaged materials. In order to present the maximum efficiency of the zone and for its analysis, the upper limit of this range was adopted. The repackaging area has 3 workstations and a total of eight employees. Two shifts work using all positions, while the third shift has two employees. This means that the duty of eight employees to obtain the baseline in the number of materials repackaged to 2300 containers (returnable packaging) - this gives 287.5 per container. After rounding, the number 288 was assumed. Taking into account the employees' break and preparation of the position before taking action - 7.5 hours of permanent work at the workplace were assumed. This means that the worker needs, after rounding, a maximum of 93 seconds to produce one repackaged container.

Summary of the output data:

- expected maximum efficiency of the repackaging area - 2300 repackaged returnable packages,
- expected efficiency of one employee - 288 repackaged returnable packaging,
- the maximum time to obtain one repackaged returnable packaging - 93 seconds.

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Having such data, it should be proceed to the preparation of an appropriate model in FlexSim, which will allow you to visualise the current work of the repackaging zone, both during shifts of three and two people. The figure below (Figure 4) shows a schematic of the process.

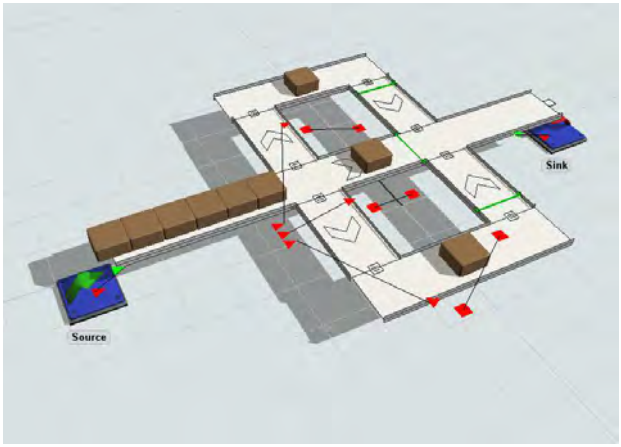

Figure 4 A model analysing the work of the repackaging zone with the active participation of three workstations

It is important to avoid unnecessary complications in the operation of the simulation. After the model was developed, all data necessary for the analysis were used. The boxes are characterised by returnable packaging that must be filled at workstations. As planned, the source was programmed to release 864 of them. The duration of the process at each station has been set at 93 seconds. It includes both the preparation of the employee to start repacking and its implementation (filling the packaging with materials). After a correctly configured model, you should start analysing the obtained results. The assumption was to present the maximum efficiency of the zone. Therefore the expected results will indicate the maximum use of human resources. This will make it possible to refer to and compare loads of specific stations after introducing changes consisting in reducing the number of materials required for repackaging, and thus also the requirements for the stations, as shown in the following data (Figure 5).

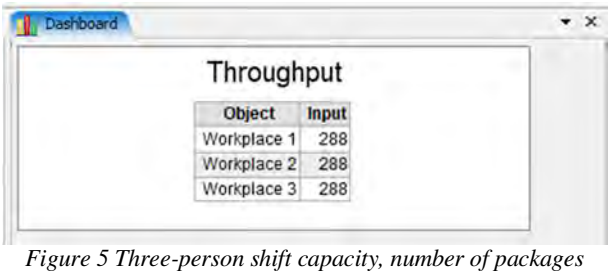

Figure 5 Three-person shift capacity, number of packages repackaged

To analyse the effects of a shift in which only two workstations are working, the same model should be used, excluding one of the paths for the process and reducing the number of multipacks generated by the source to 576 (see Figure 6).

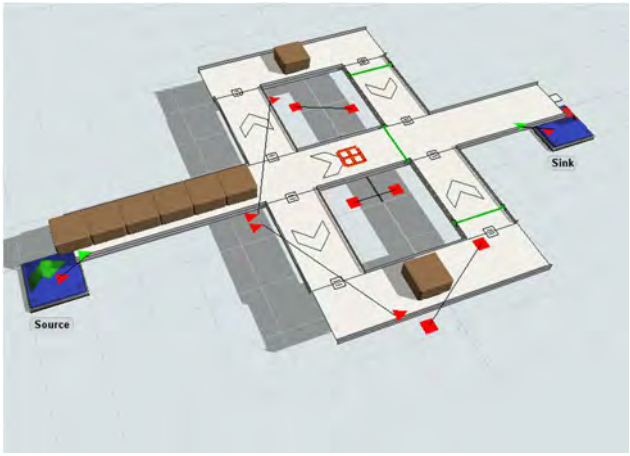

Figure 6 A model analysing the work of the repackaging zone with the active participation of two workstations

As in the case of the simulation with three workstations, we expect their maximum effectiveness to be presented. This will allow you to refer to and compare the workloads of specific positions once changes are made. The changes consisted in reducing the number of materials required to repackage and thus also the requirements for the stations (see Figure 7).

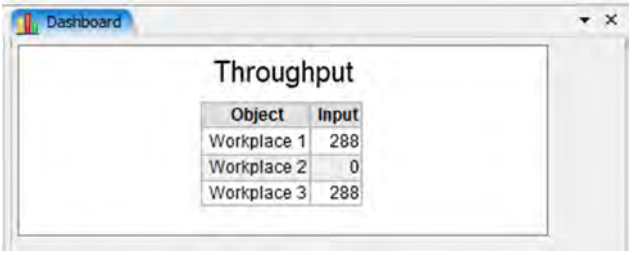

Figure 7 Two-person shift capacity, number of packages repackaged

The data obtained from the simulation system are presented in the table below. The table will be used to compare the performance of all workstations after the changes have been made (Table 1).

Table 1 shows the effectiveness of workstations during shifts in the three-person and two-person composition. The company works in a three-shift system, consisting of two shifts with three and one with two employees.

Table 1 Analysis of the effectiveness of repackaging products – situation before the changes

Work efficiency of a three-person shift					
Workstation	**Maximum possible effectiveness of the position**	**Number of repackaged containers obtained**	**Efficiency of the position**	**Effective working time of the position**	**Time of inactivity of the station**
Position 1	288	288	100%	7 hours 26 minutes	4 minutes
Position 2	288	288	100%	7 hours 26 minutes	4 minutes
Position 3	288	288	100%	7 hours 26 minutes	4 minutes
TOTALITY	**864**	**864**	**100%**	-	-
Work efficiency of two-person shifts					
Workstation	**Maximum possible effectiveness of the position**	**Number of repackaged containers obtained**	**Efficiency of the position**	**Effective working time of the position**	**Time of inactivity of the station**
Position 1	288	288	100%	7 hours 26 minutes	4 minutes
Position 2	-	-	-	-	-
Position 3	288	288	100%	7 hours 26 minutes	4 minutes
TOTALITY	**576**	**576**	**100%**	-	-

3.2 Simulation of a new process of product delivery and repackaging in the right returnable packaging without unemployment reduction – after changes

The company cooperates with one of the three main suppliers to implement the project, which will consist of the process of repackaging the materials at the manufacturers. Delivers from this company averages 30 - 40 metal containers with materials per day. Each of these containers is 22 filled returnable packages. This means that assuming an upper limit of 40 metal containers will reduce the required daily capacity of the repackaging zone by 880, which will now be 1420. Currently, eight employees are working on repackaging, which means that the efficiency of one employee will be reduced to 177.5 full returnable packagings. So the number of 178 packages per person was assumed. The time needed to complete the process must remain the same as the process itself remains the same, allowing us to observe changes in the burden on human resources. The model source will now generate 534 fill bags for a three-person shift and 356 for a two-person shift.

Summary of the output data:

- expected maximum efficiency of the repackaging area – 1420 repackaged returnable packages,
- expected efficiency of one employee - 178 repackaged returnable packaging,
- the maximum time to obtain one repackaged returnable packaging - 93 seconds.

We use a previously created model to carry out the research. Thanks to the statistics (Figure 8 and Figure 9) obtained, it will be possible to create an analogous table (Table 2).

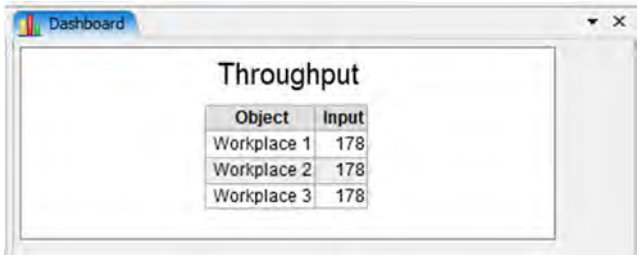

Figure 8 Efficiency of a three-person shift after implementing the project, number of packages repackaged

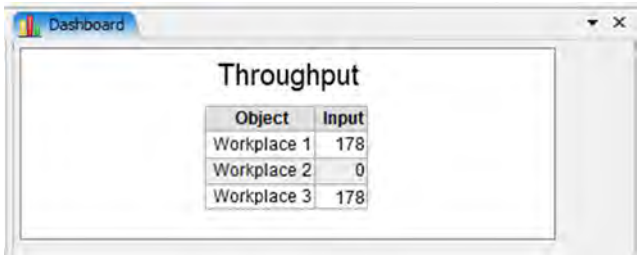

Figure 9 Efficiency of a two-person shift after the implementation of the project, number of packages repackaged

Table 2 Analysis of the effectiveness of repackaging products – situation after the changes

Work efficiency of a three-person shift					
Workstation	**Maximum possible effectiveness of the position**	**Number of repackaged containers obtained**	**Efficiency of the position**	**Effective working time of the position**	**Time of inactivity of the station**
Position 1	288	178	62%	4 hours 36 minutes	2 hours 54 minutes
Position 2	288	178	62%	4 hours 36 minutes	2 hours 54 minutes
Position 3	288	178	62%	4 hours 36 minutes	2 hours 54 minutes
TOTALITY	**864**	**534**	**62%**	-	-
Work efficiency of two-person shifts					
Workstation	**Maximum possible effectiveness of the position**	**Number of repackaged containers obtained**	**Efficiency of the position**	**Effective working time of the position**	**Time of inactivity of the station**
Position 1	288	178	62%	4 hours 36 minutes	2 hours 54 minutes
Position 2	-	-	-	-	-
Position 3	288	178	62%	4 hours 36 minutes	2 hours 54 minutes
TOTALITY	**576**	**356**	**62%**	-	-

After changing the data in the model, can be observed drastic changes in the efficiency of workstations. When the project is implemented, the human resources of the repackaging area will be only 62% effective. It also means that assuming that employees maintain the maximum pace of work, they will not be assigned any tasks for nearly 40% of working time. Therefore, immediate action should be taken for the reduction of unnecessary workplaces. Therefore, immediate action should be taken to reduce redundant jobs. After making a simple calculation consisting in multiplying the number of inefficiently used human resources (38%) by the number of all employees (8), the result is 3.04. Rounding this number down to 3 we get the number of jobs to be reduced. Employees will therefore be able to be transferred to other departments that also require support and would need more staff in the future. Reducing three jobs can bring considerable financial savings in the long term. The company cannot afford to reduce the entire shift because the repackaging processes must be ongoing and respond to production demand. This means that the reduction of employees on each shift must be even.

Table 3 Number of jobs before and after the change (after project implementation)

Shift	**Number of employees before the implementation of the project**	**Number of employees after the implementation of the project**
Shift 1	3	2
Shift 2	3	2
Shift 3	2	1

In order to confirm the expected effects after the reduction of employees, the last analysis in the FlexSim program should be carried out.

3.3 Simulate the new process of delivering products and repacking them into the correct returnable packaging with a reduction in employment – after the changes with reduction of jobs

The previously created model will be used to perform the simulation. This time, however, only solutions with the use of two or one workstations should be considered. Currently, the entire repackaging area will have five employees. This means that with a requirement of 1420 repackaged returnable packaging, this equates to 284 per person. The time needed to obtain one repackaged package remains the same.

Summary of the output data:

- expected maximum efficiency of the repackaging area - 1420 repackaged returnable packages,
- expected efficiency of one employee - 284 repackaged returnable packaging,
- the maximum time to obtain one repackaged returnable packaging - 93 seconds.

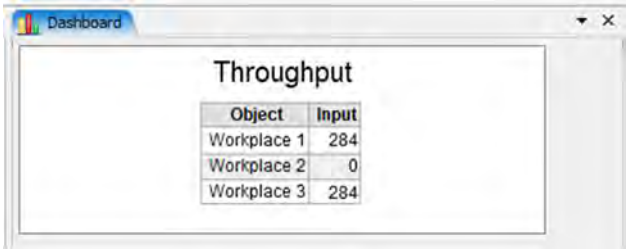

Figure 10 Efficiency of a two-person shift after the reorganisation of work, number of packages repackaged

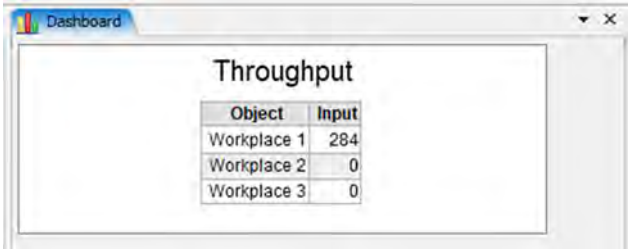

Figure 11 Efficiency of a one-person shift after the reorganisation of work, number of packages repackaged

Then, for the last time, we prepare a table (Table 4) aimed at presenting the effectiveness of the use of workstations.

Table 4 Analysis of the effectiveness of repackaging products – situation after the changes with reduction of employees

Work efficiency of a three-person shift					
Workstation	**Maximum possible effectiveness of the position**	**Number of repackaged containers obtained**	**Efficiency of the position**	**Effective working time of the position**	**Time of inactivity of the station**
Position 1	288	284	99%	7 hours 20 minutes	10 minutes
Position 2	288	284	99%	7 hours 20 minutes	10 minutes
Position 3	-	-	-	-	-
TOTALITY	**576**	**568**	**99%**	-	-
Work efficiency of two-person shifts					
Workstation	**Maximum possible effectiveness of the position**	**Number of repackaged containers obtained**	**Efficiency of the position**	**Effective working time of the position**	**Time of inactivity of the station**
Position 1	288	284	99%	7 hours 20 minutes	10 minutes
Position 2	-	-	-	-	-
Position 3	-	-	-	-	-
TOTALITY	**288**	**284**	**99%**	-	-

The obtained results show that the reorganisation of changes in the repackaging area is necessary after the implementation of the project. This will maintain maximum efficiency positions. Repackaging nearly 40% of the metal containers for returnable packaging at one of the main suppliers, and bypassing this sub-process at

KICO- Polska Sp. z o.o., resulted in a reduction of three jobs, which will bring financial savings in the long term. It is worth noting, however, that the implementation of the project also involves the implementation of returnable packaging marketing in supply chain management.

4 Discussion

A suboptimal process has been identified in the company that negatively affects the entire system. It is repackaging materials collected from suppliers from metal containers to returnable packaging. Implementation of a project to carry out part of the repackaging at one of the three main suppliers requires the introduction of the returnable packaging. However, this introduces many new challenges to supply chain management. The solution itself allows to improve the whole system, but it is also demanding. Rotation of returnable packaging means putting them into permanent circulation. This means that they must also have the material manufacturer and, in some variants, also the carrier. This is so important that the solution to the problem of repackaging is significant from the entire supply chain for only one company – KICO-Polska Sp. z o.o. Neither the carrier nor the material producer receives any direct benefits from the introduction of such a system. It is therefore particularly important for the receiving company. The returnable trade-in packaging introduces additional requirements and tasks for producers, and in some cases, also for carriers. The manufacturer of materials uses universal packaging, and the conclusion of the following agreement obliges him to make changes in his work organisation. The first important change is due to the necessity to store returnable packaging. The material producer may therefore require the recipient to cover the operating costs associated with this activity. In addition, it is the recipient's responsibility to ensure the availability of containers for all companies that participate in the supply chain, which also involves additional costs related to their purchase. The next challenge after the introduction of returnable packaging is their quantitative registration. Efficient packaging recovery is becoming an important measure that allows costs to be kept to a minimum. Keeping records allows you to efficiently locate where they are held and secure them against theft.

Designing processes in an enterprise is primarily mapping processes according to the Business Process Management (BPM) methodology. The aim of the article was to show that also designing processes in programs for their simulation can bring tangible benefits to the organisation. This article describes how to increase business efficiency and save costs by introducing improvements. This methodology can bring many benefits to manufacturing companies, including:

- saving costs and time,
- higher efficiency,
- analysis of processes in terms of their effectiveness,
- finding production and logistics bottlenecks,
- better and more efficient adjustment of processes,
- the ability to model across the enterprise, not just focusing on processes.

The last benefit of modelling the entire enterprise, and not just focusing on selected processes, is possible, although very labour-intensive and requiring large investments. Hence, it is often worth considering the possibilities and creating simulation variants for selected processes and activities.

5 Conclusions

The use of process simulation programs allows for the analysis of their effectiveness, which can be used to optimise them. Visualisation of the operation of individual activities can be used as an aid in assessing the changes that the company is planning to introduce.

When returnable packaging is introduced into the supply chain, many new obligations and challenges arise for logistics management. New flows related to the flow of returnable packaging between cooperators may complicate the operation of the entire system. Effective management of the turnover of returnable packaging is crucial to avoid financial losses and maximise the benefits that result from its use.

The article presents the packaging turnover process based on the implementation of deliveries on the example of a manufacturing company operating in the automotive industry. The paper presents an analysis which facilitates the process of receiving products from the supplier and their use in the production of the examined enterprise. A change was proposed - materials at the main supplier (one of the three) will be packed into returnable packaging provided by the manufacturing company. Thanks to this, in the analysed organisation, it is possible to reduce up to 3 jobs, which will translate into a reduction of the company's costs.

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INDUSTRIES PIONEERING BLOCKCHAIN TECHNOLOGY FOR ELECTRONIC DATA INTERCHANGE
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INDUSTRIES PIONEERING BLOCKCHAIN TECHNOLOGY FOR ELECTRONIC DATA INTERCHANGE

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Keywords: Blockchain technology, distributed ledger technology, electronic data interchange, Fintech, supply chain, cryptocurrency
Abstract: Rapid development of blockchain technologies promote involvement of methods using categorize research topics, identify the most topical trends, and ascertain the main publishing sources related to electronic data interchange. The study is based on an analysis of scientific publications (2015-2019 years) and investigation on the theory of supply chain and logistic the research is based on theoretical research methods that include a literature review and content analysis. The authors have reviewed 9,780 primary papers published between the years 2015-2019 from major academic databases (EBSCO, Elsevier ScienceDirect, Emerald Insight, Scopus, SSRN; Springer SpringerLink, Web of Science). The results of the research are presented, which at the logistics position describing the usage of blockchain technology for electronic data interchange in multiple industries. In concluding the research, the authors present the research gaps discovered, major trends, most discussed industries and suggestions for future research.

1 Introduction

Blockchain technology is quite new; however, its potential for transforming multiple industries is already being noticed. According to Bernard Marr [1], you no longer need a company or central authority to facilitate a transaction of any kind. Blockchain has already found applications across multiple fields, such as healthcare, real estate, the legal industry, security, government, and the banking sector.

Gartner now forecasts that blockchain will generate an annual business value of over $175 billion by 2025 and rise to over $3 trillion by 2030. With this potential, business interest in blockchain has increased tremendously in the last two years [2].

As per PWC's latest survey [3], it's possible to imagine that 10-20% of global economic infrastructure will be running on blockchain-based systems by the year 2030.

The growing number of blockchain projects active in industries ranging from education to insurance services to telecom and the supply chain shows the quick adoption of this technology across a number of major domains of our everyday life [4-6].

Design/methodology/approach: the research is based on theoretical research methods, which include a literature review and content analysis.

The authors have reviewed 9,780 primary papers published between the years 2015-2019 from 7 major academic databases (Web of Science (WoS), EBSCO, Springer SpringerLink, Elsevier ScienceDirect, SSRN, Emerald Insight, Scopus).

2 What is Blockchain

Blockchain, in essence, is a distributed database [7]. Essentially this technology is a decentralized ledger that records every transaction made in the network, known as a 'block', the body of which comprises encrypted data of the entire transaction history [8]. The term 'blockchain' is closely associated with the term 'bitcoin'. But in fact, blockchain is a decentralized technology allowing one to store data securely. Bitcoin is just the first use case of blockchain technology implementation.

Blockchain simply combines cryptography, distributed system technology, peer-to-peer networking technology and other well-known technologies. Blockchain as well provides a secure framework for cryptocurrencies in which no one can tamper with the content of transactions and all the nodes participate in transactions anonymously. For this reason, blockchain technology can be widely used in various fields, e.g., finance, medical systems, the supply chain, and the Internet of Things (IoT) [9-11].

Blockchain is a decentralized system, without a single "command centre" which a hacker could attack and thus receive an opportunity to delete all data about transactions and their participants or replace them. All data about any transactions is stored and checked by participants of the blockchain network. To hack blockchain, it is necessary to control the majority of nodes involved in a particular blockchain network.

Authors think that blockchain has a great potential to revolutionise the process of Electronic data interchange due to the functionality of Smart Contracts.

Electronic data interchange (EDI) is a term that describes the means by which automatic, interorganizational computer-to-computer communication is facilitated [12]. Smart contracts, cryptographic "boxes" that contain value and only unlock it if certain conditions are met [13]. Smart contracts are indeed more technologically sophisticated than EDI. Smart contract scripting languages offer a broad range of operations and greater scalability. Firms' operational and financial infrastructures are digital. Smart contracts can directly interact with these systems, whereas EDI was ultimately reliant on human intermediaries [14].

Blockchain can store data about multiple commercial and non-commercial use cases related to electronic data interchange: financial transactions; commercial contracts; purchases of services and goods; transfer of confidential information; insurance; protection and transfer of property rights; personal data management; archiving of official documents; protection of intellectual property; supply chain and logistics.

3 Research methodology

The research object of the given study is blockchain technology.

Research aim

The objective of this study is to categorize research topics related to blockchain technology, identify the most topical trends, and ascertain the main publishing sources of research papers related to blockchain technology. The study is based on an analysis of scientific publications from 2015 to 2019.

The primary research tasks

The authors outlined the following research tasks:

- determine the main publishing sources of research papers related to blockchain technology
- name the top 25 authors in blockchain-related academic research
- identify current and past trends in blockchain-related academic publications
- establish the main research topics in the papers published between the years 2015-2019 from major academic databases
- indicate industries adopting blockchain technology for Electronic Data Interchange. - draw conclusions and make recommendations for researchers

Research Questions

- What are the main publishing sources of research papers related to blockchain technology? (RQ 1)
- Who are the top 25 authors in blockchain-related academic research? (RQ 2)
- What are the trends in blockchain-related academic publications? (RQ 3)
- What are the main research topics and research gaps in the papers published between the years 2015-2019 from major academic databases? (RQ 4)
- What are the most discussed industries utilizing blockchain technology for Electronic Data Interchange? (RQ 5)

Research limitations

- The authors outlined the following research limitations:
- This research is based on secondary data.
- The authors aggregate articles from the following academic databases only: Web of Science, EBSCO, Springer SpringerLink, Elsevier ScienceDirect, SSRN, Emerald Insight, SCOPUS.
- All articles analyzed are written in English.
- There are no geographical limitations for the research.
- The authors utilized the methods of content analysis and machine learning to identify the main trends and topics.

This research is a systematic stand-alone literature review on the topic of blockchain technology applying grounded theory.

According to Fink, "a rigorous stand-alone literature review must be systematic in following a methodological approach, explicit in explaining the procedures by which it was conducted, comprehensive in its scope of including all relevant material, and hence reproducible by others who would follow the same approach in reviewing the topic" [15].

Following the concept of Fink [15] and grounded theory, the authors focused on utilizing methods that increase the reproducibility of the research: bibliometric analysis, keyword analysis and text mining.

In order to choose publications for this research, the authors carried out a keyword search based on the keyword "blockchain". This method was used in the articles of previous researchers [16-20]. Suitable articles were identified and downloaded by the authors to their database. The authors aggregated all the publications from 2015 to 2019 with the keyword "blockchain" from the major academic databases listed above. The following parameters of the selected articles were manually checked by the

authors in order to confirm that they met the criteria established for this research: title, abstract, keywords.

After the manual validation of the collected publications related to blockchain technology and exclusion of duplicates, the authors obtained a database of 9,780 publications for further analysis.

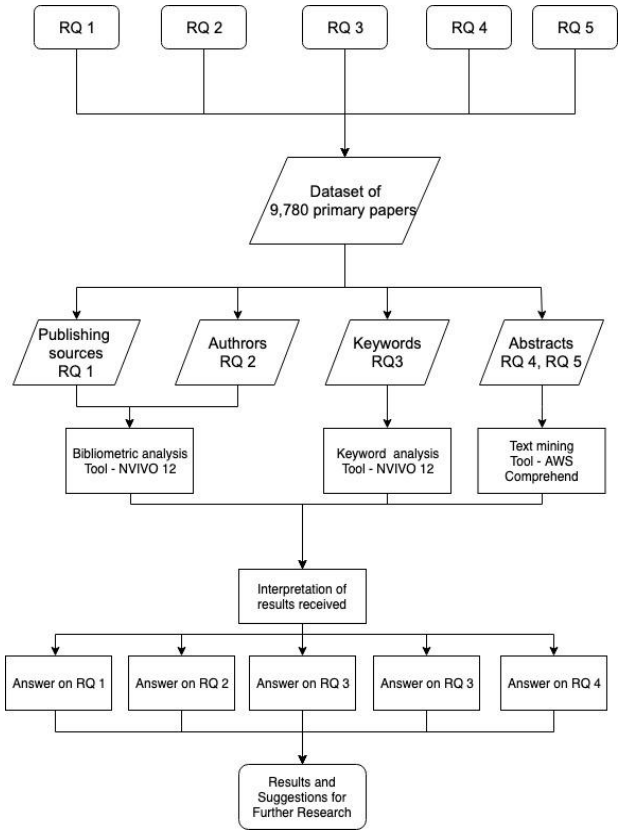

Figure 1 Conceptual model of Research

To answer research questions 1 and 2, the authors used the method of bibliometric analysis. To find the answer for research question 3, the authors used keyword analysis. Bibliometric analysis and keyword analysis were conducted using special software – NVivo 12 by QSR International [21].

NVivo is a qualitative data analysis software package widely used by researchers [22-26] and employs a word count and word cloud metric to find common themes between articles. As a result of the content analyses, a number of common themes were generated by NVivo 12.

To answer research questions 4 and 5, the authors applied the text mining method utilizing the technology of natural language processing powered by Amazon Comprehend. Amazon Comprehend is a natural language processing (NLP) service that uses machine learning to find insights and relationships in texts. Amazon Comprehend can be used to examine the content of a collection of documents to determine common themes. For example, you can provide Amazon Comprehend with a collection of articles on topics such as sports, politics, or entertainment. Text in documents does not need to be annotated. "Amazon Comprehend uses a Latent Dirichlet Allocation-based learning model to identify topics in a set of documents. It checks each document to determine the context and meaning of the word. A set of words that often belong to the same context in the entire set of documents constitute a topic. A word is associated with a topic in a document based on how often the topic is in the document and how close the topic is to the word. The same word can be associated with different topics in different documents depending on the distribution of topics in a particular document" [27].

To identify major topics and indicate the most discussed industries for blockchain technology adoption, the authors downloaded the abstracts of all the articles from the database to Amazon Comprehend and utilized tool topic modelling [27]. After the data processing, the authors obtained word groups related to 100 topics and a list of articles related to every topic. As a next step, the authors reviewed the abstracts of articles related to every topic to identify similarities, formulate the names of topics and indicate the most discussed industries for blockchain technology adoption.

4 The main findings

Analysis of the database created by the authors based on the search with the keyword "blockchain" resulted in 9,780 publications; a breakdown by years is presented in Figure 1 and a breakdown by databases is presented in Figure 2.

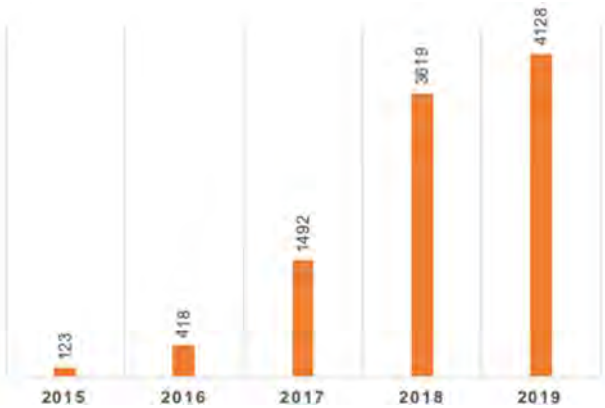

Figure 2 Number of articles by year

Figure 2 shows that the development of the interest in blockchain has promoted academic research and there is a breakthrough in 2017.

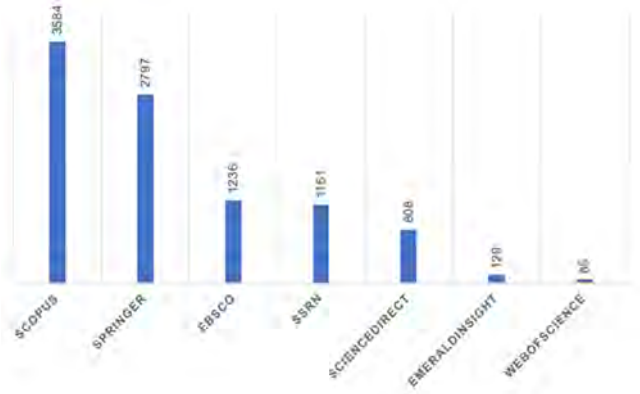

Figure 3 Number of articles by databases

Figure 3 shows that Scopus and Springer are the two main academic databases for articles on blockchain.

Research Question 1. What are the main publishing sources of research papers related to blockchain technology?

Further analysis of the database created by the authors led to the following findings on the main publishing sources for blockchain-related academic research (Table 1) and the top 25 journals publishing on the topic (Table 2).

Table 1 Distribution of sources 2015–2019

Source	Number of sources	Number of articles
Journal	1234	3837
Conference	1025	2693
Books	432	923
Research Paper	68	88
Workshop	102	385
Lecture Notes	9	141
Other	719	1067

Journals and conferences are the main sources of blockchain-related publications from 2015 to 2019.

Table 2 Top 25 journals (2015–2019)

Journals	Number of articles
IEEE Access	138
Future Generation Computer Systems	132
Economist	39
Sensors (Basel, Switzerland)	35
Advances in Intelligent Systems and Computing Journal	31
Journal of Medical Systems	31
Handbook of Blockchain, Digital Finance, and Inclusion	30
Applied Energy	29
Computer Journal	29
Computer Law & Security Review	29
Journal of Network and Computer Applications	29
IEEE Internet of Things Journal	28
Advances in Computers Journal	27
Information Sciences	27
International Journal of Information Management	27
IEEE Communications Magazine	24
Physica A: Statistical Mechanics and its Applications	24
International Journal of Recent Technology and Engineering	23
Security and Communication Networks	21
Computer Networks	20
Energy Procedia	20
IEEE Spectrum	20
New Scientist	20
Business Horizons	19
Communications of the ACM	19

Table 2 shows that IEEE Access and Future Generation Computer Systems are the leading journals for blockchain-related academic publications.

Research Question 2. Who are the top 25 authors in blockchain-related academic research?

Figure 4 Number of authors by year

Figure 4 shows rapid growth in the number of authors publishing on blockchain-related topics; there is a breakthrough in 2017.

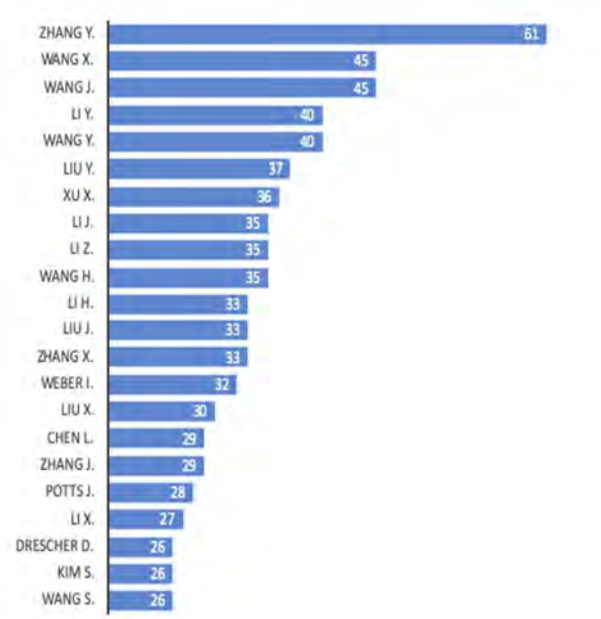

Figure 5 Top 25 authors (2015–2019)

As is evident from Figure 5, authors from Asian countries are the leaders in publishing articles related to blockchain.

Table 3 Top 25 authors from 2015–2019

Year	2015		2016		2017		2018		2019	
Author	Number of Articles		Author	Number of Articles	Author	Number of Articles	Author	Number of Articles	Author	Number of Articles
Chuen D.L.K.	3		Hegadekatti K.	11	Drescher D.	26	Zhang Y.	37	Wang Y.	23
Ali S.T.	3		Hernandez P.	9	Swan M.	17	Wang X.	23	Wang J.	22
Bhaskar N.D.	3		De Filippi P.	6	Dannen C.	13	Li Z.	18	Li J.	20
Aron J.	2		Xu X.	5	Dhillon V.	12	Blakstad S.	17	Li Y.	19
Hanke T.	2		Potts J.	4	Hooper M.	12	Allen R.	17	Zhang Y.	19
Marsden C.	2		Li S.	3	Metcalf D.	12	Chen Y.	17	Weber I.	19
Peters G.W.	2		Holden J.	3	Hegadekatti K.	11	Wang H.	17	Wang X.	18
Decker C.	2		Kiayias A.	3	Chohan U. W.	9	Liu Y.	16	Liu Y.	17
Peters G.W.	2		Baert R.	3	Drucbert A.	8	Chen L.	15	Wang L.	17
Venegas P.	2		Irving G.	3	Abu el Ata N.	8	Berg C.	15	Zhang X.	17
Papadopoulos G.	2		Chapelle A.	3	Kaal W. A.	8	Li H.	15	Liu X.	16
LEE Kuo Chuen D.	2		Huckle S.	3	Li X.	8	Liu J.	15	Zhang J.	16
Norta A.	2		Byrne M.	3	Li Y.	8	Wang J.	15	Liu J.	15
Guadamuz A.	2		S G.Y.	3	De Filippi P.	7	Liu X.	13	Wang H.	15
Wang Y.	2		Panayi E.	3	Chen S.	7	Dannen C.	12	Xu X.	15
van Lier B.	2		Marchesi M.	3	LEE Kuo Chuen D.	7	Chohan U.W.	12	Li H.	14
Barkatullah J.	2		Taft D.K.	3	Peck M.E.	7	Iyer K.	12	Li Z.	14
Noizat P.	2		Saxena P.	3	Pass R.	7	Li Y.	12	Liu Z.	14
Baert R.	2		Faisca J.G.	2	Wang J.	7	Li J.	12	Li X.	13
Nian L.P.	2		Croman K.	2	Xu X.	7	Poujol P.	11	Wang C.	13
Andrychowicz M.	2		Deichler A.	2	Bartoletti M.	6	Liu Z.	11	Kim S.	12
McCorry P.	2		Juels A.	2	Berg C.	6	Liu H.	11	Mohanty D.	12

Table 3 demonstrates the top 25 authors for each year from 2015 to 2019. This table illustrates how Asian authors became the leaders in publishing articles related to blockchain.

Research Question 3. What are the trends in blockchain-related academic publications?

To ascertain the current and past trends in blockchain-related academic publications, the authors utilized keyword analysis powered by NVivo 12.

Table 4 Top 25 keywords by trends for the years 2015-2019

Position (2015-2019)	Keyword	Position in 2015	Position in 2016	Position in 2017	Position in 2018	Position in 2019
1	Blockchain	2	1	2	1	1
2	Bitcoin	1	2	1	2	4
3	Cryptocurrency	3	3	3	3	5
4	Smart Contracts	17	5	4	4	3
5	Internet Of Things	6	9	5	5	2
6	Ethereum	56	7	6	7	6
7	Distributed Ledger Technology	51	4	7	6	8
8	Security	331	49	9	8	6
9	Privacy	307	10	8	10	8
10	Blockchain Technology	137	14	10	9	9
11	ICO	n/a	n/a	16	11	22
12	Peer-To-Peer	5	8	24	13	11
13	Artificial Intelligence	29	36	21	12	13
14	Distributed Ledger	50	n/a	17	17	12
15	Fintech	62	16	14	15	20
16	Trust	361	999	15	16	19
17	Cloud Computing	n/a	11	22	19	15
18	Technology	158	50	12	24	17
19	Big Data	119	29	13	32	14
20	Decentralisation	11	45	11	14	18
21	Supply Chain	n/a	167	25	28	24
22	Cryptography	8	18	18	22	27
23	Distributed Computing	201	6	26	18	122
24	Machine Learning	n/a	136	40	26	16
25	Consensus	n/a	58	51	21	21

Table 4 summarizes the changes in the top 25 keywords of academic publications related to blockchain from 2015 to 2019. Due to the large number of publications, articles published in 2018 and 2019 have the greatest impact on the whole spectrum of studies related to blockchain.

From 2015-2018, the main sustainable trends in publications related to blockchain were: blockchain, bitcoin and cryptocurrency.

This trend is also relevant in 2019, but it is obvious that a general trend for future research may be formulated as follows: the introduction of blockchain technology in various industries.

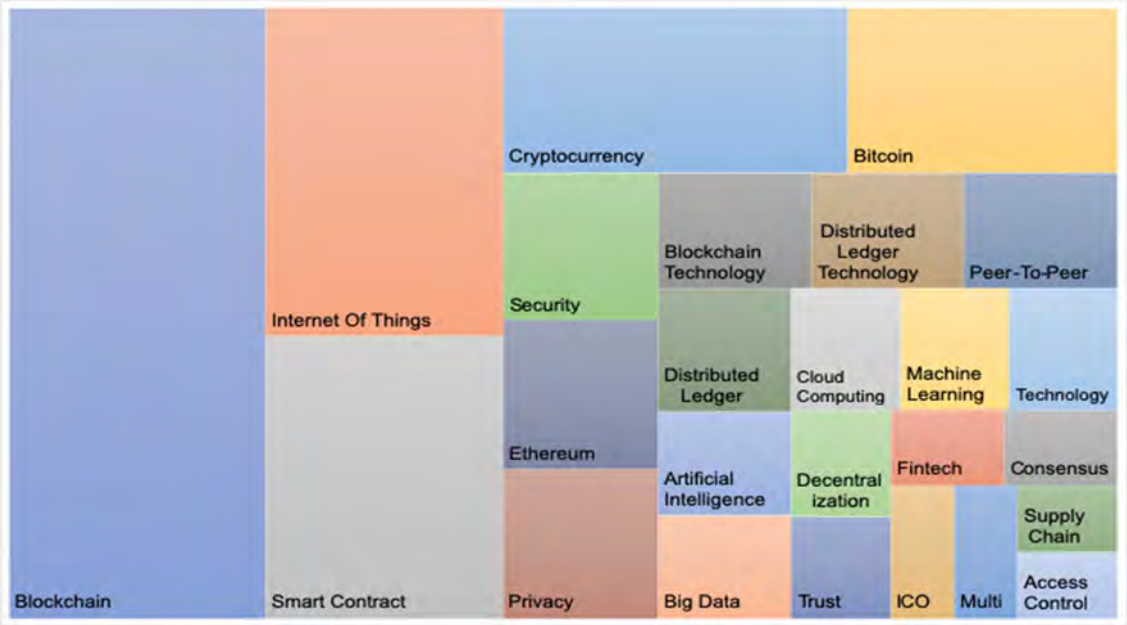

Figure 6 Top 25 keywords in 2019

Figure 6 demonstrates the top 25 keywords of blockchain-related academic publications in 2019. Comparing Table 4 and Figure 6, the trend of implementation of blockchain technology in various industries becomes more evident. Publications about cryptocurrencies are still a hot topic for the scientific community, but the focus of researchers is changing to other industries: the Internet of Things, artificial Intelligence, big data, cloud computing, machine learning, the supply chain. From the authors' point of view, the interest of the blockchain-related scientific community for fintech is decreasing due to decreasing attention to the topic of cryptocurrency. But the authors think that this trend will change in a couple of years due to the increasing amount of new non-crypto-related blockchain use cases.

Research Question 4. What are the main research topics and research gaps in the papers published between the years 2015-2019 from major academic databases?
Based on the results of utilizing the topic modelling tool powered by Amazon Comprehend, the authors formulated the top 100 research topics in the papers published between the years 2015-2019 from major academic databases.

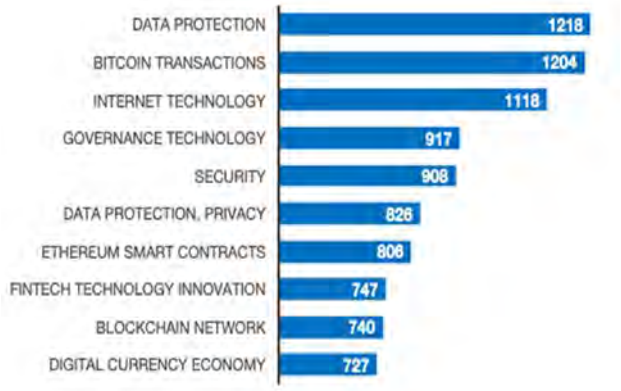

Figure 7 The main research topics

Figure 7 highlights the ten main research topics and research gaps in the papers published between the years 2015-2019 from major academic databases. Despite considerable interest in cryptocurrency and fintech use cases, topics related to other use cases of blockchain technology implementation were not so popular in the scientific community. Based on the data presented in the full list of 100 topics, the following topics are research gaps and potential areas for further research: blockchain potential use cases, blockchain for traditional money, electronic voting, big data in artificial intelligence, blockchain for real estate, blockchain and the education industry, blockchain technology potential in education, and blockchain for crowdfunding; blockchain for supply chain and logistics.

Research Question 5. What are the most discussed industries utilizing blockchain technology for Electronic Data Interchange?

After identifying the main topics, the authors found out the most discussed industries utilizing blockchain technology for Electronic Data Interchange.

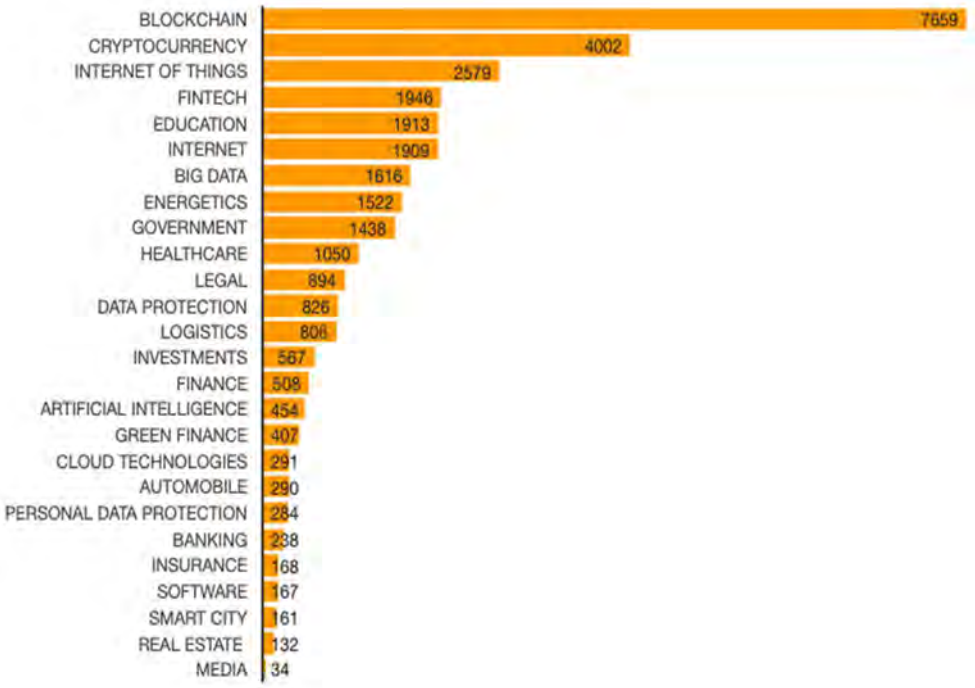

Figure 8 Industries for blockchain technology adoption for EDI

Figure 8 presents the 26 most discussed industries for blockchain technology adoption. The largest proportion of scientific discussions in the papers published between the years 2015-2019 are related to the blockchain industry only and was focused on the technology aspects. The second most discussed industry is cryptocurrency, which is the most well-known use case of blockchain technology implementation.

It is very important to highlight that the results received with the help of Amazon Comprehend show that the blockchain and cryptocurrency industries become separated in scientific discussions. Publications mentioning the Internet of Things industry are the third largest group of interest in academic research on blockchain technology implementation. Other industries like fintech, education, internet, big data, energetics, government, healthcare, legal, data protection, and logistics also receive a reasonable amount of attention in the scientific community.

Asian researchers lead in the publication of blockchain-related articles.

Previous authors focused mostly on understanding the basic principles of blockchain technology implementation and cryptocurrencies. In 2019 a new trend has developed: implementation of blockchain technology in various industries.

Despite considerable interest in cryptocurrency and fintech use cases, topics related to other use cases of blockchain technology implementation for Electronic Data Interchange were not so popular in the scientific community and can be defined as research gaps.

The most discussed industries utilizing blockchain technology for Electronic Data Interchange are the blockchain industry, the cryptocurrency industry, the internet of things industry, fintech industry, education industry, internet industry, big data industry, energetics, government, healthcare industry, legal industry, data protection industry, logistics industry.

5 Conclusions

After the analysis of 9,780 primary papers published between the years 2015-2019 from major academic databases, and adhering to research limitations described in chapter 3, the authors made the following conclusions:

Journals and conferences are the main sources for blockchain-related publications from 2015 to 2019.

6 Further research

According to the analysis of relevant literature on blockchain, future research on blockchain will focus on the following aspects:

Blockchain potential use cases including but not limited to blockchain for traditional money, electronic voting, big data in artificial intelligence, blockchain for real estate, blockchain and the education industry, blockchain

technology potential in education, and blockchain for crowdfunding, blockchain for logistics and supply chain.

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INTEGRATION OF LOGISTICS SYSTEMS OF DEVELOPING COUNTRIES INTO INTERNATIONAL LOGISTICS CHANNELS

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Keywords: logistics systems, logistics performance, integration, transit, LPI
Abstract: Modern logistics significantly influences the globalization and internationalization processes. Logistics systems are becoming increasingly important in today's rapidly changing environment. The aim of the article was to investigate the national logistics systems of developing countries in the context of their integration capabilities. The main methods used in this study are statistical analysis, index, graphical and analytical methods, methods for estimating structural dynamic shifts, comparisons. Commonly used methods of economic research, as well as statistical analysis and interstate comparisons, economic modelling (trend analysis to determine the forecast level of LPI for Ukraine), etc. were also involved. The logistics environment of Poland, Bulgaria, India and Ukraine, as well as the factors of its formation are evaluated. The components of the logistic portrait of the country in the context of integration capabilities of the logistic system are offered. It was found for the studied countries that the destimulator of the national logistics system is infrastructure (for Poland), infrastructure and customs (for Bulgaria and Ukraine), customs (for India). It is these components that need priority attention in the context of increasing the integration capabilities of logistics systems, because the results indicate that they lag far behind international standards. Prospects for further research involve studies of the impact of pandemics, globalization, digitalization on logistics systems, including that of developing countries.

1 Introduction

The development of logistics systems and their integration into international logistics channels form the competitiveness of the state, because they are a factor of influence and allow diversifying the national economy, prepare the ground for economic growth and reduce poverty. After all, the state has the opportunity to become a transit country with all the positive consequences.

Developing countries are characterized by policy changes, unstable economies, lack of basic infrastructure and limited use of business management technologies, low standards, including environmental ones. The governments of these countries identify ways to succeed either through localization or through integrated globalization. At the same time, they must decide how to build supply chains: remain a unique market or integrate into global operations and scales.

Usually, these issues in global business have individual answers for each country or remain unanswered at all, because there are no correct and effective solutions. Globalization focuses the attention of governments on the need to meet financial goals and increase the country's competitiveness. Thus, the Logistics Performance Index (LPI), which defines a country's competitiveness in terms of logistics and is a tool for benchmarking, is designed to help countries identify the challenges and opportunities they face in trade logistics and find areas for improvement. This indicator of the analysis of competitiveness and potential of logistics support reflects the logistics capabilities of the countries in which global freight forwarders and express carriers work, and trade partner countries.

Seeking to develop their own economies, countries resort to various measures, which includes improving the national logistics system. Focusing on logistics, developed countries receive additional benefits. However, developing

countries need to review the status quo in favour of building and improving a logistics system. Therefore, the integration of logistics systems of developing countries into modern international logistics channels remains an urgent problem today.

The aim of the article is to study the national logistics systems of developing countries in the context of their integration capabilities.

Research objectives:

- identify the features of the integration of logistics systems of developing countries;
- analyse the dynamics of indicators used to assess logistics performance, in particular, the Logistics Performance Index (LPI) in terms of developing countries;
- study the change of digital expression of LPI structuring within the studied countries during 2010-2018;
- identify the stimulants and disincentives for the efficiency of logistics systems of the studied countries;
- analyse the logistics environment of the studied countries using appropriate indicators;
- outline the factors influencing the logistics environment of developing countries;
- draw analytical conclusions on the possibilities of integrating the national logistics systems of developing countries into international channels.

Our study presents a comprehensive comparison of the logistics systems of developing countries with an emphasis on Ukraine, given the possibility of its involvement in global logistics channels. To achieve this goal, statistical analysis and analysis of structural dynamics are used in the work, which will highlight the main trends in the development of logistics systems of the studied countries.

2 Literature review

Logistics and transport are playing a key role in international trade relations. Some studies link the logic of performance indicators to changes in international trade [1,2], which shows a correlation between key logistics indicators and international trade.

T. Yildiz [3] also notes that the rapidly growing interest in trade facilitation has stimulated many initiatives and projects aimed at increasing the competitiveness of logistics in developing countries. He drew attention to the studies [4-7], which focus on the following:

- landlocked countries depend on transport corridors, foreign trade of these countries as a sector of the economy is directly interested in facilitating trade and reducing transport costs for goods and services;
- transport and logistics systems in developing countries, including support for integration into other international logistics channels, still face infrastructure obstacles.

The modern logistics industry has opened up new strategic prospects in establishing the relationship with economic growth. In recent years, understanding this impact has become a political issue, given the ever-increasing factors and their impact on this relationship. Most existing studies identified this relationship from a general perspective or for developed countries. S. Hanif et al. [8] analysed dynamic variables and their impact in both short and long term on the relationship between the modern logistics industry and economic growth, which is quite important, especially for developing countries.

The relationship between logistics infrastructure and economic growth is dynamic, as the growth of the logistics industry accompanies economic development and vice versa. This is the point in the following studies:

- logistics as a major factor in economic growth [9,10];
- the impact of transport and logistics on economic growth [11,12].

Similarly, other studies have focused on logistics infrastructure in terms of positive impact on economic growth [13,14]. When studying correlation, Y. T. Mohmand et al. [15] found that long-term unidirectional economic development depends on infrastructure investment. Moreover, geographical features were also considered in the study of similar relationships [16-18].

In recent years, developing countries have competed fiercely trying to boost their economies by modernizing logistics systems [19,20]. Besides, discussing the logistical path to growth, S. A. R. Khan et al. [21] argue that developing countries often find themselves in a vicious circle of low productivity. In general, these studies show that economic growth is driven by the level of logistics performance in developing countries [19,20].

In order to create a logistical competitive advantage, governments need to evaluate the current logistics system at the country level and identify which subsystems need to be optimized, developed, created or completely removed, and address integration through policies and initiatives [22].

The logistics performance really plays an important role in economic growth and increasing the country's competitiveness. According to M. A. Mustra [23], logistics is one of the most important factors in increasing national competitiveness. Inefficient logistics increases transport costs and reduce the likelihood of global integration. This places a huge burden on developing countries that are trying to compete globally [7].

S. Brar et al. [24] noted that logistics in developing countries is a product of complex interactions that are significantly influenced by geography, as well as the decisions of many manufacturers, consumers, transport/other service providers and governments. Logistics services in developing countries are mainly related to supply chains in the agricultural sector. Strategies can be simple consolidation services provided by traders or highly developed forms of vertical integration. They can be useful in low-income countries that are developing major commercial corridors, but which find it difficult to connect the corridor internally or globally.

The main problem of logistics services in developing countries is low demand both in space and time. Therefore,

special measures are needed to encourage and promote the consolidation of volumes in order to reduce the unit costs of logistics services. The strategies cover all major dimensions of logistics, including the provision of appropriate infrastructure, services, payment systems and mechanisms of coordination between producers. The development of basic infrastructure, taking into account the purpose, type and location of transport infrastructure has a great impact on the logistics performance.

An efficient logistics system can accelerate the country's industrialization through rapprochement within industrial centres, as well as create a basis for deepening economic cooperation and further integration of countries into the world economy. Moreover, the strategically advantageous geographical location of the country allows obtaining a significant source of income through the active introduction of transit opportunities.

Assessing the effectiveness of macrological systems for developing economies, we note that in 2020 the number of countries falling into the category of "developing" reached 132. The situation in early 2020 resulting from the pandemic, which caused negative changes throughout the world economy, has led to the fact that the market for transport and logistics services is now experiencing ups and downs: there has been an adaptation to the sanctions regime, oil prices and the national currency [25].

Transformation of the market of transport and logistics services, due to its underdevelopment, requires mechanisms to increase the competitiveness of logistics companies and manoeuvre in times of crisis and political tension [26]. Thus, a common feature of logistics systems in developed European, American and Asian markets is the focus on modernization through the introduction of modern information technology and expanding the range of IT services. The economies of developing countries face a wider range of transport logistics problems that need to be addressed [27].

The research focused mainly on developed economies [28]. In the complex of general problems of development of logistics systems of developing countries, researchers ignored the issues of integration of the logistics systems through participation in various international transport initiatives, in particular, transport and regional projects.

3 Methods

3.1 Research design

In a generalized form, the research design is illustrated in Figure 1. The countries were selected for the study according to the World Bank's classification, where developing countries are low- and middle-income countries (measured by gross national income per capita in US dollars below $3,855).

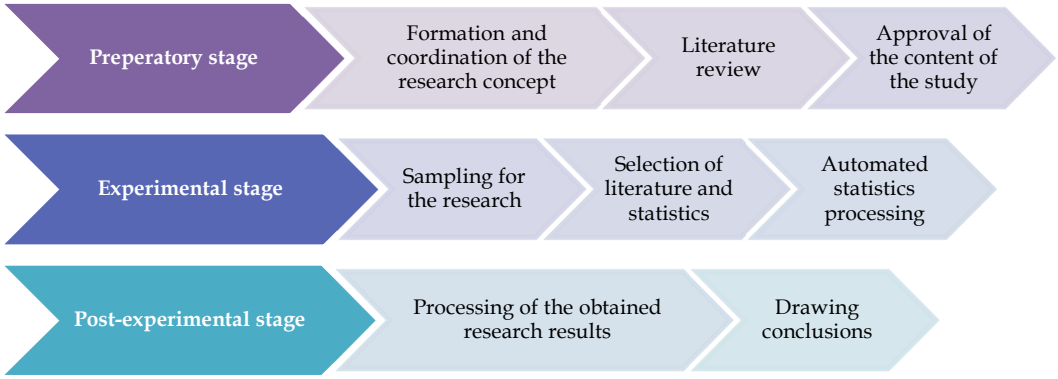

Figure 1 Abstract research design

The main methods used in this study are statistical analysis, index, graphical and analytical methods, methods for estimating structural dynamic shifts, method of comparison and monographic method.

Common methods of economic research were used to fulfil the research objectives, in particular: theoretical generalization and comparison, induction and deduction (in revealing the essence and features of integration of national logistics systems into international channels, drawing conclusions); synthesis and economic analysis (to assess the current state and development trends of logistics systems in developing countries); graphical, statistical analysis and interstate comparisons (for the analysis of structuring the indicators of efficiency of logistic systems); statistical groupings (to assess the logistics environment of the studied countries); economic modelling (trend analysis to determine the forecast level of LPI for Ukraine).

The complexity and ambiguity of economic processes that describe the peculiarities of the integration of logistics systems of developing countries in international channels, necessitated the use of the method of multidimensional comparisons in the research process. This approach allows carrying out the analysis on the basis of systematisation and generalisation of different indicators in order to obtain certain analytical conclusions. In this case, the range of representative indicators is wider than when using other methods. In addition, it allows assessing the nature of the impact of each of the indicators on the object of study, as it provides for their differentiation into stimulators and destimulators.

The basis for this division is the study of the impact of changes in the nature of each indicator on the state of the object. If the positive dynamics of the indicator reflects the efficient use of the logistics system, it is a stimulator. If the positive dynamics of the indicator has a negative impact on the efficiency of the logistics system, it is a destimulator. This, in turn, allows a comprehensive assessment of the logistics capabilities of countries and the efficiency of their logistics systems.

The method of multidimensional comparisons has a fairly wide arsenal of algorithms for systematisation and allows combining different economic and mathematical approaches for research. In this case, it is used to implement benchmarking techniques and visualise the results of interstate comparisons by building appropriate graphical models, which allowed for a comprehensive study of the integration potential of developing countries in the logistics sector.

3.2 Sample

The following countries belonging to the group of developing countries, namely Poland, Bulgaria, India and Ukraine, were selected as the object of the study according to the typification of countries proposed by the World Bank, as they are comparable in terms of economic development and state of the logistics system.

3.3 Instruments

Currently, there are several approaches to assessing the logistics performance of countries, where the researchers note LPI, AEMLI and GCII. An analysis was performed to select the most relevant and accurate existing logistics measurement tool. We first compared the scope of each tool, with LPI covering 160 countries, AEMLI — 50 countries, and GCII — 140 countries. However, the study used the Agility Emerging Markets Logistics Index [29] in Poland, Bulgaria, India and Ukraine, which allows assessing the logistics potential of developing countries at different levels of regulation of the country's economy.

Another indicator used for the study was LPI. It is calculated on the basis of a global survey of global freight forwarding companies and logistics carriers. It is an online benchmarking tool developed by the World Bank that measures performance throughout the supply chain within the country [30]. The index can help countries identify the problems of logistics systems and find opportunities to improve the efficiency of logistics activities. The World Bank conducts surveys every 2 years. The latest current rating was compiled by the World Bank in 2018 comprising 160 countries. The higher the value of LPI, the more developed the logistics system in the country.

The statistical function "Trend Line" in MS Excel was used for statistical analysis, which allowed predicting positive changes in the development of the logistics system in Ukraine.

4 Results

4.1 Key results of the research

With the search for optimal directions of development for most developing countries, issues related to the effective realization of resource potential, in particular, logistics, become especially urgent. After all, the integration of national logistics systems into international channels is one of the vectors for harmonizing international cooperation between countries with different levels of economic development.

It is proposed to understand ***integration of logistics systems*** as formation of a system of international relations, which aims to ensure the smooth operation of supply chains through the effective use of the benefits of national logistics systems in the context of international logistics channels.

According to the World Bank's 6th Establishing Relationship to Improve the Competitiveness Report, which includes the Logistics Performance Index (LPI) and is published every two years, logistics performance in high-income countries is, on average, 48% higher than in low-income countries. Thus, the report contains a rating of 168 countries, which determines the degree of efficiency of supply chains that provide companies with access to national and international markets. The LPI for 2018 also pays special attention to new issues, such as the sustainability of supply chains, their impact on the environment and the need for skilled workers, in particular:

1. The problem of labour shortage in the field of logistics, which is typical for both developed and developing countries. However, developing countries need more managers, while developed countries face shortages of workers, such as truck drivers.

2. The desire of high-income countries to get better prepared to counter cyber threats compared to low-income countries.

3. High-income countries are much more likely to demand environmentally friendly logistics services than low-income countries. This is important because CO_2 emissions from vehicles are a significant source of environmental pollution.

Low-income countries, as well as isolated, unstable countries, or countries facing conflicts or unrest typically occupy the bottom lines of the LPI rankings. In the group of below-average income, large countries such as India and Indonesia and developing economies such as Vietnam and Côte d'Ivoire have the highest logistics performance.

Developing countries are exporting goods and increasing their weight on the world market. However, transport costs remain quite high. Thus, regional integration becomes an effective tool for strengthening trade ties and reducing dependence on geographical location.

International trade in developing countries depends on transit through other countries. Additional border crossings and long distances from major markets, combined with costly transit procedures and inadequate infrastructure,

significantly increase overall transport and other transaction costs, which undermine the competitiveness of developing countries, reduce economic growth, and subsequently adversely affect their ability to promote sustainable economic development, human and social progress and environmental sustainability. Integration of developing countries' logistics systems into international logistics channels is impossible without the support of transit countries, donor countries and appropriate organizational support.

The international integration process in the logistics sector can take place through functional (creation of joint ventures, firms and corporations in the transport sector as a result of international cooperation), institutional (participation of countries in international logistics organizations, dissemination of common standards, rules and regulations on logistics services) and infrastructural integration (unification of disparate logistics systems into a single logistics system of two or more countries (participation in joint projects for the development of international logistics infrastructure)).

The integration of some developing countries into international logistics channels is complicated by the fact that they do not have access to maritime transport. Landlocked developing countries have traditionally been unattractive in terms of foreign direct investment due to the small-size economies and unfavourable geographical location, as well as the impact of other factors, including underdeveloped infrastructure, high transport costs, inefficient logistics systems and a weak institutional framework.

Exporters and importers of landlocked countries face high logistics costs, which is detrimental to their competitiveness in world markets. These high costs are due to the unreliability of logistics suppliers and low predictability.

In 2003, the Almaty Declaration and Program of Action were adopted at the International Ministerial Conference held in Almaty, Kazakhstan. This measure and its results helped developing countries to participate effectively in the international trading system, among other things, by establishing transit systems. The most difficult task of the Almaty Program of Action is to create partnerships to overcome particular problems of developing countries, which arise due to their land lockness and remoteness, isolation from world markets [31]. This situation contributes to their relative poverty, significantly increasing transport costs and reducing effective participation in international trade.

Thus, it was noted that the improvement of railway, road, air and pipeline infrastructure will take into account local transport regimes, as it significantly depends on national peculiarities. In Africa, highways are the preferred mode of transportation, while it is most often a railway in South Asia. International technical and financial assistance has been introduced, which envisages that donor countries will borrow know-how and financial resources to developing countries to modernize logistics and transit.

In order to increase the effectiveness of the Almaty Program, an innovative targeted 10-year program of action has been established, based on strengthening partnerships to accompany developing countries in supporting the benefits of international trade, structurally transforming their economies and achieving more inclusive and sustainable growth. The Vienna Programme of Action for Developing Countries for the decade 2014-2024 is based on the renewal and strengthening of partnerships between developing countries, transit countries and their development partners [32]. This document provides for the strengthening of partnerships in the context of triangular cooperation, as well as partnerships with relevant international and regional organizations and between public and private sector actors. Politicians understand that countries that are able to produce better products at a lower price or are able to be a convenient and cheap transport corridor for goods will have undoubted competitive advantages in the international market.

It is fair to assume that the integration capabilities of national logistics systems are determined by the logistics performance of each country and the favourable integration of their logistics environment.

Among the main indicators used to assess logistics performance, it is advisable to analyse the Logistics Performance Index (LPI) developed by the World Bank, which includes a comprehensive assessment of customs, infrastructure development, participation in international transport, logistics competence, tracking capabilities in the country, timeliness of transportation. Let's analyse the dynamics of this indicator on the example of some developing countries, namely: Poland, Bulgaria, Ukraine and India. In generalized form, the LPI dynamics is shown in Figure 2.

The obtained results allow drawing conclusions that from the group of studied countries Poland and India had the highest value of LPI during 2010-2018, while Ukraine — the lowest. The obtained results indicate the low efficiency of the logistics systems of the studied countries, although they have a strong starting point for the development of this area.

Figures 3-6 illustrate the structuring of the LPI, calculated according to the indicators of the countries selected for the study. Based on the results obtained, the following conclusions should be drawn. The values of individual indices representing the LPI components during the study period did not change significantly, maintaining an upward trend, and were characterized by an average level of values on the rating scale from 0 to 5. This indicates that each country has significant logistical potential, however, some factors constrain its development and effective use. The average value of the index for Poland is 3 throughout the analyzed period. The exception is 2010, when the Timelines was 4.5. Note that a similar situation is observed in other countries. The worst

indicators of the components of the index in Ukraine, which in some years have a value of 2.5. And the best index indicators are observed in India, which are consistently above 3.0 throughout the analyzed period.

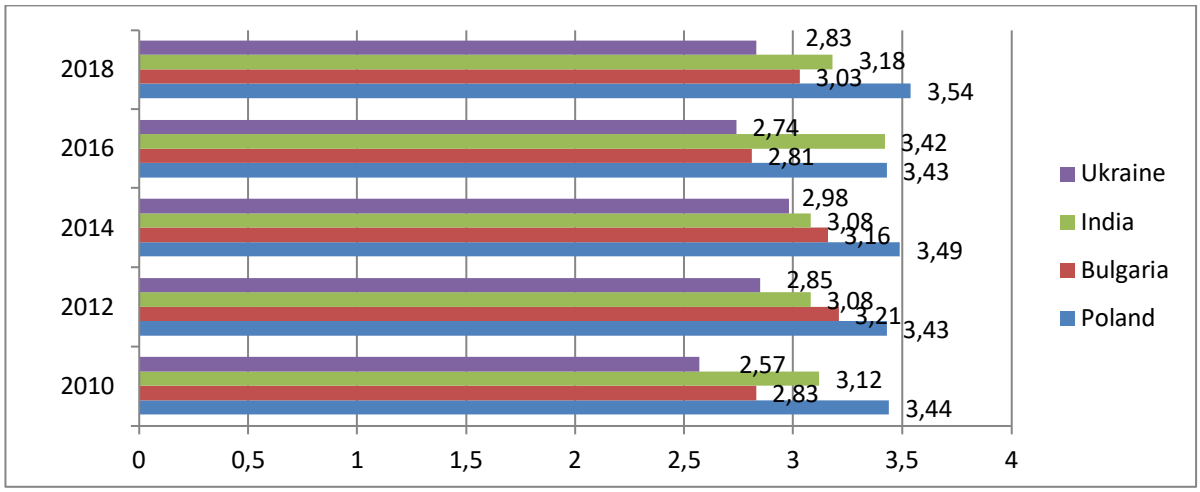

Figure 2 Dynamics of the LPI for the group of studied countries for 2010-2018 [33]

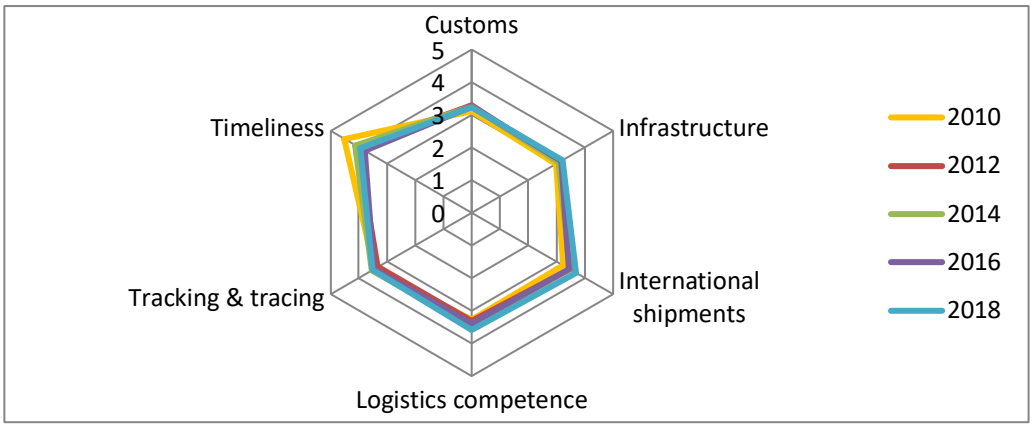

Figure 3 Graphic representation of the structuring of LPI in Poland in 2010-2018. [33]

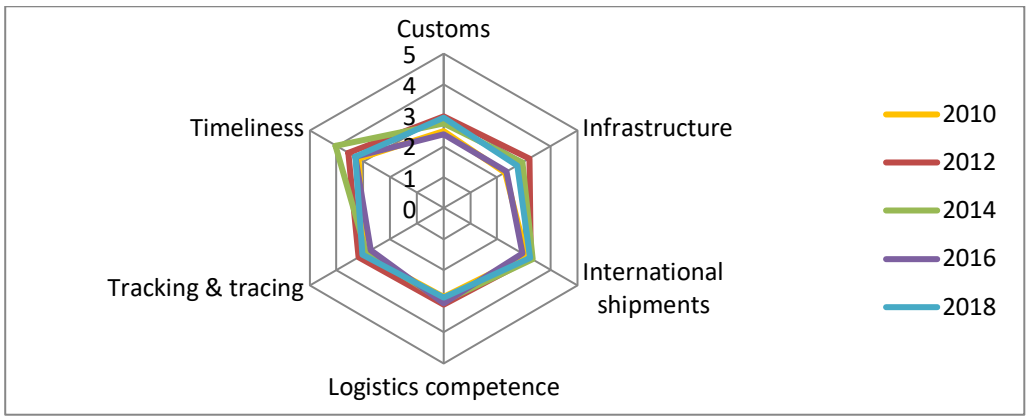

Figure 4 Graphic representation of the structuring of LPI in Bulgaria in 2010-2018 [33]

INTEGRATION OF LOGISTICS SYSTEMS OF DEVELOPING COUNTRIES INTO INTERNATIONAL LOGISTICS CHANNELS

Hassan Ali Al- Ababneh; Ilona Dumanska; Ella Derkach; Anna Sokhetska; Liliia Kemarska

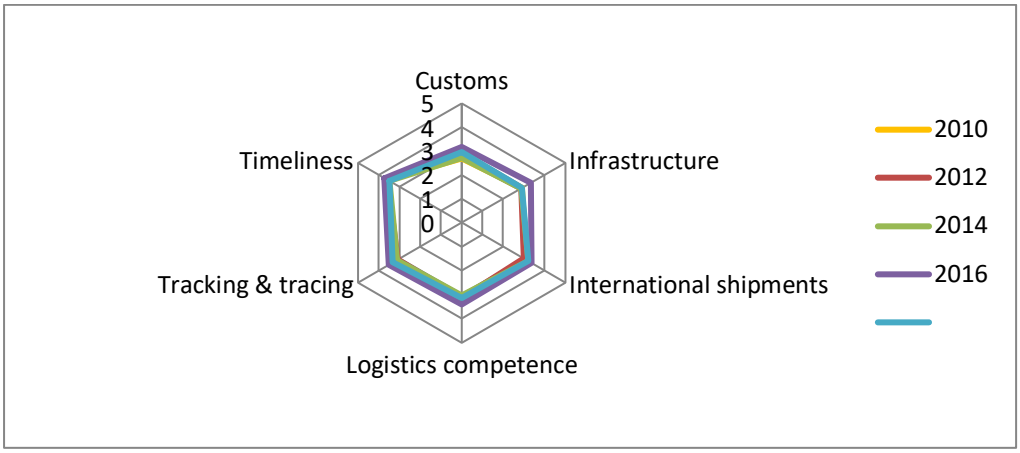

Figure 5 Graphic representation of the structuring of LPI in India in 2010-2018 [33]

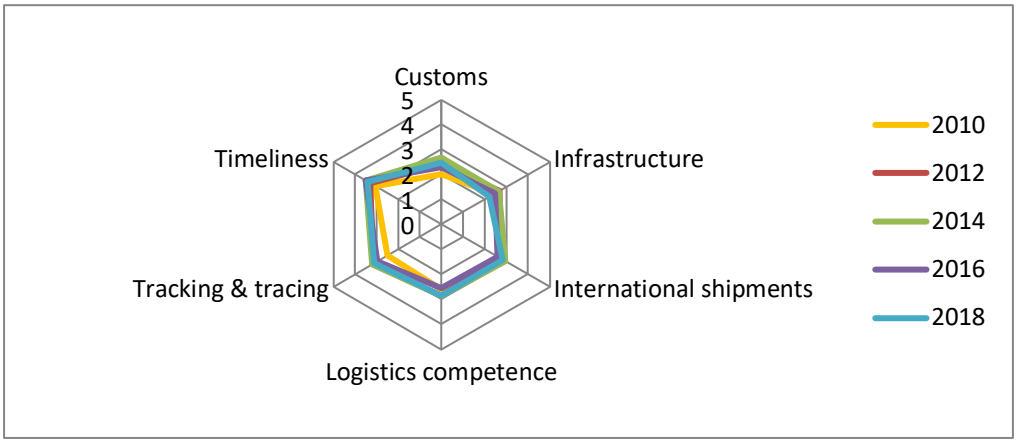

Figure 6 Graphic representation of the structuring of LPI in Ukraine in 2010-2018 [33]

Summarizing the obtained results, it is reasonable to determine the constituent stimulators and destimulators for the efficient use of logistics systems of the studied countries (Table 1).

According to Table 1, it is worth noting that the most effective element of the studied national logistics systems from the standpoint of LPI evaluation is the timeliness of transportation (Timeliness). It is this component that was characterized by the highest value of the indicator during 2010-2018, and therefore is a stimulator of logistics development. At the same time, the destimulator of the national logistics system for Poland is infrastructure, for Bulgaria and Ukraine — infrastructure and customs, for India — customs. It is these components that need priority attention in the context of increasing the integration capabilities of logistics systems, because the results indicate that they lag far behind international standards.

In addition, as already mentioned, in order to determine the ability of countries to integrate national logistics systems into international channels, it is advisable to analyse the logistics environment of each country.

Such factors of formation of the logistic environment include the following:

- natural and geographical location and length of the country, maritime borders;
- economic and political situation in the country;
- regulatory support for logistics;
- level of development of logistics infrastructure and logistics service;
- customs efficiency;
- availability of qualified labour resources;
- technical and technological development of the country;
- transit potential of the country.
- the level of investment in the development of the logistics sector.

In order to assess the favourableness of the logistics environment for integrational transformations, it is advisable to use the Agility Emerging Markets Logistics Index [29], which allows assessesing the logistics potential of countries at the macro (International Logistics), meso (Domestic Logistics) and at the micro level (Business Fundamentals).Of the countries selected for the study, only India and Ukraine are included in the list for which this indicator is calculated. The comparison of the specified indicator is illustrated in Figure 7.

INTEGRATION OF LOGISTICS SYSTEMS OF DEVELOPING COUNTRIES INTO INTERNATIONAL LOGISTICS CHANNELS

Hassan Ali Al- Ababneh; Ilona Dumanska; Ella Derkach; Anna Sokhetska; Liliia Kemarska

Table 1 Constituent stimulators and destimulators of national logistics systems

Indicator	2010	2012	2014	2016	2018
Poland					
Customs					
Infrastructure	-	-	-	-	-
International shipments					
Logistics competence					
Tracking & tracing					
Timeliness	+	+	+	+	+
Bulgaria					
Customs		-	-		
Infrastructure	-			-	-
International shipments					
Logistics competence					
Tracking & tracing					
Timeliness	+	+	+	+	+
India					
Customs	-	-	-	-	-
Infrastructure					
International shipments					
Logistics competence					
Tracking & tracing					
Timeliness	+	+	+	+	+
Ukraine					
Customs	-	-		-	
Infrastructure			-		-
International shipments					
Logistics competence					
Tracking & tracing					
Timeliness	+	+	+	+	+

Figure 7 Structuring of AEMLI for India and Ukraine in 2020 [29]

According to Figure 7, it is worth noting that in 2020 India had a much higher logistics potential than Ukraine. At the same time, the most favourable in India are domestic opportunities for logistics development (Domestic Logistics), while the business environment (Business Fundamentals) needs to be improved. Analysing the situation observed in Ukraine, it should be noted that international (International Logistics) and domestic (Domestic Logistics) opportunities logistics development were approximately at the same level, while the value of the indicator that describes the conditions of doing business (Business Fundamentals) was slightly lower than the previous components. Thus, Ukraine is characterized by a relatively low level of logistics market development [34], imperfect regulatory framework on the issues under study, political bias of domestic markets, low purchasing power

of the population, low efficiency of customs control and quality of logistics services, which in turn determine the country's logistics environment. Thus, when making a logistical portrait of the country from the standpoint of determining its integration capabilities the following components should be taken into account:

- geopolitical location of the country;
- features and favourableness of logistics environment;
- efficiency of the national logistics system.

We tested the expediency of applying such an approach on the example of Ukraine.

Ukraine as a transit country is characterized by a very favourable geographical position, and therefore is quite interesting in terms of integrational transformations in the logistics sector. Nevertheless, since 2014, political instability in the country and the annexation of Crimea have significantly affected the development of logistics in the country. It should be noted that there are 33 airports, more than 20 seaports, 6 railways and a well-developed market of logistics intermediaries in Ukraine. It is crossed by 4 Pan-European Corridors (PECs), 4 Transcontinental Transport Corridors (TCTC) moreover, the country is part of the Black Sea Pan-European Transport Area (BlackSeaPETrA). According to the results of the study, it is obvious that the logistics system is in poor condition, the logistics environment is unfavourable. Nevertheless, Ukraine has a high transit rating, which indicates the country's logistical attractiveness.

Understanding the benefits of integrational transformations in the field of logistics, Ukraine has ratified a number of international agreements, initiated accession to international transport entities and organizations, is taking measures to improve logistics infrastructure, improve regulations, urge issues of logistics hubs, etc. In the near future, this is expected to positively affect the logistics performance, which significantly shapes the country's ability of integrational transformations in this area. For this purpose, it is reasonable to carry out the trend analysis of LPI. Figure 8 contain the initial data for the analysis.

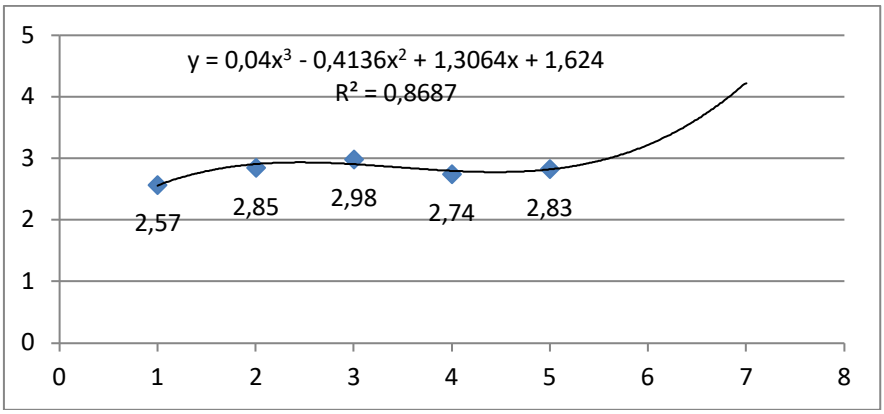

Figure 8 LPI trend line of Ukraine

It can be concluded from the obtained results that in the next 2 forecast periods the value of LPI will still tend to increase, which indicates the probable positive changes in the development of the logistics system in Ukraine.

Thus, Ukraine is characterized by significant logistics potential, however, the actual state of development of its logistics system, like most developing countries, needs significant improvement and optimization of efficiency by intensifying the development of its key components, such as infrastructure, customs and others. It is the attraction of additional funding in these areas, the formation of appropriate conditions for international cooperation that will be key aspects of the feasibility of integrating the national logistics systems of developing countries into international systems.

4.2 Limitations and implications for the research

LPI, AMELI do not take into account the state of inland waterways that can be used to transport goods within the country, as such information is missing in the statistical database, which excludes it as the international tool for assessing logistics performance. Both tools do not take into account any distance parameters. Although many countries benefit and/or depend on large hubs and ports for their trade, it is logical that, except for the emergence of new hubs, the distance between countries will remain constant, which requires taking into account the distance. We believe that the impact of the state of transport logistics in the field of air, rail and road transport may also require further research in the future to adjust the actual assessment of LPI, AMELI.

5 Discussion

Analysis of scientific research allows concluding that the integration of logistics systems of developing countries in modern international logistics channels provides opportunities in the following areas of national economy advantages of the transit country; transformation into modern logistics systems by improving the relevant institutional, organizational, financial, personnel support of logistics. Ukraine, having a favourable transit location, must take into account the concept of Eurologistics, which

is aimed at creating a single European transport and logistics system. O. V. Tkach and I. A. Voloschuk [35] identify areas of Ukraine's integration into the European transport and logistics system: 1) pan-European transport corridors (No. 3, 5, 7, 9); 2) transcontinental transport corridors (Organization for Cooperation between Railways No. 3, 4, 5, 7, 8, 10, and the Transport Corridor Europe Caucasus Asia (TRACECA)); 3) pan-European transport zones, which are characterized by the geo-spatial organization of transport communications and logistics terminals as their part; 4) international logistics terminals (or centers).

At the same time, we found that the key disincentives for the development of the logistics system in Ukraine are customs and infrastructure. According to O. Ye. Sokolova [36], the integrated transport and logistics system of Ukraine is a subsystem of the economic system of the country and international transport logistics systems. However, author does not mention that in addition to transport infrastructure, customs also needs development, the main problem of which is corruption and the complexity of customs clearance of goods.

A. S. Malovychko [37] also noted the Greater Europe concept, considering Eurologistics as the basis for the creation of a single European transport and logistics system, which would connect the transport and logistics systems of Asia and other parts of the world. However, in his opinion, it is necessary to unite all components of logistics in Ukraine into integrated logistics systems (chains). We consider such a statement somewhat irrational, as the formation of a single integrated system at this stage in Ukraine is impossible. Due to the fact that customs and infrastructure are subordinated to different ministries, these systems should be separated at the subsystem level.

Upon analysing the logistics system of the EAEU countries, Z. S. Raimbekov et al. [38] also came to the conclusion that the logistics system of the EAEU countries needs to be restructured and further integrated with the systems of more developed countries. In addition, it is necessary to increase the level of regulatory framework governing the industry to address the training of highly qualified personnel, the introduction of new technologies and improve the quality of services provided. It is also important to use public-private partnerships, as evidenced by the international experience of the world's leading countries, which currently take the lead in the LPI rankings.

J. F. Arvis et al. [7] underlined China's One Belt, One Road initiative, which has significant implications for logistics operators, which is led by China and targeting more than 60 countries. This ambitious program aims to improve trade links between the Silk Road economies as well as countries on major sea routes from China. In the initial stages, the initiative aims to develop logistics infrastructure in different locations by attracting financial and investment resources and reforming regulatory bodies in the markets of services such as transport, logistics and telecommunications.

6 Conclusions

In modern conditions, increasing the efficiency of logistics is of particular importance, especially for developing economies. The development of logistics is the driving force of competitiveness of the country's economy, improving the quality of life and rational integration into the world economy. Therefore, the developing economies face the global task of becoming a transit and logistics hub of the region, a "bridge" between Europe and Asia, which directly depends on the development of transport logistics, a major factor in stimulating sustainable industrial growth and competitive advantage of the economic system.

It was found for the studied countries that the destimulator of the national logistics system is infrastructure (for Poland), infrastructure and customs (for Bulgaria and Ukraine), customs (for India). It is these components that need priority attention in the context of increasing the integration capabilities of logistics systems, because the results indicate that they lag far behind international standards. In addressing integration issues, it is necessary to take into account the geopolitical location of the country, the features and favourability of the logistics environment, as well as the efficiency of the national logistics system. Therefore, developing countries need to significantly improve their logistics systems and integrate them into international logistics channels for the sake of their development, strengthening their transit and logistics potential.

Currently, we expect the development of logistics in emerging markets, the emergence of new trade corridors, new flows of goods, the development of the market for certain logistics products and services in Ukraine. The next scientific explorations may be changes in logistics systems in the context of globalization, sustainable development and determining the impact of the pandemic on the logistics capabilities of the world.

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LOGISTICS PLATFORMS - TRENDS AND CHALLENGES
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LOGISTICS PLATFORMS - TRENDS AND CHALLENGES

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Keywords: logistics platforms, typologies, concepts
Abstract: Logistics platforms (LP) are business models developed to improve the performance of all logistics activities of a supply chain (SC). About logistics platforms, the scientific literature details the management, implementation, importance, typologies, comparisons with international platforms, as well as cited case studies therein. The literature also highlights many trends of the adoption of technology as well as challenges resulting from the rapid evolution of said technology. We present a discussion of an LP, as well as an LP's importance to its SC. We discuss eight types of LPs, their applications, and their associated implementation phases. This important volume of articles that we summarize seeks to solve complex problems with mathematical formulations. The literature potentiates the processes carried out in LPs by means of case-study analyses through comparing some LPs of South America against the more technological-based and automation-based LPs of Europe, of Southeast Asia, and of North America. The studies of LPs in global SCs, and enclosed cycle SCs, have shown that there are many challenges stemming from global climate change, which places uncertainty in the process of estimating stochastic parameters in the new global market. This would mandate strengthening the methodologies of Hub- and Cross-docking and understanding trends, such as the need to fortify the management of LPs by utilizing information technologies and communication technologies and updating local markets to make global markets more resilient in the face of pending environmental shifts.

1 Introduction

Logistics generates a competitive advantage from the optimized management of material flows and the efficient use of resources in supply chains (SC). In recent decades, logistics platforms (LP) have become a fundamental resource for logistics management in SC and contribute to the balance between supply and demand by regulating material flows between the different factors in a SC [1]. Given the importance and proliferation of different types of platforms in many countries and economies globally, it is vital to establish some fundamental concepts about LPs, their management forms, typology, and a comparative analysis between various LPs from around the world.

This article presents a literature review of LPs. We show our research methods in the following section. We present a corresponding literature review of logistics platforms, which unpacks the importance, management, implementation, typologies, comparison of national and international platforms and analyses of case studies. This article concludes with further research recommendations.

2 Literature review methodology

For the development of this article, we present a systematic literature review based on what was proposed in [2]. Initially, we asked some guiding questions in order to structure this review. We asked the following: What is a logistics platform? How are they managed and implemented in Colombia and around the world? Why are logistics platforms important? How do they function? What are some advantages and disadvantages of logistics platforms? After asking ourselves these questions, we followed in stages: Protocol and search strategy, review and selection criteria, data extraction, data synthesis and report.

The exhaustive search in the databases produced a total of 56 documents, with the protocol shown in Table 1.

Figure 1, shows the trend of publications over the years and it is evident that the year with the highest number of publications is 2013 with 16 documents. This graph was made from articles reviewed in databases such as Scopus with 29, Science Direct with 27, Google Scholar with 24, Web of Science 20, Springer Link 10 and 8 in IEEE.

Based on the information consulted in the aforementioned databases, the countries with the highest number of publications were identified as China, Brazil, Iran and the United States (see Figure 2).

Figure 3. The results show the formation of 33 clusters using the VOSviewer tool based on the keyword grouping criterion. It also presents an evolution of how the literature presented each topic through time.

Table 1 Sequence of the Literature Review

Stages	Order of Activities	Results
Search strategy	Search in Web of Science, Science Direct, Springer Link, IEEE, Scopus and Google Scholar databases.	We found (118) articles, of which (62) were discarded according to the exclusion terms. Thus, (56) viable articles were published between the years 2002 and 2021, which demonstrates the relevance and timeliness of the topic.
	Search with the search terms: "LOGISTICS PLATFORM" and "PLATAFORMAS LOGISTICAS"	
	Six specific subtopics are established: concept, importance, management, typologies, comparison with international platforms and analysis of case studies.	
	Spreadsheet tabulation, used for item categorization and data analysis.	
	Research on the implementation of LPs and comparison of the same with respect to Colombia and other countries.	
Review and selection criteria	Selection criteria: review articles and in applications, those with the most citations with keywords in the title. Articles related to chemical studies, medicine, computer science, E-commerce and digital platform content are excluded.	Of the (56) articles selected, (15) are empirical and (41) are theoretical.
	General reading of each article to identify whether it is theoretical (based on theories) or empirical (with an applied study) and discard those that do not meet the selection criteria.	
Data extraction	Completion of the reference list for the one hundred and four articles, with general data of the article such as: objective, source, problem, methodology, results, contributions, and number of citations.	Review of 56 documents for the conceptual framework.
	Specific forms are filled out to extract the relevant information regarding the 6 established subtopics.	
	Review of articles and analysis of the same in the established formats.	
Data synthesis and report	Each of the authors' contributions was analyzed in the defined subtopics.	A conceptual and theoretical framework related to logistics platforms is generated.
	A compilation of information on the seven subtopics established for logistics platforms was carried out.	
	Comparative tables were prepared for the status of information on logistics platforms in the international environment with respect to the article "Operators and logistics platforms" [3].	

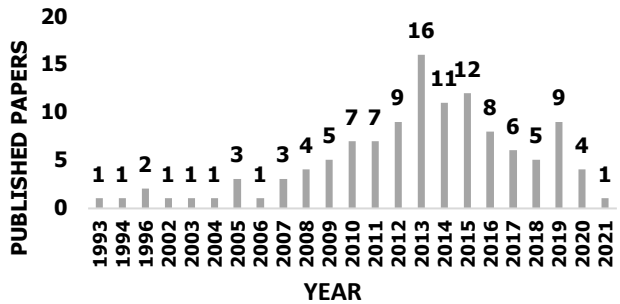

Figure 1 Year of publication of articles reviewed for logistics platforms

In 2010, the topics discussed are supply chain management (with a frequency of 10), in mid-2012 logistics (with a frequency of 18), logistics platforms (with a frequency of 11), in 2013 concepts such as hub location (with a frequency of 10) and intermodal transport (with a fre-quency of 5), in 2016, logistics platforms such as cross-docking (with a frequency of 4), and freight transport (with a frequency of 2) and case studies related to this topic (with a frequency of 3). In 2018 the environmental perspective appears in the LP finding words such as green initiatives.

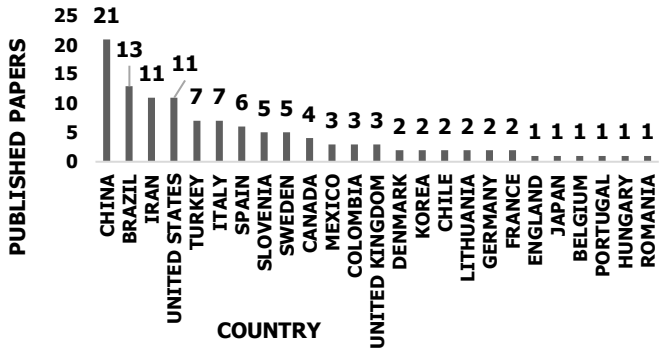

Figure 2 Place of origin of the articles reviewed for logistics platforms

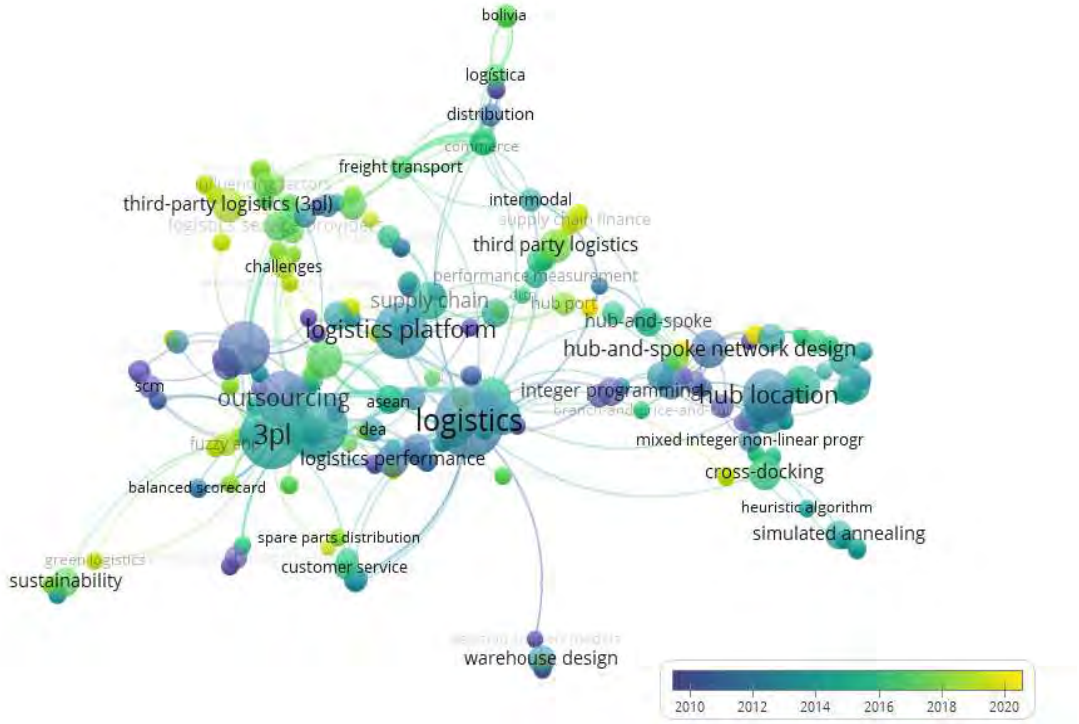

Figure 3 Elaborated in the tool VOSviewer, Bibliometric networks by year of publication and keywords for LP

3 Result and discussion

Based on the literature we reviewed, under the criteria of our methodology, we present the results. We initially look for the concept of LP, followed by: importance, management, typology, comparison, and analysis of case studies of logistics platforms.

3.1 Logistics platform: history and definition

The concept of the logistics platform is not a recent one, thus many unique definitions exist, though many share common themes and vocabulary. We emphasize that there is no common agreement on exactly what logistics platforms are. Many authors have used the term in a wide diversity of contexts. There is discrepancy in research and in the literature [4]. The first definition emerged in France in the 1960s as a result of the development of management operations studies [5,6]. Later, other names appeared such as: plateformes logistiques publiques (public logistics platforms), distriport, distripark, interport, freight village, integrated freight centers, logistics park [5-8], logistics center, distribution center, central warehouse, freight/transport terminal, transport node and logistics depot [9,10]. Table 2 compiles the myriad definitions.

Table 2 Logistics Platform Definitions

According to (EUROPLATFORMS) 1997 "It is a delimited area within which the activities related to the transport, packaging and distribution, for national and/or international transit of goods of one or several operators are carried out"[3,6,8,11-15].
According to Abrahamsson, Aldin, and Stahre 2003 "A logistics platform is a homogeneous part of the logistics system, which an organization manages and controls centrally, a resource base for new market positions. The LP includes logistics operations, a physical structure, processes, activities and information systems" [5,13,15-19].
"A logistics platform is defined as a strategically located site, performing various logistics activities, with a large transportation infrastructure that provides competitive advantages and improves the logistics operations of the participants involved in the companies' business" [6].
Dubke (2006) states that LP allows the: "Coordination of the network of all logistics services, providing greater competitiveness through lower costs of management and operation of the logistics chain" [13].
Carvalho et al (2010), state that the LP: "is where different supply chain actors can integrate in the same physical location, assisting logistics flows and acting as a strategic interface between global and regional networks with the objective of improving SC efficiency"[13,15].
Antúna & Alarcón (2014), define it as a specialized area with the necessary infrastructure and services for co-modal transportation, which adds value to the products that use it [13,15,19].

LPs provide a complex service to communicate and evaluate relevant information that affects the performance of SCs [13-15].
The LP is a specific place where activities related to transportation, logistics and distribution of goods are carried out, uses the same basic services to the different actors involved and achieves greater efficiency in its operations [14].
An LP is the place where it supplies transport and storage infrastructure areas, improving the competitiveness of companies, by de-bureaucratizing and speeding up business operations through efficient logistics operations [20].
LP is a flattened organizational structure that connects more than one logistics agency. It designs negotiation mechanisms to improve network effects. It decreases information asymmetry between industries, improves operational efficiency and saves operating costs [21].
LPs show a special configuration where a large group of companies can be found in a limited geographical area; in these areas, there is a breakdown of transportation chains, as well as other activities such as consolidation, deconsolidation and warehousing of cargo. The LP share several services, transportation areas and resources that allow the execution of activities related to distribution, transit of goods and associated costs [22].
LPs are distribution components where goods are trans-shipped, stored, marketed in bulk, packed, sorted and grouped for shipment to beneficiaries [23].
The LP is an area of logistics services, whether delimited in the territory or not, located at a point in the transport or logistics chains, contributing to the value chain by providing services to the transport and telecommunications network, stakeholders (users, operators and customers), vehicles and equipment [14,24].
A logistics park refers to the physical location of logistics facilities, where there are several logistics companies to conduct business. It is established to concentrate logistics facilities and conduct collective logistics operations, or the rational distribution of space of urban facilities [25].

In summary, a logistics platform, of any type, can be considered as a source of resources for the implementation of logistics processes in a predefined environment, offering customized infrastructure, a developed information communication system, logistics technology, specialized logistics workforce, and favorable support at the highest level [10].

A logistics platform can be defined as a physical management and control space, where general and specialized logistics processes such as loading, unloading of goods, shipments, storage, packaging, unpacking and transship-ment are carried out. It provides competitive advantage to stakeholders by coordinating operations, through the collaboration of logistics agents, integrating the use of resources, and achieving efficiencies by reducing associated logistics costs.

3.2 Importance of logistics platforms

- The relevance of logistics platforms, as internally coupled systems linked to a complex system of interrelationships, derives from the functions and services they offer. Among the services provided in the LP, some are shown [26]:Territorial planning, promotion and intermodal development with routing and traceability analysis.
- Scheduling and management of plant equipment and real estate.
- Logistics services for warehousing, handling of goods, management of shipping and receiving of goods, planning of transportation services, and coordination of routing and traceability.
- Coordination of intermodal terminals in the management of shipment, reception and maintenance of containers, commercialization of freight transport by rail services.By having these services and functions in the same physical location, transportation cycle time is reduced and customer service is improved, therefore generating competitive advantage [27]. There are different benefits with a logistics platform. The most important is to make its region of influence more logistically friendly. It offers benefits to companies by providing greater flexibility, responsiveness, sustainability to distribution activities, effective logistics adaptation to changes in advertising and sales tactics, timely business expansion to new markets, and reduction in logistics costs. Regarding the supply chain, LP is important in the standardization of logistics processes, lower costs, faster material flow, less operational work and the integration of new partners [28]. Some authors claim that logistics platforms decrease negative environmental impacts by increasing collaboration between transportation systems, reducing carbon dioxide emissions, and shortening the distances traveled by delivery vehicles [6].

Some advantages of LPs are [23]:

- Upstream, they provide advanced inventory management, quality control, mass customization of in-process products, assembly operations, flow coordination and optimization, reliable logistics processes, and just-in-time deliveries on production lines.
- Downstream, they can map the distribution of finished products with distribution platform management, pre-order unit, packaging or customization collaboration, quality control, presentation media coordination, and sales promotion strategies.

3.3 Management of logistics platforms

This section presents the implementation phases and forms of LP management found in the literature, Marques de Souza et al. [20] establishes the implementation phases, Figure 4.

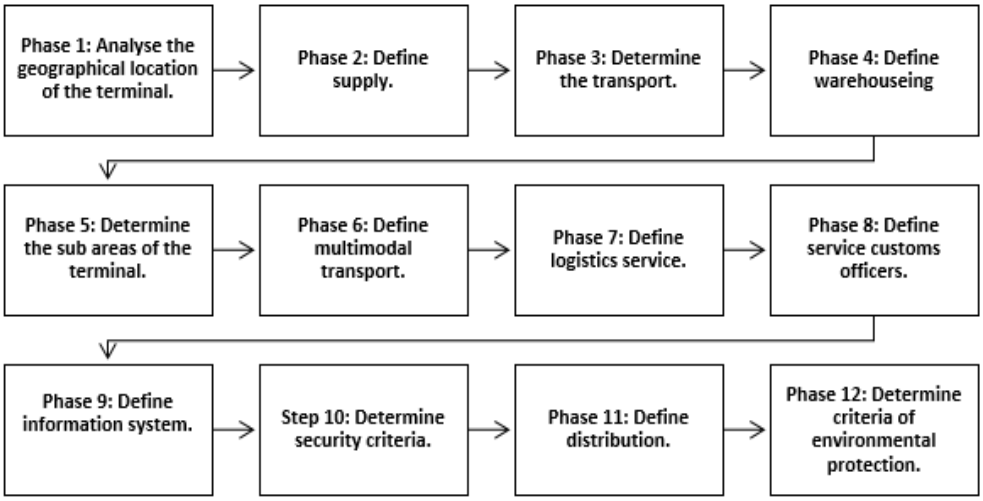

Figure 4 Implementation phases of a logistics platform
Source. Elaborated from [20]

Marques de Souza et al. [20] determine as activities within each of the phases the following: (1) the location of the region, intermodal connections, and logistics needs are identified, (2) where suppliers are, how they are categorized, and their needs are identified, (3) define the appropriate mode for the terminal that is related to the logistics network activities, and it is stipulated whether the transport is of the logistics company or of third party, (4) operationally define the shipment criteria at the terminal, allowing the exchange of data on the shipment as well as specific needs and type of storage, (5) define the transport, logistics user, and general service sub-units, (6) determine the multimodal user, transport, and actions in the logistics network, (7) identify and establish the logistics user and specific activities in the logistics network, (8) determine the areas and customs authorities, (9) isolate each activity in the logistics network, (10) define the security criteria used, (11) define how the nature of distribution is identified, strategies are configured, physical distribution management is carried out, and the needs in the logistics network, (12) determine the economic stages of resources, and analyze waste management plans and environmental protection for the physical area of, and surrounding, the terminal.

Because of their broad definitions, both LP management and SC management come into being in many different forms. A few examples are listed below:

- **AS SUPPORT FOR MARKETING STRATEGY:** In SC management, an LP is a homogeneous, controlled and designed part of the logistics system. It is the basis for new marketing channels. Logistics platforms do not evolve independently. They are affected by the marketing channel strategy and must support the business strategy. The logistics platform must be flexible in the short term to offer operational opportunities and in the long term to apply to new marketing channels. Centralizing logistics with an LP increases proximity to marketing strategy and market channels [29].
- **THROUGH AN ARCHITECTURE:** The context of the logistics platform is composed of three elements: the network of members, marketing and the structure of the logistics module, to design and establish an adequate infrastructure and provide logistics services supported by information technologies [30].
- **THROUGH INFORMATION AND COMMUNICATION TECHNOLOGIES:** A logistics platform must evaluate and communicate information that can have an effect on the flow of materials. The LP provides specific means and rules to manage interactions and links basic planning functions of various levels of aggregation in companies and their SC, through information and communication technologies with privacy and security to partners [31].
- **THROUGH VALUE CREATION:** Logistics platforms create value through reduced costs, customized service options, greater operational efficiency, and higher quality services. Advantages have been identified in collective logistics platforms, such as resource matching, route planning, driver monitoring, matching, routing, tracking, driver selection, feedback, and online payments [32].

ECLAC, in the 2015 Logistics Guide, proposes four management models for the development of logistics platforms [33]:

- **Fully Public:** The state is in charge of the construction and operation of the logistics platform, operating through companies contracted with public financing and risk, and they promote a balanced economic and territorial expansion. They promote and improve key logistics corridors for the country and the development of logistics platforms with the objective of favouring the competitiveness of small and medium-sized entrepreneurs, facilitating border trade and reducing logistics costs.
- **Public-Private Partnership:** Public-private arrangement that seeks a specialized company as logistics operator, delegates the execution of the logistics participation to the private sector, but without releasing the control of state-led economic and commercial development, which would be administered through government supervision in strategic decisions during the execution phase. It is formalized by and restrained by public law.
- **Concession:** The construction and operation of the LP is entrusted to the private sector by transferring the risks. The public sector provides land and controls the fees to be charged. Monitoring is limited to the provisions of the concession contract, and execution is left to the private sector.
- **Totally Private:** The purchase of land, design, investment, and operation is totally private, and there is no state intervention, or it is limited to granting tax incentives. It responds to the needs of industrial or commercial companies with problems of regulation and competition between the State and regional or local authorities.

3.4 Typologies of logistics platforms

In the literature review, eight classes of logistics platforms are found according to their operational complexity and operational integration [34], which are summarized in Table 3.

Table 3 Types of Logistics Platforms

TYPE	DESCRIPTION	APPLICATION
Distribution Logistics Platforms - PLADIS	Facilities are responsible for managing transportation and logistics in distribution and linking cross-border supply chains. There are three types of distribution logistics platforms (PLADIS): metropolitan, regional, and international. These, in turn, are related to the physical distribution of goods that articulates transportation and urban operations and the location of distribution centres.	• Urban, regional, and megalopolis cargo distribution. • For companies that produce and commercialize consumer goods.
Logistics Platforms at Border - PLF	Support facilities for the production of transportation and logistics services near land border crossings [35].	• To provide facilities to carriers. • For interchange of locomotives and personnel, as well as the transfer of cargo from one vehicle to another. • Inventory management, order processing and office and freight broker facilities. • Lodging and restaurant services for drivers.
Logistics Platform for Cluster Support - PLC	Facilities for the production of transportation and logistics services to support distribution and marketing in companies' supply chains. Logistics operators, distribution centres, reception centres, and terminals for transportation companies are generally located on these platforms.	• To support the logistics supply chains of companies, industrial, and commercial distribution.
Port Logistics Activities Zone - ZAL	Facilities are responsible for receiving, handling, and distributing goods from port and catchment areas. The range of services includes real estate services for logistics operators, freight forwarders, and customs brokers, carriers, railroads, importers and exporters.	• Consolidation and deconsolidation services of maritime cargo, warehousing and/or storage, unpacking and/or labelling, packaging, palletizing, customs services.
Air Cargo Centers - CLCA	It is dedicated to logistics processes related to air cargo. It has only one area, commonly called air cargo logistics, centred on the first line.	• Logistics services (consolidation and deconsolidation, labeling, quality control, inventory control, etc.), and customs services.

Intermodal Terminals Railway – ITR , Dry Ports - DP	Logistics platforms for rail interchange. Dry ports are a special category of intermodal rail terminals that are located within the territory and connected by rail to a seaport, whose port authority formally assumes a certain degree of responsibility for the operations carried out there.	• Modal interchange (rail, road and/or maritime).
Agrolog Centers - AGROLOG	These are logistics platforms to contribute to the efficiency of agricultural and agro-industrial production. These platforms are managed depending on the type of agricultural and agro-industrial production, their area of influence, and the logistic requirements of the commercialization channels.	• Companies sorting and packaging agricultural products such as tomatoes, avocados, citrus and berries. • Agricultural processors of sauces, juices, thin cuts of beef, honey, and jams. • Trucking unions involved in the transportation of agricultural products. • Associations of small producers. • Cold chain logistics operators. • Government agencies in phytosanitary control.
Food Logistics Centers - FLC	Also called wholesale markets, FLCs combine distribution and marketing logistics and are typically located near cities in order to supply food to the population and market to wholesale suppliers and distributors. Commonly they must have warehouses for the collection and marketing of products, as well as parking areas for loading and unloading, and in some cases, they have auction yards.	• Associated with the marketing of fruits, vegetables, meat, seafood and groceries.

Source: based on [34].

3.5 Comparison of logistics platforms

Around the world, logistical processes are managed by logistics operators using logistics platforms. This section shows the description, surface area, and services provided by representative logistics platforms from Europe [36], Asia, the United States, Canada, Brazil, and Colombia [37]. These platforms were selected in order to observe the contrast between logistics platforms with high levels of automation (i.e. the United States and Canada) to those found in Colombia, which tend to have less automation.

The literature describes the particular case of nineteen logistics platforms in Europe, of which nine are in Spain (Coslada Transport Center, ZAISA, Madrid Transport Center, Vitoria Transport Center, Pamplona Transport City, Azuqueca Dry Port, Zaragoza (PLAZA), ZAL Barcelona and Bilkakobo-Aparcabisa) with surface areas between 13,117,977 m² and 200,000 m². There are five logistics platforms in Germany (GVZ Bremen, GVZ Hamburg, GVZ Koblenz, GVZ Rostock and Rheinhafenge Sellschaft Weil am Rhein) with surface areas between 4,720,000 m² and 260,000 m². There are three logistics platforms in Italy (Interporto di Novara, Ce.P.I.M.M.S.p.A. and Interporto Quadrante) with surface areas between 2,500,000 m² and 840,000 m². There is one logistics platform in Denmark (The Scandinavian Transport Center (Freight Village)) with a surface area of 1,300,000 m². There is one logistic platform in Hungary (BILK Kombiterminal) with a surface area of 1,000,000 m². The services offered in the LPs are reception, movement, repacking, reassembly, transhipment, distribution, storage, consolidation, production, trade, assistance, loading, unloading, sorting, technical inspection for general shipments, express deliveries, permanent exhibition, vehicle sales, refrigerated chambers, and dry and liquid bulk [36].

In South Korea, there are two logistics platforms (Busan New Port Distripark and Gamcheon Distripark), each with a surface area of 3,070,000 m², that provide manufacturing, storage, distribution, consolidation, customs clearance, packing, repacking, loading and unloading services for all shipments. Three logistics platforms are identified in the United States (Alliance Texas, Pureland and Rickenbacker) with surface areas between 180,000,000 m² and 5,260,934 m². There is one logistics platform in Canada (Halifax Gateway) with a surface area of 505,850 m², and it performs activities such as receiving, manufacturing, assembly, distribution, consolidation, exchange or transhipment, loading, unloading and storage for shipments in general, refrigerated chambers, and dry and liquid bulk. To conclude the international platforms, reference is made to the case of Brazil, where there are two logistics platforms (Multimodal de Goiás in Anápolis and Multimodal Viracopos in Campinas) with a surface area of 6,967,790 m² and 7,000,000 m², respectively, and they provide services of consolidation, loading, unloading, storage for

general shipping, refrigerated chambers, and dry bulk and liquids [36].

In the case of Colombian logistics platforms, the corresponding information can be seen in Table 4.

Table 4 Logistics Platforms in Colombia

Type	Logistics Platform	Extension (Acres)	Capacity to mobilize (ton per year)	Number of employees	Type of load	Services	Benefits
Maritime	Chocó	44	829.147	-	Liquid bulk	Storage area, general logistics activities, product transformation, land and river docks, parking, delivery, receipt of goods, inspections, cargo nationalization, labeling, weighing, invoicing, container terminal, and cross-docking center.	Employment generation, optimization of logistic times, reduction of gas emissions, integral and functional urban development, increase of regional income, greater logistic-economic efficiency, consolidation of the international market for producers, channeling of traffic, and reduction of transportation cost overruns.
	Cartagena	15	34.558.932	989	Containers, Bulk coal, Liquid and solid bulk		
	Barranquilla	94	10.860.562	378	Containers, Bulk coal, Liquid and solid bulk		
	Santa Marta	33.63	10.738.633	335	Containers, Bulk coal, Liquid and solid bulk		
	Urabá	120.4	13.953	-	Liquid bulk		
	Buenaventura	1.10	17.383.324	-	Containers, Bulk coal, Liquid and solid bulk		
Terrestrial	Eje Cafetero	38	31.900	-	Products of the agricultural, manufacturing, mining and livestock sectors		
	Soacha	45	7.555	-			
	Tocancipa	38	271.648	1.000			
	Cúcuta	21	17.522	-			
	Bogotá	64	246.613	30.200			
	Manizales	24	17.042	-			
	Buga	70.5	9.640	-			
	Dibulla	355	21.906	-			
	Rionegro	46	110.514	-			
	Cartagena	72.81	236.487	-			
	Cali	93	107.526	17.000			
Fluvial	Barrancabermeja	120	421.038	-	Containers, Liquid Bulk		
	Puerto berrio	-	200.000	50	Bulk, hydrocarbons, minerals		
Aerial	Bogotá	690	370.630	1.818	Flowers, vegetables, fruits, medicines, plastics, books, semiprocessed products, etc		
	Medellín	120	2.088	6.500			
	Cali	370.74	15.105	-			
	Barranquilla	33.5	10.470	-			

Source: elaborated from[37-40].

Based on the above information, it is evident that the platforms in Spain, Denmark, Germany, Hungary, South Korea, the United States and Italy use more technology and are more automated, which means that they can cover a

larger territory in a shorter time, allowing them to handle larger volumes of merchandise and services than those in Colombia and Brazil.

3.6 Analyses of case studies

Several authors seek to solve problems and enhance the processes carried out in the LP by means of surveys, methods, algorithms, mathematical models, and simulations. In [41], the authors present problems related to the reception of vehicles and goods in an LP of the agri-food sector, which is solved by means of a stochastic and dynamic discrete event simulation. In [42], the authors explored the implementation of an LP where a fourth-generation supplier (4PL) operates harvesting processes, conducted an online survey to transporters in the sector to analyze the technological, organizational, and environmental criteria they could apply to streamline productivity. In [43], the authors discovered that mathematical programming could solve delays in LP networks through the precise allocation of resources.

In [44], the authors apply governance theory in LP and derive a typology of governance relationships. While [45] and [46] propose performance indicators that can be used in management. In [47], the authors propose, through a review of the literature and a survey with a group of experts, the principles of corporate and public management. In [48], the authors analyze the environmental performance of a Belgian logistics platform, employing a multi-criteria strategy to assess how it affects stakeholders.

In [49], the authors examine the relationship between logistics park platforms, geographic location, and operational performance. In [50], the authors, with the informational support of LP, predict logistics performance, and surveys were conducted to companies in the logistics sector in China for further analysis. In [51], the authors implemented local search algorithms to create a feasible and useful schedule of LP with fluctuations in the duration of operations.

The authors in [52] seek to determine the optimal location of logistics platforms, the necessary sectors and the allocation of customers in order to minimize the costs for their stakeholders and suppliers, for which a linear integer programming model is formulated and solved with a hybrid algorithm. Finally, [53] optimizes the container loading of intermodal logistics platforms with the purpose of reducing the inventory and labour required by means of a mixed-integer linear programming model, solved with a decomposition heuristic.

4 Challenges

Researchers face challenges regarding the representation and study of LPs of supply chains in globalized economies, where flows of materials and/or goods occur between towns, cities, states, provinces, departments, countries, and continents. Every decision regarding—including but not limited to—the location of the LP, inventory levels, vehicle route optimization (including various links and multimodal transportation), storage and warehouse design will have cascading consequences throughout the entire LP. In this context, performance measures that promote sustainability must be evaluated, taking into account economic, environmental, and social factors [54].

It becomes necessary to explore LP design environments with modelling for efficiency analysis [55], the design of a logistics platform, and the integration of reverse flow requirements in logistics platforms to assess their performance and maturity, as well as additional direct and reverse flow features that help in optimizing the location of LPs [49].

Studies with stochastic parameters are required, which also evaluate the behaviour of Hub-docking, Cross-docking, and distribution centres with storage, with respect to the dynamics of flows in the supply chain. It is evident for the need to carry out studies that evaluate the inbound, storage, and outbound flows in the LP, the order picking and consolidation, with respect to their incidence in the design inside the LP. As well as in the layout of the areas and decisions on static and dynamic shelving [56].

The need to expand the effective management of logistics platforms with information and communication technologies is evident. Our analysis of case studies focused on determining their future capacity and performance by means of additive and/or multiplicative mathematical models, as well as Decision Making Unit (DMU) in the analysis, for the implementation of logistics platforms that add resiliency to adapt to new distribution challenges.

Logistics platforms are the future of the global economy. With them, the planning of the distribution of goods and services around the world becomes ordered and logical. Without them, the global economy would collapse, leaving only a minimum of goods and services available to small regional centres. Human beings are good at many things, but one in particular: adaptation. Logistics platforms are a brilliant example of humanity's ability to solve global problems of immense complexity, which has given humanity the ability to survive in the distant past, the ancient and historical times, and will allow civilization to flourish into the future.

5 Conclusions

Although the concept of logistics platform is an old one, there is no unified consensus in the research literature on what a logistics platform actually is, since authors use the term in a wide variety of contexts. However, we identified that the most commonly used definitions are those corresponding to (EUROPLATFORMS - 1997) and (Abrahamsson, Aldin, and Stahre - 2003), in which a LP is understood as a delimited area where logistics operations management and control activities are performed, also several proposals are identified for the implementation of a logistics platform and eight types of logistics platforms.

There are similarities and differences between the LPs in Europe, Asia, Brazil, and Colombia with respect to the operation, size and services they provide. The platforms in Spain, Denmark, Italy, Germany, Hungary, South Korea, and the United States are more technologically advanced and are more automated, and therefore cover a broader area of territory, which allows them to handle larger volumes and with a higher turnover of goods than those in Colombia and Brazil.

Finally, the literature identifies a large number of articles that seek to solve problems and enhance the processes carried out in the LPs by means of case study analyses in which tools such as surveys, methods, algorithms, mathematical models, and simulations are used.

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STRUCTURAL EQUATION MODELING OF SUPPLY CHAIN MANAGEMENT, EMPLOYEE INVOLVEMENT, AND EMPLOYEE WORK PERFORMANCE IN THAILAND'S AUTO PARTS INDUSTRY

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***Keywords*:** supply chain management, employee involvement, employee work performance, Thailand's auto parts industry
Abstract: The objective of this research was to analyse the structural equation modelling (SEM) of supply chain management, employee involvement, and employee work performance in Thailand's auto parts industry. The sample group included 383 employees operating in the aforementioned industry using SEM processing by the AMOS program as the tool. From the research, the latent variable of supply chain management had a direct positive influence on the latency of employee involvement and employee work performance with statistical significance. Simultaneously, the latency of employee involvement had no direct positive influence on the latency of employee work performance. Therefore, the latency of supply chain management did not indirectly influence the latency of employee work performance through the latency of employee involvement.

1 Introduction

The automotive industry in Thailand is one of the national strategic industries that generate revenues for the country. Thailand has developed for more than 40 years from an assembler of auto parts to top automotive manufacturing and exports. However, huge disruptive forces to the auto parts supply chain, such as the rise of electric vehicles, causing many conventional parts will be useless. In particular, auto parts that are related with engine, gasoline tank and air intake and exhaust systems are affected. The development of a supply chain to support the disruption is needed urgently [1] in addition. Labour-intensive production is normally found in auto parts industry. These employees are skilled workers. Auto parts suppliers, therefore, need their collaboration, i.e., executing tasks following work standards and self-development to maintain more effective at work [2].

During 2017-2019, the auto parts industry of Thailand displayed a tendency to continually increase. In the fourth quarter of 2017, Thailand's export value of automobiles and auto parts amounted to USD 2,361.92 million, an increase of 12.35% (%YoY) compared with the same quarter of the previous year. In comparison in the fourth quarter of 2018, Thailand's export value of automobiles and auto parts amounted to USD 212.07 million, an increase of 32.88% (%YoY) compared with the same quarter of the previous [1].

Even though the automotive industry in the recent two-three years has increasingly grown, the world's economic fluctuation and other factors have affected the industry; for instance, the energy issue that is tending to change automotive manufacturing from fuel vehicles to electric vehicles has resulted in entrepreneurs in this industry dealing with the change. In particular, the auto parts groups that belong in the supply chain must adjust to the automotive manufacturers because the parts of the automotive system and related systems must be changed. In consequence, if not well-prepared for the supply chain of the automotive industry, this would probably affect the business operation and they might not be able to compete. As a result, this research attentively studied the supply chain of Thailand's auto parts industry in order to prepare for dealing with the oncoming changes as aforementioned. [3].

The current supply chain management is an essential issue of the business since it is the key to a sustainable business operation by depending on collaboration in organisations that differs from the past operation that focused on achieving their own goals [4]. Supply chain management is the core of business alliances from the beginning to the end. The organisations would collaborate in planning the strategy, share resources and benefits fairly. Then, when every unit in the supply chain operates efficiently, the competitive performance would increase and they would be able to survive through every business change. This is different from the stand-alone organisation, as they take one main role as buyer or seller focusing on obtaining quality products but at a low price [5,6]. This sometimes affects a short-period of collaboration and leads to a change of partners. Partnerships for the development of the product and working process, therefore, may take a long time, but the business preparation to manage the

change could be difficult. In other words, supply chain management is the key to emphasising the connection of collaboration among the stakeholders for effective performance in sharing information and benefits; for example, activity coordination that is related to procurement, production, and transportation. As the supply chain accelerates the speed of information, product, and investment flow while decreasing the working time and value in managing the inventory, the operational result of supply chain management would lead to advantages in the stability over rivals and reduce job repetition [7].

On the other hand, even if the concepts or systems are beneficial, the personnel of the organisation would be the driver and the motivator, which means every principle must be accepted or has employee involvement [8,9]. The people would see the benefits for themselves and the organisation when they follow the concepts; consequently, the operation would be effective. However, if the people disapprove or refuse to participate, the application would find some difficulty to be successful and the quality of jobs would not be as expected [9]. To conclude, employee involvement and the appropriate operating system of the organisation share critical roles in the success of the application or systems and quality of the work [10,11].

In compliance with the aforementioned, this has become the background of this study to find the relationship of supply chain management, employee involvement, and employee work performance in Thailand's auto parts industry and to analyse the structural equation modeling (SEM) of the three latent variables to describe how employee work performance would lead to an efficient operation.

1.1 Objectives

To study and analyse the SEM of supply chain management, employee involvement, and employee work performance in Thailand's auto parts industry.

1.2 Research scope

The scope of the study on the SEM of supply chain management, employee involvement, and employee work performance in Thailand's auto parts industry would comprise the concepts, theories, and related research as shown in Figure 1.

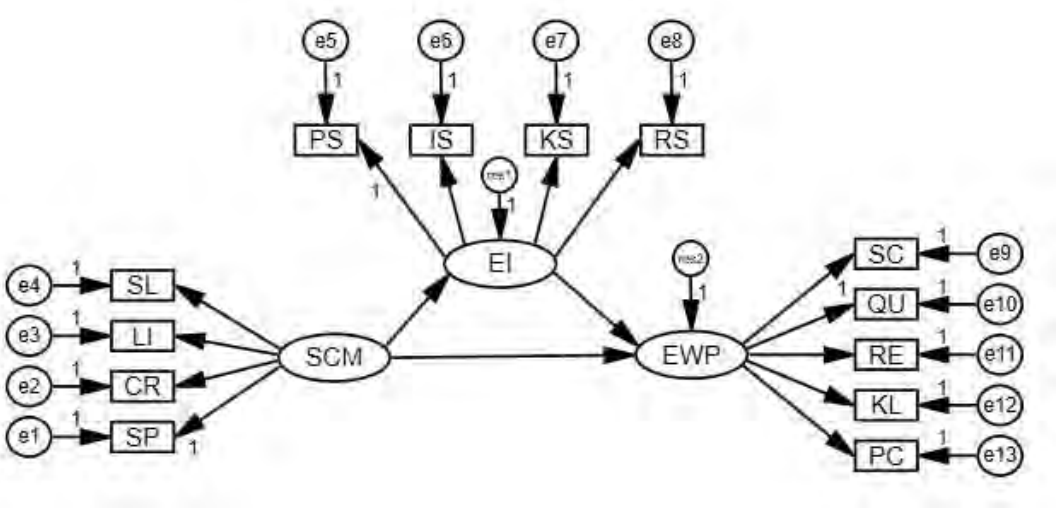

Figure 1 Scope of the research

Hypotheses:

Hypothesis 1: Supply chain management directly affects employee work performance.

Hypothesis 2: Supply chain management directly affects employee involvement.

Hypothesis 3: Employee involvement directly affects employee work performance.

Hypothesis 4: Supply chain management indirectly affects employee work performance and employee involvement.

1.3 Theories and literature review

The Situation of Thailand's Auto Parts Industry

Automotive manufacturing is a major industry that has increased the economic value to Thailand with the proportion of the domestic product value in the production industry being 10%, resulting in the direct employment of over 500,000 skilled human resources [2]. Furthermore, the country was placed as the top leading automotive manufacturer of ASEAN and ranked fifteenth in the world in 2011. Additionally, this has become an interesting regional manufacturing base of automobiles and auto parts. In 2017, Thailand's export value of automobiles and auto parts amounted to USD 2,361.92 million, an increase of 12.35% (%YoY) compared with the same quarter of the previous year. In terms of domestic investment, the country is regarded as the center of the global automotive manufacturers and as the top manufacturing base of pickup vehicles and motorcycles of the world. As for the exports of Thailand in 2020, the value of automobile exports was ranked the second top, second to jewelry and accessories,

with the export value amounting to THB 216,357.7 million approximately USD 7,091,37 million [1].

1.4 Concept of supply chain management

Supply chain means the business process that stresses the collaboration of partnership in product and service production and distribution. This starts from the origin upstream, raw materials to transport, inventory, delivery, and customers downstream with efficiency and effectiveness in the cost and delivery duration.

Supply chain management has also continuously evolved. The heart is to emphasise the product and service delivery to the customers with rapidity, accuracy, and appropriate cost. To succeed, supply chain management depends on the collaboration of all units from upstream to downstream. What connects these elements in the supply chain, which is regarded as the success factor, is good business relations. Thus, this results in reliability that guides the business alliance; therefore, the internal process goes smoothly; specifically supply chain management concerns the long-term operating result of a business that would produce benefits for all. Moreover, this would sustain the supply chain rather than focus on a short-term goal [12]. Supply chain management consists of 1. strategic supplier partnership, 2. level of information sharing, 3, customer relationship, and 4 service level. These are detailed as follows:

1.4.1 Strategic supplier partnership

Strategic supplier partnership is to make a plan in the *supply chain operations reference* (SCOR) model. This is the primary step to balance resources in the organisation as demanded. Planning, communication and connection, and strategic supplier partnership would make the objective of the operators, who are entrepreneurs and distributors, achieve the same goal. Moreover, these processes: return, source, make, and delivery; rules and regulations in business management; supply chain performance measurement; data collection; inventory level; transport; structural planning, and demand would become more efficient.

Table 1 Theories and literature review for supply chain management

Author (Year)	Four Criteria of Supply Chain Management			
	Strategic Supplier Partnership	Customer Relationship	Level of Information Sharing	Service Level
Sriprasert (2007) [25]	✓	✓	✓	✓
Ding et al., (2018) [24]	✓	✓	✓	✓
Zhu et al., (2018) [26]	✓	✓	✓	✓
Boiko et al., (2019) [23]	✓	✓	✓	✓
Gong et al., (2019) [5]	✓	✓	✓	✓
Hong et al., (2019) [4]	✓	✓	✓	✓
Jia et al., (2020) [6]	✓	✓	✓	✓

1. **Level of information sharing** is one of the SCOR model's steps relating to the procurement, delivery scheduling, receiving, inspection, product transportation, and payment approval for the raw material suppliers. Information sharing with partners would result in better process accuracy and to examine other details; such as, rules and regulations in terms of business, capacity evaluation of raw material suppliers, information confidentiality, management of inventory, assets, new products, raw material supplier connection, demands for imports and exports, and agreement of raw material suppliers.
2. **Service level** is one of the SCOR model's aspects relating to the production process (Make), which involves storage, made-to-order, and inventory management. The service level means to construct a measurement to respond to the customers' demand. This affects the production schedule, product design, production and testing, packaging, storage, and product approval for delivery; all are set by the customers. In addition, this includes the management of the factory's rules and regulations, productivity, information of production, work-in-process products, tools and facilities in transport, production network, and the consistency of the rules and regulations in production.
3. **Customer relationship** is one of the SCOR model's steps that is related to delivery and return. It includes product delivery in advance, made-to-order, customer's claiming management process, transport route management, vehicle selection: size selection, lowest cost, rules of receiving; for example, delivery capacity, information flow, inventory management, capital

assets, transport, product cycle, demand for imports and exports, product errors, or return problems. Customer relationship, therefore, takes an important role because it means to satisfy customers to operate the business.

1.4.2 Employee involvement

Employee involvement means the employees of the organisation obtain the authority to control their job under responsibility [11,13] and for the quality management system, employee engagement must be supported. Employees of every level participate in the decision-making depending on the scope of their work, and they can voice an opinion for the design or suggestion of the work they are responsible for [10,14]. The stimulation for employee engagement and the quality management system directly affect the increase of the organisation's performance [11]. job satisfaction, and organisation's satisfaction [15].

The past compression of employee involvement was to allow employees engage in the decision-making for the operation and their roles were reserved for the high levels. Later, this concept was broadened, and the definition included the employees of all levels to take part in setting the goal, solving problems, and giving information. The organisation must stimulate them to have this behavior by offering the opportunity for them to join in the activities. Employee involvement also benefits the development of the organisation and personnel [15,16]. as follows:

Benefits for the organisation's development:

1. To clarify the ambiguous issues because it means to brainstorm ideas from the related people.
2. As a pathway to brainstorm for creativity that could be adapted in the organisation's operation.
3. To prevent potential problems and conflicts that might occur.
4. The organisation would make a more all-inclusive plan due to the variety of attitudes toward the operation or systems thinking.

Benefits for employees' development:

1. To expand new knowledge of the executives by listening to experienced people.
2. To encourage collaboration between the executives and the employees. Sometimes, the executives might be the advisor or supporter. This would be regarded as exchanging experiences.
3. The employees perceive their existence, as they can engage with the issues operated by the organisation.
4. The employees have determination in their jobs because they engage in the decision-making process.

After the literature review of engagement support toward the application of a quality management system, it was found that employee involvement consisted of the following four aspects: 1. power-sharing, 2. information sharing, 3. knowledge sharing, and 4. reward sharing. The description of every aspect is as follows:

Table 2 Theories and literature review for employee involvement

Author (Year)	Four Criteria for Employee Involvement			
	Power Sharing	Information Sharing	Knowledge Sharing	Reward Sharing
Maciariello et al., (1989) [27]	✓	✓	✓	✓
Wilkinson et al., (1998) [28]	✓	✓	✓	✓
Sun et al., (2000) [13]	✓	✓	✓	✓
Taylor and Wright (2003) [15]	✓	✓	✓	✓
Kaynak (2003) [29]	✓	✓	✓	✓
Lin (2006) [30]	✓	✓	✓	✓
Maurer et al., (2008) [31]	✓	✓	✓	✓
Cheung and To (2010) [10]	✓	✓	✓	✓
Lee et al., (2016) [8]	✓	✓	✓	✓
Lei et al. (2018) [9]	✓	✓	✓	✓
Pitafi et al. (2018) [32]	✓	✓	✓	✓

1. **Power sharing** defines employee engagement in the decision-making for the organisation that influences the improvement of their performance and the improvement of organisational performance.
2. **Information sharing** refers to the access to essential information of the organisation for employees' performance development and unit development, including transferring the information to their teams and the authorised people to efficiently make a

decision; for example, data relating to their performance, competitive condition, and new ideas of technology that could develop their performance and the organisation's products and services.

3. **Knowledge Sharing** defines the employee involvement in skills development and knowledge enhancement; for instance, to present the topic they want to be trained or to open the chance for them to exchange knowledge with internal and external units for dimensional learning and flexibility because the organisation must depend on the diversity of the employees' skills.
4. **Reward Sharing** means that the employees receive rewards from their performance with appropriateness and fairness. The rewards include intrinsic rewards with a mental effect; for instance, rewards for the success of work and for praising, and extrinsic rewards as many forms of returns; such as, income, bonus, promotion, good welfare, and honest performance evaluation.

1.4.3 Employee work performance

Work performance with efficiency and effectiveness is what the organisation expects from all employees, specifically the effectiveness relating to better output or equivalent to the goal set by the organisation. If considering the capability of employees' performance in accordance with the objective, this would indicate how much the job description affects the result. The efficiency of work performance infers the activities that the employees participate in the transformation process. Additionally, input means resources used in the operation; namely, raw materials, machines, human resources, management process, and capital cost, to receive the output which could be a product or a service, for the highest benefit of the organisation. The evaluation of the employee's work performance is to review the relationship between performance and the organisation's output in comparison with its standard criteria or the working goal. This is a means to realise the working level of employees and to improve the working process that follows the policy of the organisation [17]. however, apart from the evaluation of employee's performance by regarding the efficiency, there are appraisals in other dimensions. According to the related studies, performance output means the result from the behavior of the employees in the organisation, which indicates the relationship between competency and personnel efficiency. The performance appraisal is to assess under the standard criteria for the personnel's efficient performance and the achievement of the organisation's goal. With regard to the authors, they have explained the related concepts of efficiency in performance into five aspects that are success, quality, responsibility, knowledge, and process.

Table 3 Theories and literature review for employee work performance

Author (Year)	Five Criteria of Employee Work Performance				
	Success	Quality	Responsibility	Knowledge	Process
Porter and Lawler (1985) [17]	✓	✓	✓	✓	✓
Steers (1977) [33]	✓	✓	✓	✓	✓
Tuomi et al., (2005) [34]	✓	✓	✓	✓	✓
Pitafi et al. (2018) [32]	✓	✓	✓	✓	✓
Sujatha and Krishnaveni (2018) [35]	✓	✓	✓	✓	✓
Kloutsiniotis and Mihail (2019) [36]	✓	✓	✓	✓	✓
Stollberger et al., (2019) [37]	✓	✓	✓	✓	✓
Peiró et al., (2020) [38]	✓	✓	✓	✓	✓

2 Methodology

2.1 Population and sample selection

The population in this research comprised employees from 227 factories in the auto parts industry of Thailand. Most worked in the Eastern Industrial Estate and Bangkok and the surrounding vicinity. The research selected the formula of to specify the number of the samples, which was 383 people, using non-probability sampling. [18]. The sample group was categorised by the location of the factories in each province (Table 4) using convenience sampling to collect data by using a questionnaire.

Table 4 Number of the sample population categorised by the location of the industrial estate

Area (Province)	Number (Company)	Number (Participants)
1. Bangkok	17	29
2. Pathum Thani	4	7
3. Samut Prakan	33	56
4. Chachoengsao	31	52
5. Chon Buri	128	215
6. Rayong	14	24
Total	227	383

Source: [2].

Variables

According to the literature review, the authors could summarise two independent variables: supply chain management and employee involvement, and one dependent variable: employee work performance. These could be regarded as latent variables and observed variables (Table 5).

Table 5 Variables for the initial model

Latent Variable	Observed Variable
Supply Chain Management (SCM)	Strategic supplier partnership (SP), customer relationship (CR), level of information sharing (LI), and service level (SL).
Employee Involvement (EI)	Power sharing (PS), information sharing (IS), knowledge sharing (KS), and reward sharing (RS).
Employee Work Performance (EWP)	Success (SC), quality (QU), responsibility (RE), knowledge (KL), and process (PC).

The methodology began by studying the basic data from the primary data source in order to design the research scope and create the initial model before collecting data from the sample group with the questionnaire. The questionnaire was divided into 4 parts, namely, general characteristics of the sample, Supply Chain Management (SCM), Employee Involvement (EI), and Employee Work Performance (EWP). An analysis was processed by these computer programs: SPSS and AMOS. The statistics applied in this research were descriptive statistics to describe the data and the characteristics of the key informants by the mean and percentage. The results were displayed in tables. As for the inferential statistics, SEM for testing the hypotheses was used and searched for the relationship from the model of supply chain management, employee involvement, and employee work performance of Thailand's auto parts industry. In the initial stage, the relationship model of the variables was planned and indicated the variable path based on the literature review before analysing the data from the survey following the initial model; and considering the statistics, if the model of the empirical data conformed to the model of the literature review or not (Hair et al., 2010).

The model fit was evaluated in order to examine the goodness of fit measures between the casual model of the literature review and the empirical model of the data survey. The results are shown in Table 6.

Table 6 Statistics recommended value for the model fit

Index (Goodness of Fit Measures)	Description	Recommended Value	References
p (χ^2) (CMIN)	Chi-square	ns. (p > .05)	[39]
χ^2-test statistics/df (CMIN/DF)	Relative Chi-square	≤ 3.00	[40]
GFI	Goodness of fit index	≥ .90	[40,41]
AGFI	Adjusted goodness of fit index	≥ 0.9	[40,42]
CFI	Comparative fit index	≥ 0.9	[42,43]
NFI	Normed fit index	≥ .90	[39,42,43]
RMSEA	Root mean square error of approximation	≤ 0.08	[40,44,45]

3 Analytical results

3.1 Analysis of the primary statistics of the sample's general characteristics

The results of the personal factor analysis of the sample group in this research, totaling 383 participants, could be divided in detail as follows: (1) Gender: There were more males than females or 55.1% and 44.9%, respectively. (2) Age: Participants aged 25-35 years were the main group or 34.7%, followed by under 25 years, 26-45 years, and over 45 years, or 31.1%, 19.8%, and 14.4%, respectively. (3) Education: Those who graduated with a bachelor's degree or equivalent were the main group (51.2%), followed by high school level and postgraduate degree or, 33.7% and 15.1%, respectively. (4) For working experience (only the duration at the current factory), it was found that most had one-five years' experience or 42.8%, followed by those with five-10 years' experience, less than one year, and over 10 years, or 27.4%, 19.3%, and 10.4%, respectively. (5) Monthly income: the majority of the sample group or 37.9% earned THB 20,001-30,000, followed by THB 15,000-20,000, THB 30,001-40,000, more than THB 40,000, and less than THB 15,000, or 26.9%, 18,0%, 15.7%, and 1.6% respectively. (6) Working unit: Most of the samples (18.8%) worked in the production division, followed by inventory/delivery, research and development, marketing/sales, purchasing/procurement, office, human resource, and accounting/financing, or 12.8%, 12.5%, 11.7%, 11.2%, 11.2%, and 10.4%, respectively (Table 7).

Table 7 Frequency and percentage of general characteristics of the sample group (n=383)

Details	Frequency	Percentage
Gender		
Male	211	55.1
Female	172	44.9
Age (Years)		
Under 25	119	31.1
25-35	133	34.7
36-45	76	19.8
Over 45	55	14.4
Education		
High school level	129	33.7
Bachelor degree or equivalent	196	51.2
Postgraduate degree	58	15.1
Working Experience (only the duration at the current factory) (Years)		
Less than one	74	19.3
One to five	164	42.8
From five to 10	105	27.4
More than 10	40	10.4
Monthly Income (Baht)		
Less than 15,000	6	1.6
15,000-20,000	103	26.9
20,001-30,000	145	37.9
30,001-40,000	69	18.0
More than THB 40,000	60	15.7
Working Unit		
Marketing/Sales	45	11.7
Accounting/Financing	40	10.4
Purchasing/Procurement	43	11.2
Office	43	11.2
Human Resource	43	11.2
Research and Development	48	12.5
Production	72	18.8
Inventory/Transport	49	12.8
Total	383	100.0

3.2 *Reliability analysis of the observed variables and bivariate correlation*

The reliability test of the questionnaire in this study used the Cronbach's Alpha method [19]. The result of 383 questionnaires showed the reliability at 0.96, which meant that the credibility of the questionnaire was at a very good level. As for the question analysis of the observed variables used to measure every latent variable, it was found that the result passed the recommended value because the corrected item-total correlation was 0.2-0.8 [20]. and the Cronbach's Alpha's value was over 0.7. In consequence, the data could be applied in the survey, and the result could be exerted in the next analysis.

The relationship analysis of the observed variables regarding multicollinearity found that the relationship value of every pair variable was 0.450-0.700, which was lower than 0.750 [21]. In conclusion, the variables used in the analysis had the relationship value not over the recommendation.

3.3 *The confirmation factor analysis of supply chain management*

Supply chain management as the latent variable from the literature review could measure four observed variables: (1) Strategic supplier partnership, (2) customer relationship, (3) level of information sharing, and (4) service level. From the confirmation factor analysis (CFA), there were four observed variables. In conclusion, the analytical result from the data of the sample group conformed to the literature review with significance. The results of the CFA as aforementioned are displayed in Figure 2.

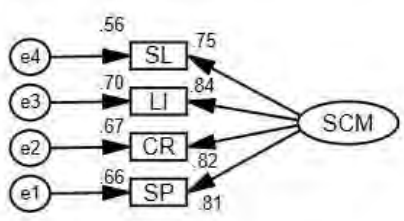

Figure 2 Confirmation factor analysis of supply chain management

The CFA of supply chain management found four observed variables that conformed to the literature review with Variable LI having the highest factor loading at 0.836, while Variable SL had the lowest factor loading at 0.749. The factor loading of all variables had the significance less than 0.001 (Table 8).

Table 8 Statistics showing the relationship consistency of the supply chain management model

Goodness of Fit Measures	Recommended Value	Structural Model (Result)
χ^2 -test statistics/df	≤ 3.00	2.081 (p=0.125)
GFI	≥0.90	.995
AGFI	≥0.90	.973
CFI	≥0.90	.997
NFI	≥0.90	.995
RMSEA	≤ 0.08	.053

To consider the overview of the CFA, it was found that the supply chain management model was p = 0.124 while the structural model (Result) passed the recommended value as shown in Table 8. To conclude, the supply chain management model conformed to the data of the literature review, and it could be used in the next SEM analysis.

3.4 *The confirmation factor analysis of employee involvement*

Employee involvement as a latent variable received from the literature review and applied in the research could measure four observed variables: (1) Power sharing, (2) information sharing, (3) knowledge sharing, and (4) reward sharing. According to the CFA of the survey data, the four observed variables were found. In conclusion, the CFA result conformed to the data of the literature review with significance. The result as aforementioned can be seen in Figure 3.

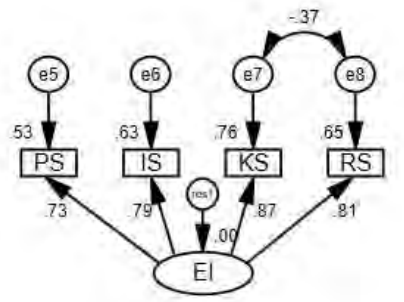

Figure 3 The confirmation factor analysis of employee involvement

According to the CFA of the latent variable, employee involvement, four observed variables were found, and they conformed to the literature review with Variable KS having the highest factor loading at 0.786, while Variable PS had the lowest factor loading at 0.769. The factor loadings of all variables had statistical significance less than 0.001 (Table 9).

Table 9 Statistics showing the relationship consistency of the employee involvement model

Goodness of Fit Measures	Recommended Value	Structural Model (Result)
χ^2 -test statistics/df	≤ 3.00	.716 (p=0.397)
GFI	≥0.90	.999
AGFI	≥0.90	.991
CFI	≥0.90	1.000
NFI	≥0.90	.999
RMSEA	≤ 0.08	.000

When considering the overall CFA result, it was found that employee involvement was p = 0.397, and the structural model (Result) passed the recommended value as shown in Table 9. It could be concluded that the SEM of employee involvement conformed to the literature review, and it could be applied to the next SEM analysis.

3.5 The confirmation factor analysis of employee work performance

Employee work performance as a latent variable received from the literature review and applied in the research could measure five observed variables: (1) Success, (2) quality, (3) responsibility, (4) knowledge, and (5) process. The result as aforementioned can be seen in Figure 4.

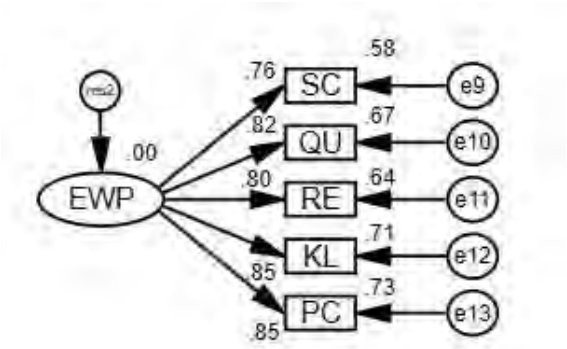

Figure 4 The confirmation factor analysis of employee work performance

Table 10 Statistics showing the relationship consistency of the employee work performance.

Goodness of Fit Measures	Recommended Value	Structural Model (Result)
χ^2 -test statistics/df	≤ 3.00	2.969 (p = 0.018)
GFI	≥0.90	.988
AGFI	≥0.90	.954
CFI	≥0.90	.993
NFI	≥0.90	.990
RMSEA	≤ 0.08	.072

According to the CFA of the latent variable, employee work performance, five observed variables were found, and they conformed to the literature review with Variable QU having the highest factor loading at 0.833, while Variable SC had the lowest factor loading at 0.778. The factor loadings of all variables had statistical significance less than 0.001 (Table 10).

When considering the overall CFA result, it was found that employee work performance was p = 0.018, and the structural model (Result) passed the recommended value (Table 10). It could be concluded that the SEM of employee work performance conformed to the literature review, and it could be applied in the next SEM analysis.

3.6 The structural equation modeling in the full model

The CFA confirmed the ability of the observed variables to be the measurement of the latent variables; in other words, the measurement model. The analysis could conclude the values of the observed variables as aforementioned, while the SEM in the full model was the analysis of the empirical data obtained from the survey. This inferred examining how much data conformed to the literature review. The approach started from the data analysis of the initial model designed by the research scope intending to consider if the statistics completely passed the recommended value or not. If it failed, the model must be improved until it passed. After that, the model obtained from the empirical data would be assessed to examine the consistency and the conformity to the literature review before concluding the SEM following the hypotheses of the research.

3.7 The structural equation modeling under the research scope (initial model)

The SEM regarding the initial model was the analysis of every variable obtained from the literature review and the empirical data according to the research scope. There were three variables: supply chain management, employee involvement, and employee work performance. A total of 13 variables were observed for each latent variable, which could be demonstrated through a linear relationship (Figure 5). In regard to the SEM to find the statistics for testing the initial model under the research scope, it was

found that most values obtained from the SEM analysis of the initial model were unable to pass the recommended values (Table 11). Only CFI, NFI, and RMSEA passed the statistical criteria with modest scores; however, other statistics could not pass. In consequence, the result that the empirical data conformed to the model of the literature review was unable to be concluded. In addition, the values in Figure 5 could not describe the relationship between the variables. As a result, the model had to be improved until it passed the criteria before the discussion of the influence or the relationship of the variables [22].

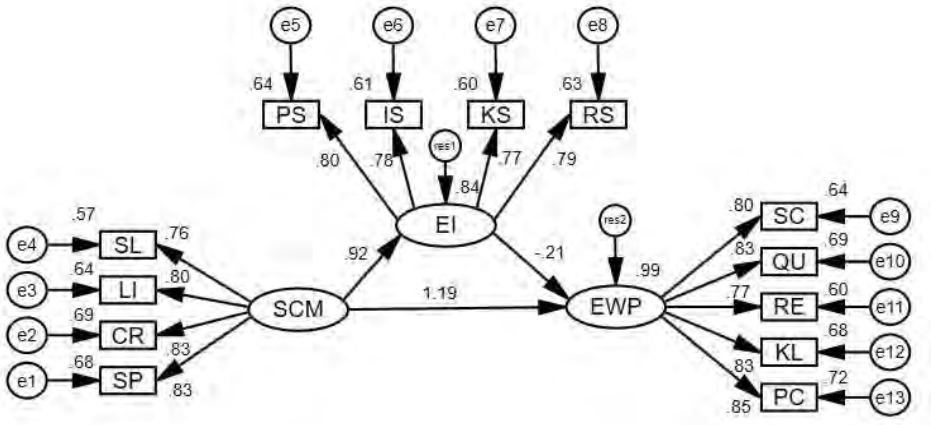

Figure 5 The structural equation modeling analysis under the research scope (initial model)

Table 11 Statistical evaluation of the structural equation modeling under the research scope (initial model)

Goodness of Fit Measures	Recommended Value	Structural Model (Result)
χ^2 -test statistics/df	≤ 3.00	3.366 (p=0.000)
GFI	≥0.90	.923
AGFI	≥0.90	.886
CFI	≥0.90	.962
NFI	≥0.90	.946
RMSEA	≤ 0.08	.079

3.8 The structural equation modeling after improvement (fit model)

The improvement of the structural model from the initial model had been proceeded by data reduction. In other words, the pair of variables that shared the high relationship value and caused the model to be unacceptable were considered. However, data reduction was indispensable to be utilised [22]. The model improvement until passing the recommended values is shown in Figure 6 and Tables 12 and 13, respectively.

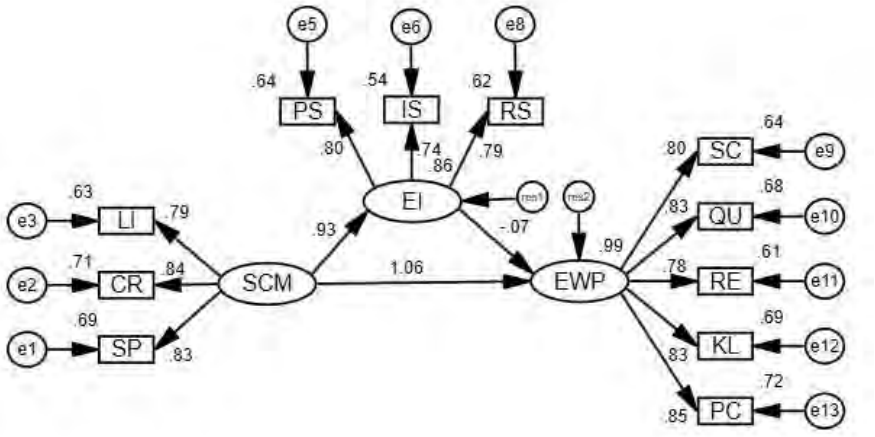

Figure 6 The structural equation modeling after improvement (fit model)

Table 12 The statistical evaluation of the structural equation modeling after improvement (fit model)

Goodness of Fit Measures	Recommended Value	Structural Model (Result)
χ^2 -test statistics/df	≤ 3.00	2.546 (p=0.000)
GFI	≥0.90	.953
AGFI	≥0.90	.924
CFI	≥0.90	.980
NFI	≥0.90	.967
RMSEA	≤ 0.08	.064

Table 13 The structural equation modeling result after improvement (fit model)

Variable	Estimate		Standard Error	Critical Ratio	P
	Influence Coefficient	Standardised Influence Coefficient			
EL <--- SCM	.882	.927	.054	16.251	***
EWP <--- EL	-.073	-.074	.159	-.458	.647
EWP <--- SCM	.997	1.062	.159	6.255	***
SP <--- SCM	1.000	.829			
CR <---SCM	1.003	.844	.049	20.351	***
LI <--- SCM	.841	.791	.046	18.414	***
PS <--- EI	1.000	.800			***
RS <--- EI	.993	.787	.060	16.476	***
QU <--- EWP	1.000	.826			***
RE <--- EWM	.891	.779	.050	17.884	
KL <--- EWP	1.012	.829	.052	19.625	***
PC <--- EWP	1.040	.847	.051	20.311	***
SC <--- EWP	.938	.800	.050	18.597	***
IS <--- EI	.890	.737	.059	15.211	***
$R^2_{EI} = 0.86$, $R^2_{EWP} = 0.99$					

*** Having statistical significance less than 0.001.

From Table 12, according to the consistency validation of the developed models from the literature review and the empirical data, the models passed the recommended values as Chi-Square = 2.546, P = 0.000, GFI = 0.953, AGFI = 0.924, CFI = 0.980, NFI = 0.967, and RMSEA = 0.064. Therefore, it could be concluded that the model obtained from the empirical data conformed to the data of the literature review. The results of the relationship and influence of variables are shown in Table 13 and Figure 6.

Supply Chain Management had three observed variables for measurement: (1) Strategic supplier partnership, (2) customer relationship, and (3) level of information sharing. Their factor loadings were .829, .844, and .791, respectively. According to the study, supply chain management had a positive direct influence on employee involvement with statistical significance with a standardised influence coefficient at .927 and P-value less than 0.001.

Employee Involvement had three observed variables for measurement: (1) Power sharing, (2) information sharing, and (3) reward sharing. Their factor loadings were .800, .737, and .787, respectively. According to the study, employee involvement had no direct influence on employee work performance with statistical significance.

Employee Work Performance had five observed variables for measurement: (1) Success, (2) quality, (3) responsibility, (4) knowledge, and (5) process. Their factor loadings were .800, .826, .779, .829, and .847, respectively.

4 Result of the hypothesis testing

From Table 14, it could be seen that the testing of the hypotheses showed that the study results conformed to two hypotheses.

Table 14 Research hypotheses and result

Research Hypothesis	Result
H_1 Supply chain management directly affects employee work performance.	Direct influence with significance.
H_2 Supply chain management directly affects employee involvement.	Direct influence with significance.
H_3 Employee involvement directly affects employee work performance.	No direct influence with significance.

Research Hypothesis	Result
H_4 Supply chain management indirectly affects employee work performance through employee involvement.	No indirect influence with significance.

4.1 Discussion

According to the supply chain management by the improved SEM analysis, supply chain management as a latent variable had a positive direct influence on employee involvement and employee work performance with statistical significance, while employee involvement had no positive direct influence on employee work performance. In consequence, supply chain management did not indirectly affect employee work performance through employee involvement. It could be interpreted that supply chain management significantly stimulated employee involvement in the organisation to perform any activity with efficiency. Likewise, supply chain management was the key to the organisational operation that directly influenced employee work performance in Thailand's auto parts industry. Nowadays, industrial operations depend on each other rather than stand alone, particularly in the auto parts industry in which the products must be assembled, and the field needs the diversity of knowledge. The collaboration with efficiency in the supply chain that consists of stakeholders from several groups, for instance, suppliers, customers, or internal units, would stimulate the employees to exchange knowledge and understand the problems. Furthermore, this would reduce the use of predictive information because data sharing would make them realise the strengths and weaknesses of the allies in the supply chain. Thus, they could plan to prepare for the incoming problems in advance, and the performance of the employee would be improved. In regard to the study results, this could be discussed following the variables in the SEM as follows:

Strategic supplier partnership is a part of the operation and policy planning to make the objective of the project lead to the same direction. This would result in data exchange in terms of theory, skills, knowledge, and new techniques to develop the organisation and the supplier's competency; this would also increase the competitivity in the market and work success with quality due to the collaboration of the operation and strategic planning. The reason why strategic supplier partnership would elevate the employee's performance is the employees would have unambiguous appropriate guidelines for their jobs. When other partner units in the supply chain have a comprehensible appropriate strategy that conforms to the other organisation in the same chain, the employees would cooperate with efficiency and reliability to each other, as well as use resources together. Furthermore, strategic supplier partnership with the product and service manufacturers for the organisation would correctly respond to the demands and reduce errors; for example, the product does not respond to the demands or the market. If the organisation has a strategic supplier partnership to guide their working process that corresponds with each other, each party would look for the co-market to sell a chain of products and services. In other words, they would have the same direction. If the organisation could sell products, the suppliers could do it, too because the products would be purchased from the supplier to produce the products and services. This would result in an exchange of knowledge and skills that would support the stable growth of the organisation and the supplier. As a consequence, this would lead to long-term collaboration [5,6,23,24].

Customer relationship is an important stage in the service process. The building of customer relationship in accordance with the supply chain management starts from the design of the products and services to the customers' demand, the production, purchasing and delivery to the customers, times and volume of the transport, product imports or exports, product errors or problems of return management or reverse logistics, and planning of the future product and service demand tendency. Customer relationship has a major role because it builds satisfaction to customers. Consequently, the operation that could manage a good relationship with the customers would affect the goal achievement without doing a forecast analysis or prediction of the customers' demands. Therefore, there would be no information confidentiality or informing for the negation, no over-demanded supplied products, and a decrease in errors with efficiency. This would be because the customers do not specifically mean the final consumers, but every unit in the supply chain or every related division. This would also involve the next unit or the closer unit, who could be customers to each other, from both internal or external units. Therefore, to send a job to the next unit would require quality inspection and to accept the return of the products or pieces if they did not match the conditions. This would be to inform the error incident, and the waste in the process would be reduced because every employee would have checked the quality by themselves before sending the product. In addition, managing a good relationship benefits the employee work performance; for instance, the communication or job transfer would become more efficient, have work performance enhancement, good comprehension of the present and future customers, work better or be able to satisfy the customers. In terms of the benefit to the organisation, the costs could be reduced due to the decrease of errors; as a result, the organisation could retain a good long-term relationship with customers, which would lead to good collaboration and profit in the future operation [4,5,23,25,26].

Level of information sharing with the business partners is related to every division; for instance,

purchasing, procurement, raw material transport, delivery scheduling, receiving, inspection, product transfer, and payment approval to the raw material suppliers. Information sharing would increase the accuracy of the operating process and examine the consistency of the related issues. As a result, information sharing with customers is important to the operation of the employee from purchasing and procurement, product monitoring, and delivery because if the employees acknowledge information; for example, the demand, production status, inventory volumes, and future production and operating plan, their work performance would be more efficient and they could coordinate with other units in the same chain well. Furthermore, if sharing information about good management and the operation method, the employees in other units of the supply chain could possibly apply to develop this as their own. In the industry, large automotive manufacturers organise the project to send their personnel to help develop or to be trained with the suppliers' employees. This idea is if the supplier has the quality, they would produce quality products for the company. Moreover, the company would help the supplier to develop the products per its demand. Additionally, information sharing of feedback would be very indispensable in the development of products and services to respond to the demand of the trading partners because they could realise the errors of the products and services rapidly, whether it be the product or service quality, or transport quality under the standardised time scope, this would affect the development of employee work performance and the organisation's stable growth [4,6,24,25].

Nevertheless, regarding the consideration of the SEM after improving the observed variables, service level could not be summarised with statistical significance that it influenced employee work performance. The reason was the service level was the rules or the basic regulations of the co-business. This would be regarded as the practice that all employees of the organisation must follow, and the practice scale must be at the same standard. If each unit in the supply chain regulated a stricter service level, it would be nearly impossible to build a good relationship for the collaboration. Similarly, making supply chain management possible would also be difficult, too. However, if the service level is excessively relaxed, the errors would increase and this would cause more waste or mistakes in the process. For that reason, a suitable service level would mainly affect the success of the supply chain management, and the rules would have to be clear, which every employee would have to respect and follow. In this topic, the service level was unable to demonstrate that it could directly influence employee work performance.

5 Recommendations

This research studied the SEM of supply chain management, employee involvement, and employee work performance in Thailand's auto parts industry. The author presented the results by applying general data analysis, CFA, and SEM. Therefore, the results could be described only under the scope of the research. In conducting future research, qualitative data analysis could be added by collecting in-depth data from an interview or other approaches, where the result might be more detailed. Alternatively, other variables that could affect the automotive and auto parts industries could be further added; for example, a lean production system that could reduce the waste process resulting in a higher efficient working process, and quality of working lift would be the system that could create a balance between the work and private life of the employee for better efficiency, thus resulting in good physical and mental work performance.

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A COMPACT AND PORTABLE DESIGN DEVELOPMENT OF A LOW ROLLING RESISTANCE TEST RIG

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Keywords: low rolling resistance, conveyor system, test rig
Abstract: Low Rolling Resistance (LRR) conveyor systems are generally preferred over traditional conveyors because of better overall efficiency lesser energy consumption required to operate. In this work, the design development and analysis path in the process of downscaling the size of an existent LRR test rig to a compact, portable and desktop-sized model is presented. Simulation has been developed using SolidWorks and finite element analysis is conducted using ANSYS to obtain the deformation, stress and strain of each part of the new design.

1 Introduction

A conveyor's primary function is to provide transport to bulk solids/materials across a vast distance; usually linear in geometry with the exception of inclines and declines, depending on application. In the manufacturing industry, conveyor belts are designed to move products from one point to another or through a chain of assembly. Due to the increase in goods and services, conveyors are becoming an increasing interest for many large-scale industries. These conveyors are most commonly seen in airport baggage claims, mining industries, and escalators [1].

In essence, a conveyor belt is simply an endless strap of flexible material stretched between two drums and supported at intervals by idler rollers. As industries commonly use conveyors to transport bulk materials across a vast distance, it is imperative to ensure the belt cover is regularly monitored for damage as well as reducing the overall cost of operating the system; as with extended usage, the possibility of damage and cost to function increases accordingly. The indentation rolling resistance of conveyor belts is an important design consideration for long belt conveyors and can also be important for heavily loaded belt conveyors [2]. Indentation rolling resistance occurs due to the deformation of the conveyor belt bottom cover as it is squeezed between the carcass and successive idler rolls. The bottom cover is compressed as the belt drives into the roll, and then recovers as the belt travels over the roll compressed due to the viscoelastic (time-dependent) properties of the rubber, an asymmetric pressure distribution forms, resulting in indentation rolling resistance [3]. It is dependent on the properties of the conveyor belt including the carcass and bottom cover as well as properties of the belt conveyor including induced loads, belt speed, and ambient temperature and idler roll diameter [2].

From the previous studies which have been focused on the components of energy loss of trough conveyors, it can be found that the idler indentation rolling resistance can account for approximately 60 % of the total rolling resistance [4,5]. Therefore, reducing the indentation rolling resistance is an effective way to decrease the overall power consumption and the belt tension.

The aim of designing Low Rolling Resistance (LRR) conveyor systems is to reduce the rolling resistance of the conveyor belt; thereby increasing the overall efficiency and decreasing energy consumption required to operate. There are a multitude of reasons as to why LRR conveyors are typically preferred over conventional conveyors. The most salient feature is due to the fact that the belt reduces the rubber hysteresis losses of the running cover compounds. The LRR belt has a modified bottom cover rubber with less hysteresis energy loss, compared to the conventional belt bottom cover rubber.

The design of an LRR conveyor testing rig will be largely influenced by the resources available as conveyors are renowned for their vast lengths in transporting goods and materials. However, the primary objective of this work is to minimize space taken and downscale the existent LRR test rig situated in the University of Newcastle to a compact, portable and desktop-sized model. This report will highlight the development and analysis path undertaken in the construction of the proposed design.

The rest of this paper is organized as follows. In Section 2, key considerations for designing and analyzing of the new test rig design are proposed. Section 3 details the design development and numerical results. Finally, conclusions are presented in Section 4.

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2 Methodology

2.1 Existing test rig

As shown in figure 1, the test facility is classified as a "two pulley test machine" by CEMA (Conveyor Equipment Manufacturers Association) and is designed to accept both fabric and steel cord belts and test over a range of typical operating parameters and conditions.

Figure 1 Rolling resistance test facility [2]

Figure 1 shows the undulating conveyor belt path that is created by the hold-down rolls. These two rolls are equally spaced on either side of the test idler roll and are arranged such that they push the belt down and hence apply a load to the test idler roll. The use of this type of loading method was first proposed by Spaans [6] and is designed to simulate actual belt operating conditions. Primarily the loading mechanism is designed to transfer the load to the test idler roll through the belt carcass in the same manner that the belt and bulk material weight that is suspended between successive idler sets is transferred through the carcass. This loading method also simulates the conveyor belt sag that occurs between idler sets.

Assuming the LRR testing machine will be working under industrial atmospheres with moderate sulphur dioxide pollution in a coastal area with low salinity, corrosivity protection for a C3 environment is adequate which cathodic protection, galvanizing and painting are able to provide.

2.2 Material selection and corrosivity protection

This section provides comparison and justification for of the materials selected to construct the components of the LRR testing machine. Decision matrices have been utilized to justify the material selection for these components. Selection of the material to be used for the structural supports requires consideration for mechanical properties including strength, as well as cost, machinability and size availability. For this purpose, according to materials listed in Table 1, a decision matrix was generated in Table 2.

From the decision matrix, it was found that the most suitable material for the structural supports is 300 XLERPLATE due to its cost, ease of manufacturing and strength.

Although structural steel has exceptional physical and mechanical characteristics, due to its nature, it tends to react with oxygen and water present in the air to form a more stable compound called ferrous oxide, this natural reaction process is called corrosion or oxidation of the metal, and for this reason, protection from this corrosion is an important factor in the design of the system. Metal corrosion can be managed, slowed or even stopped by using the proper techniques. As shown in Table 3, the corrosivity of certain atmospheres has been classified and standardized into 5 levels by the International Organization for Standardization (ISO), in order of increasing corrosivity. It is important to know the corrosivity level of the environment before doing any corrosion protection to find a correct and suitable anti-corrosion solution.

Table 1 Considered materials for structural support [7]

Material	Description	Typical Uses
G450	Cold-rolled, high strength, low alloy steel	Roll-formed sections for structural applications
CM350-G	High strength structural steel plate	Structural sections
300 XLPERPLATE	High strength structural steel plate	Structural members and general fabrication
350 XLERPLATE	Cold-rolled, high strength, low alloy steel	Structural members and general fabrication

Table 2 Decision matrix for structural material selection

Properties		Mechanical Strength	Cost	Ease of Manufacturing	Corrosion Resistance	Total
Weighting coefficient		X3	X3	X3	X2	
Material	G450	5	2	3	4	38
	CM350-G	4	2	3	4	35
	300 XLPERPLATE	3	5	4	2	40
	350 XLERPLATE	4	3	4	2	37

Assuming the LRR testing machine will be working under industrial atmospheres with moderate sulphur dioxide pollution in a coastal area with low salinity, corrosivity protection for a C3 environment is adequate, which cathodic protection, galvanizing and painting are able to provide.

The cathodic protection can provide strong corrosion resistance to the protected metal, as its applications are specially designed for C5M marine usage. However, this also comes with higher cost of installation by fully trained personnel, constant maintenance and the necessity for an external power source which comes with extra electrical costs. Because of this, cathodic protection will not be considered as a corrosion protection option.

Table 3 Atmospheric corrosivity categories and examples of typical environments [8]

Corrosivity category	Low- carbon steel Thickness loss (μm)	Exterior	Interior
Cl (very low)	$t_l < 1.3$	-	Heated buildings with clean atmospheres, e.g. offices, shops, schools, hotels
C2 (low)	$1.3 < t_l < 25$	Atmospheres with low level of pollution: mostly rural areas	Unheated buildings where condensation can occur, e.g. depots, sports halls
C3 (medium)	$25 < t_l < 50$	Urban and industrial atmospheres, moderate sulphur dioxide pollution; coastal area with low salinity	Production rooms with high humidity and some air pollution, e.g. food processing plants, laundries, breweries, dairies
C4 (high)	$50 < t_l < 80$	Industrial areas and coastal areas with moderate salinity	Chemical plants, swimming pools, coastal ship and boatyards
C5I (Industrial very high)	$80 < t_l < 200$	Industrial areas with high humidity and aggressive atmosphere and coastal areas with high salinity	Buildings or areas with almost permanent condensation and high pollution
C5M (Marine extreme)	$200 < t_l < 700$	Offshore areas with high salinity and industrial areas with extreme humidity and aggressive atmosphere and sub-tropical and tropical atmospheres	Industrial areas with extreme humidity and aggressive atmosphere

Galvanization has relatively strong corrosion protection with much lower cost and maintenance requirements compared to the cathodic protection. However, certain coating techniques and equipment is required for this which can be achieved in two ways, hot dipping and thermal spraying. The hot dipping method is needed to be done in the factory, which is inconvenient for onsite installation. To complete onsite the thermal spray method should be used, however this requires specific equipment and technicians. For these reasons, galvanization will also not be considered.

Painting is a widely used corrosion protection method for medium to low corrosivity environments due to its ease of application and maintenance, and much lower cost compared to the other two methods. Painting requires little to no technical expertise whilst still being able to provide the benefits of a corrosion protection coating. Furthermore, touch-up painting can be included as part of the regular maintenance schedule to continually fix abrasions in the coating, something that is not as simple with the other methods. Because of this, it can be concluded that the anti-corrosion solution for the system should be painting which is suitable to cover corrosivity level of C3 with minimum cost and maintenance requirements.

2.3 Relevant standards

To ensure the quality of the system, all work must be in accordance with relevant Australian Standards and professional expectations. Table 4 below lists key standards when contemplating a design for any type of conveyor. These standards ensure products, services and systems are safe, reliable and consistently perform as intended; without them, operational and safety requirements will not be met from the table below, it can be seen that AS, NZS and DIN standards are used throughout.

Table 4 List of Australian Standards pertaining to conveyor belts [9]

Standard Number	Standard
AS 1755-2000	Conveyors Safety Requirements
AS 1334. 13:2017	Methods of testing conveyor and elevator belting, determination of indentation rolling resistance of conveyor belting.
AS/NZS 4024.3610:2015	Safety of machinery Conveyors – General requirements
AS 4035-1992 (R016)	Conveyor and elevator belting - Glossary of terms
AS 4024.3610	Safety of Machinery Conveyors: General Requirements
AS 4024.3611	Conveyors: Belt conveyors for bulk materials handling
AS 4100	Steel Structures
AS 3990-1996 (R2016)	Mechanical Equipment
DIN 22101	Continuous conveyors - Belt conveyors for loose bulk materials

2.4 Supporting structural

The design of the supporting structure must be capable of supporting the testing assembly during operation with the combined weight of itself, the idlers, the belt and the LRR testing frames. The structural design consists of a simple box frame of universal columns and beams. The loading on the sections must be analyzed using AS 4100-1998 and other methodologies such as ANSYS modelling to ensure that the load of the fully tensioned belt can be supported through each beam and footing. Torsional and stiffness analysis of the structure will indicate if cross members and stiffeners are required.

2.5 Installation

The planned LRR replacement or upgrade is to be placed indoors for a table top size testing machine. This presents a challenge, as the area size and accessibility were unknown, and restricted access for large machinery is a likely problem. The proximity of the surrounding will restrict to the height and footprint of the design. Therefore, a design that can be constructed on site is preferable to remove most of the issues that would be encountered with the unknown destination. A design is also needed to take into consideration of safety as the testing machine will need to be surrounded by a safety guard.

3 Results and Discussion

In order to obtain the best possible design for the LRR testing machine, a concept development process was undertaken. In this process, components including the tensioning method, frame size weight and the roller size and design were considered. Influence on the designs were taken from Australian Standards. The final design incorporated as many positive aspects that are reasonably possible when maintainability, constructability, practicality and safety are considered. Further justification of the designs is achieved through FEA.

Note that, the existing machine utilizes two 1000 mm diameter pulleys and accepts pre-spliced endless belt samples 29 m in length and up to 600 mm wide, with 400 mm wide belts preferable to simulate higher loading per unit width of belt. The maximum load that can be applied to the test idler roll is 800 kg which allows a maximum belt load of 19.6 kN/m for a 400 mm wide belt [2].

3.1 First concept

The first concept was that developed by an existing machine which is approximately 13m long and 100T in weight. With large 1m rollers and the measurement frame being approximately 2 m × 1 m × 1.25 m a large reduction in size is needed. A Model has been developed using SolidWorks 2017 (see Figure 2) and FEA was conducted using ANSYS Workbench 18.2 to analyses the deformation, stress and strain of each part of the LRR machine. This model was designed with the supporting structure made from structural steel that can be easily acquired from most metal distributors as they are common sizes making access to materials much easier. The testing was completed under the assumption that the force acting upon the structure was under a static load.

The stress and strain distribution are obtained through the structural analysis to check different parts and find out which one needs to be modified. It has shown that the LRR testing machine is more than capable of withstanding the forces acting upon it from the tension of the belt with a maximum Von-Mises stress of 86.6 MPa (see Figure 3(b)), a maximum Von-Mises strain 0.0004 (see figure 3(e)) and a maximum deformation of 0.00048 m. Therefor the material used in construction is well within a high factor of safety for its use.

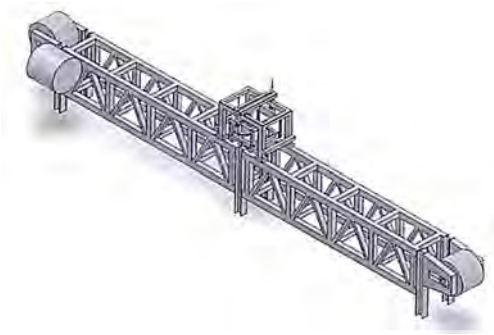

Figure 2 Initial concept of LRR testing machine

The construction of the LRR testing machine is of segmented design with 6 main U beams bolted into the floor where the 2 large 6 m supporting structures are connected. Once the supporting structure is connected the two large 1 m rollers and outer and inner measuring frame are connected and indentation roller can then be attached. All sections are bolted together making transportation easier. However, as the total machine is extremely heavy a crane is needed to place the parts in place for construction of the testing rig.

The within the connection between the inner and outer frames for the measurement roller consists of two main threaded rods which can be adjusted to raise or lower the measurement roller changing the pressure upon the belt itself. This pressure is measure using a knife edge support between the inner supporting frame and the measurement roller. This knife edge is 60 degrees to 30 degrees match giving the roller a movement of 15 degrees in each direction making the friction force negligible. A torque sensor is connected to the end of the of the measurement rollers section of the knife edge connection reading the force applied to the roller under operation. There are both horizontal and vertical load cells attached between the inner and outer measurement frames to measure the force applied to both the belt and measurement roller for precise calibration and result collection.

Variable hold down rollers are attached at either side of the measuring rollers position. The use of these hold down rollers is to level the belt coming into the measurement system as well as applying a variable load depending on the position of these rollers. There is a similar adjustment method used for the outer rollers, where the large 1 m diameter rollers are connected to a bearing attached to a block and then a threaded rod which can be adjusted to tension the belt or so that different sized belts can be used.

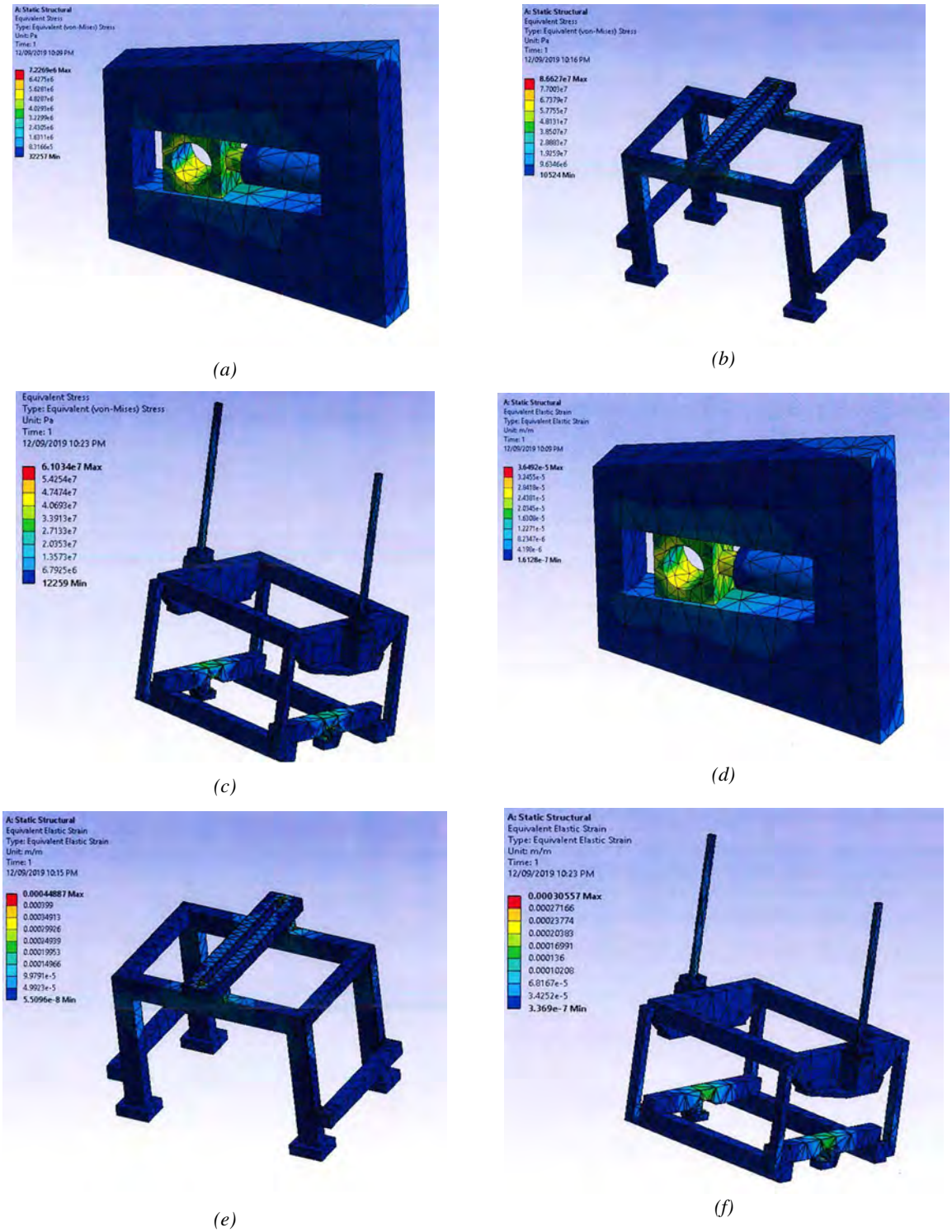

Figure 3 first design: (a) Tensioner stress (b) Outer measuring frame stress (c) Inner measuring frame stress (d) Tensioner strain (e) Outer measuring frame strain (f) Inner measuring frame strain

The LRR testing machine over all is a very well designed for its use of testing belts of different sizes under different conditions. Because of this downscaling the machine will be easy as nothing needs to be changed, however, a few adjustments may be implemented. Replacing the knife edge system with a torque rod sensor as well as putting sliding rails on the top of the supporting frame to move the variable hold down rollers, as the current system is moved by unbolting moving and re bolting the rollers. Finally having the motor and its roller fixed in place

at one end and having the opposing end be the only one to have a tensioner assembly to decrease parts and increase stability of the machine.

3.2 Second concept

The second concept is almost the exact same as the first concept as the first concept has all the functionality needed to complete the task but it has been reduced in size considerably (see Figure 4).

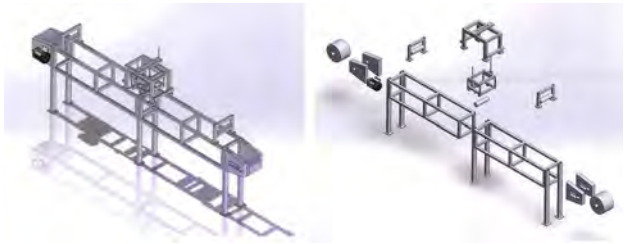

Figure 4 Final design of LRR testing machine

Table 5 Pulley specifications

Parameter	
Minimum pulley diameter	108 mm
Pulley face width	200 mm
Clearance for the pulley face to belt edge	25 mm
Shell thickness	17.9 mm
Shaft diameter	90 mm

For this design the improvements have been made from the initial design. The first improvement was that of the variable hold down rollers are more mobile with a runner system, the tensioning method is that where the motor pulley is fixed at one end and the opposing side has a screw tensioner that can be adjusted to the correct tension, the supporting frame has been simplified as its previous design was over engineered for its application and finally the pulleys were mathematically analyzed to determine their design. Pulley parameters are listed in Table 5 based on the calculations presented below. Figure 5 specified pulley design parameters.

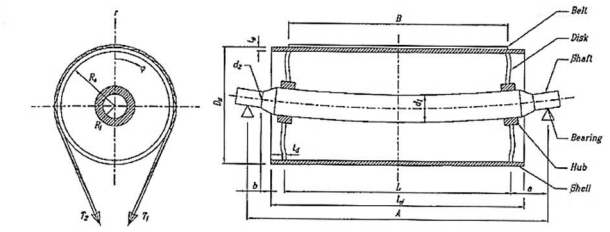

Figure 5 Pulley design parameters used in the LRR testing machine

In order to determine the minimum diameter (D_s) for a pulley the following equations is used:

$$D_s = t_{cs} C_{cs} \quad (1)$$

Where t_{cs} is the belt carcass thickness in mm which for the given belt is 4.6 mm and C_{cs} is a factor dependent on the carcass material which for the given belt is 108. Therefore, the minimum diameter for the drive and head pulley should be no less than 300 mm. The minimum pulley face width is dependent on the belt width, with the other appropriate dimensions. As the maximum belt width is 150 mm the face width needs to be 200 mm, the clearance for the pulley face to belt edge should be 25 mm. The locking elements, bearings and plumber blocks are off-the-shelf products which are manufactured in standard sizes and for certain limitations, hence, the design of the pulleys and shafts will take this into consideration. To determine the shell thickness two checks must first be made. The first is a stress check which is done using the following equation:

$$t_{s1} = \sqrt{\frac{0.127\, k_s\, p_1 D_s}{F_r}} \quad (2)$$

$$p_1 = \frac{T_{max}}{B} \quad (3)$$

Where k_s is a safety coefficient which is assumed to be 1.2, T_{max} is calculated to be the carrier side tension for an overloaded belt equal to 58.4 kN and B is the belt width of 150 mm, D_s is the pulley diameter previously calculated and F_r is endurance limit of the shell material equal to 55 MPa for 250 Grade carbon steel. Therefore, the thickness for the drive and head pulley should be 17.9 mm. The second check is a buckling check. This is given by:

$$t_{s2} = \sqrt[3]{\frac{(1-\nu^2) p_2 D_s^3}{2E}} \quad (4)$$

$$p_1 = \frac{2\, T_{max}}{D_s\, B} \quad (5)$$

Where ν is Poisson's ratio which is 0.3 for steel, E is Young's modulus which is 210 GPa for steel. This gives a drive and head pulley thickness of 5.33 mm. The greater of these two thicknesses is to be selected. Therefore, the wall thickness of the drive and head pulley is equal to 17.9 mm and should therefore be no less than 18 mm when constructed. To determine the shaft diameter, torque and bending moment need to be first calculated. Torque is calculated using:

$$T_q = T_e \frac{D_s}{2} 10^{-3} \quad (6)$$

Where T_e is the effective tension in N which is equal to 58.4 kN for the overloaded case. Torque will be equal to 8.76 kNm. Bending moment is calculated by:

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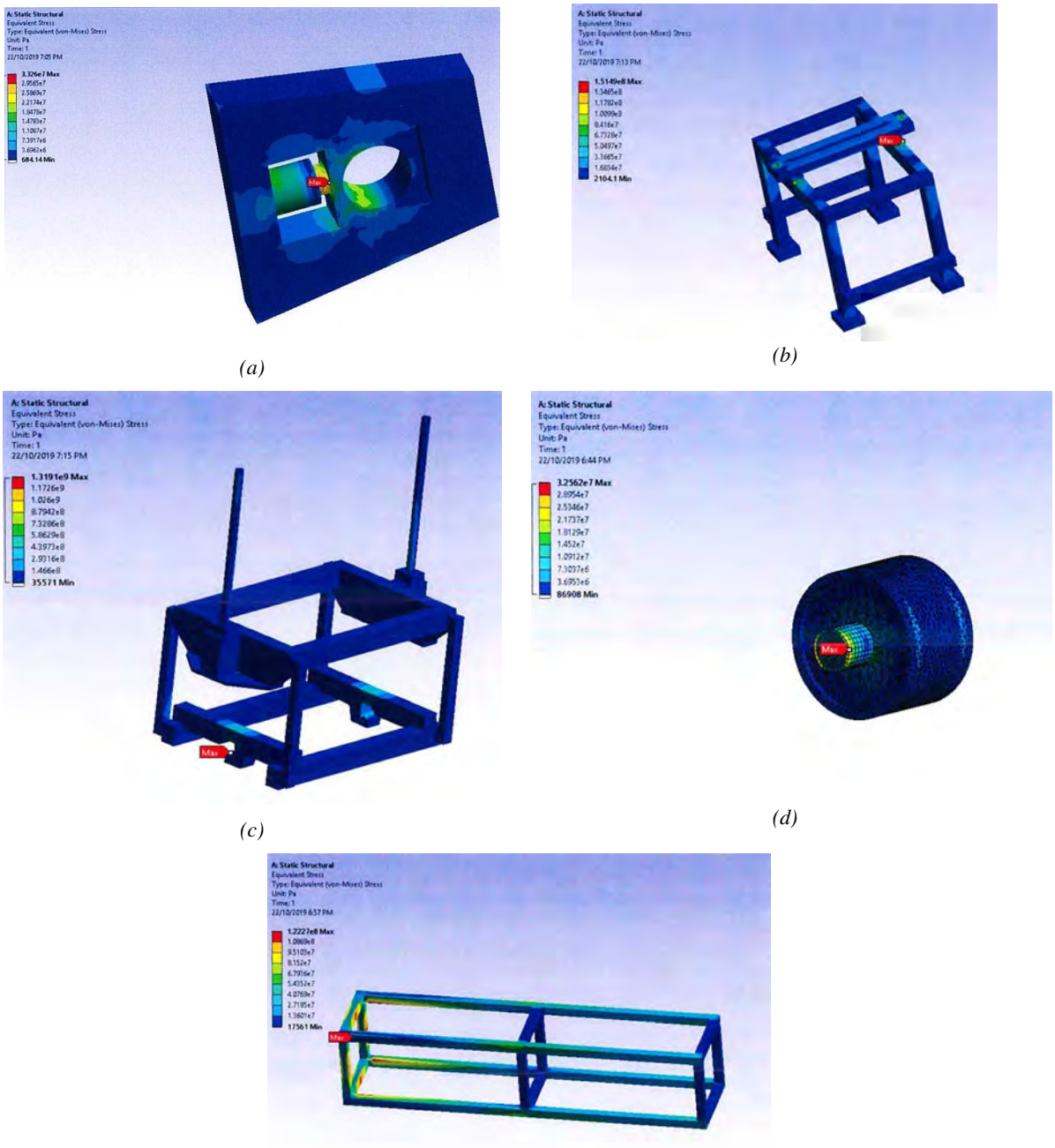
$$M_b = \left(\frac{T_{max}}{2}\right)\frac{(A-l)}{2} \quad (7)$$

Where T_{max} is the pulley total load, A is the distance between bearing centres which is equal to 0.28 m and l is the distance between disc plates which is equal to 0.175 m. Therefore, bending moment is 1.53 kNm. Finally, to determine the diameter the following equation is used:

$$d_s = \left[\frac{10^4 K_s K}{F_r}\sqrt{M_b^2 + 0.75T_q^2}\right] \quad (8)$$

Where K is a stress rising factor which for this given situation is 3, F_r is the endurance limit of the shaft material which is 630 MPa for 1060 steel and K_s is a size factor which for the expected shaft diameter is 1.71. Therefore, a shaft diameter of 90 mm is to be used.



(a) *(b)* *(c)* *(d)* *(e)*

Figure 6 final design stress distribution: (a) Tensioner (b) Outer measuring frame (c) Inner measuring frame (d) pulley (e) frame

The supporting structure was designed from available sized steel that can be bought from steel wholesalers. For the FEA analysis it was assumed that the machine is under static load while it is being operated. From the 300 XLERPLATE steel being used has a yield strength of 320 MPa and a tensile strength of 430 MPa, it is clearly shown that the final design can withstand the forces acting upon it when under operation. As the maximum stress acting upon on the outer measurement frame being 151.5 MPa (see Figure 6(b)) making the lowest factor of safety being 2.11, a maximum strain of 0.0066 and a maximum deformation 0.0022151 m showing that for the chosen material and design the LRR testing machine will be to standard.

The final design having two main 1.5 m long frame sections with 6 legs that can be segmented so that construction and transport can be completed easily. The new design has two 300 mm diameter pulleys at either end, the motor pulley is fixed which will be attached directly to the outside of the frame with the other side having the tensioner assembly attached. The tensioner assembly is the same as that of the previous design however it has been downsized to accommodate the new roller and belt forces. Variable hold down rollers are attached at either side of the measuring rollers position. The new design has rails for the variable hold down rollers to slide along so that they can be changed easily and accurately. The final LRR testing machine will be able to handle the forces acting upon it from that of the belt while maintaining its long life.

3.3 *Technical specifications and design compliance*

This section details the mechanical analysis process carried out to assess the specifications and performance of the currently existing system operating in Newcastle, and the new downscaled version. It contains the development of critical load cases with which calculations can be carried out to find necessary parameters, such as belt tensions (carry side, return side and effective), drive power, as shown in figure 7, and mass flow rate for various materials.

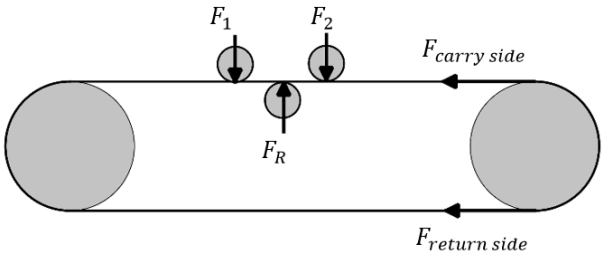


Figure 7 General load case free body diagram

Results are obtained using the following equations from DIN 22101-2011 and proposed in Table 5 with the definition of all parameters:

Carry side tension

$$F_{T1} = \frac{g\left(m'_L + m'_g\right).l_r}{8\,h_{rel}} \tag{9}$$

Where

$$m'_L = \frac{F_{max}}{b} \tag{10}$$

Return side tension

$$\frac{F_{T1}}{F_{T2}} = e^{\mu\phi} \tag{11}$$

Effective tension

$$F_e = F_{T2} - F_{T1} \tag{12}$$

Drive power

$$P = F_e.v \tag{13}$$

Mass flow rate

$$\dot{m}_s = \rho_b.(0.5 \times b^2 \tan(\delta)).v.k_s \tag{14}$$

Knowing these parameters allows the designer to make informed design decisions especially in terms of scaling of the machine. The main advantage of this analysis process is its ease of application to any load case scenario. Any load case can be very simply analyzed, only requiring the altering of key variables such as line load. Utilizing this universal approach is also advantageous in that it allows for easy comparison between any load cases of interest, such as the maximum versus operating parameters, or the original rig's maximums versus that of the downscaled version. As shown in Table 7, two conditions were considered to investigate their performance. The initial analysis considers the "worst-case scenario" loading condition, while the second one is a more reasonable "standard operation" case. Parameters for these cases can be drawn directly from ref [3]. It should be noted that the maximum load capable of being applied by the test rig is determined with respect to both the belt width and belt speed. Iron ore was considered for the mass flow rate calculation due to it having the highest bulk density as shown in Tables 6-8 and Figure 8. Steady-state operating conditions and rigid body belt due to the short belt length are assumed in the calculation process. Moreover, line load resulting from the conveyor is considered to zero.

Physical specifications were downscaled drastically from a machine approximately 100 tonnes in weight and 13 m or more in length (hence requiring extensive supporting infrastructure- and subsequent effort and cost

for installation or moving). The new machine as currently designed will easily fit within a bounding box of approximately 3 m (length) × 2 m (height) × 1.5 m (width).

The existing machine could operate at a maximum belt velocity of 10 m/s (standard operation was approximately 4 m/s), and the new design is intended to be able to match that velocity specification. As far as belt options, the current machine can test belts up to 600 mm in width, as opposed to the new design which can test up to 150 mm.

Table 6 Relevant properties of a selection of familiar bulk solids [10]

Material	Bulk density (tonnes/m*)	Angle of repose	Recommended max angle of inclination	Surcharge angle
Alumina	0.8-1.08	22°	12°	10°
Ammonium chloride	0.72-0.83	-	10°	10°
Ammonium nitrate	0.72	-	23°	25°
Ashes (coal) - dry	0.56-0.64	45°	20°	30°
Ashes (coal) - wet	0.72-0.80	45°	20°	30°
Ashes (coal) - fry	0.5-0.8	42°	220	30°
Barley	0.61	23°	12°	5-10°
Barytes (fine)	1.8-2.0	35°	15°	10°
Bauxite(granular)	1.20-1.36	30°	20°	20°
Cement	1.20-1.36	30°	15-18°	10-20° *
Chalk (fine)	1.0-1.2	42"	25°	25°
Chalk (lumpy)	1.2-1.4	42°	!5°	10°
Clay (dry fine)	1.6-1.9	35°	20"	22°
Coal (bituminous)	0.72-0.88	35°	18°	18°
Coke	0.4-0.5	38°	18°	25°
Copper ore	1.92-2.56	38°	20°	25°
Iron ore	2.08-2.88	35°	18°	20°
Kaolin clay	1	35°	19°	20°
Limestone	1.44-1.52	38°	18°	25°
Phosphate rock (broken dry)	1.2-1.3	28°	14°	10°
Pyrites (lumpy)	2.1-2.3	35°	16°	20°
Sand-dry	1.4-1.60	35°	16°	20°
Sand-foundry	1.3-1.4	-	24°	30°
Soda ash (light)	0.35-0.55	37°	220	25°
Sugar-raw	0.88-1.04	45°	18°	30°
Wheat	0.77	28°	120	10°
Wood chips	0.16-0.48	-	27"	30°

** Surcharge can be 0° if cement is aerated and max. inclination could then be 5-10°)*

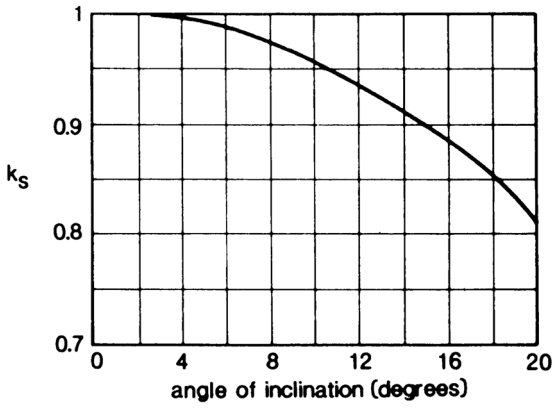


Figure 8 Slope factor k_S, for smooth (unpatterned) belts operating on a gradient [10]

Table 7 Recommended friction coefficients μ for the friction between belts with a rubber cover and pulley surfaces of different finishes [11]

Operating condition	Friction coefficient for pulley surface (μ) *			
	bright metal surface (plain steel pulley)	polyurethane lagging (arrow pattern)	rubber lagging (arrow pattern)	ceramic lagging with pores (arrow pattern)
Dry	0.35-0.4	0.35-0.4	0.4-0.45	0.4-0.45
Wet (clear water)	0.1	0.35	0.35	0.35-0.4
Wet dirty (with mud and clay)	0.05-0.1	0.2	0.25-0.3	0.35

** For conveyor belts with a PVC cover approx. 10 % smaller friction coefficients shall be assumed*

Table 8 Performance comparison

			Existing system		New design	
	Parameter	Definition	Load case 1	Load case 2	Load case 1	Load case 2
Output	F_{T1}	Carry side tension (N)	122600	35600	81700	17800
	F_{T2}	Return side tension (N)	34890	10130	23300	5070
	F_e	Effective tension (N)	87710	25470	58400	12730
	P	Drive power (W)	877100	101880	584000	50920
	$\dot{m}_s$	Mass flow rate (kg/s)	237.456	94.982	33.29	13.32
Input	F_{max}	Maximum load capable of being applied by the test rig (kg)	800	232	200	43.5
	m'_L	Line load resulting from the material conveyed (kg/m)	2000	580	1333.3	290
	b	Belt width(m)	0.4	0.4	0.15	0.15
	v	Belt velocity (m/s)	10	4	10	4
	l_r	Carrying idler spacing (m)	0.5			
	h_{rel}	Maximum belt sag related to spacing between carrying idlers	0.01			
	m'_g	Line load resulting from the conveyor (kg/m)	0			
	g	Acceleration due to gravity (m/s^2)	9.81			
	ϕ	Angle of wrap (for a plain drive)	π			
	μ	Coefficient of friction- from	0.4			
	ρ_b	Material bulk density (ton/m^3)	2.88			
	k_s	Slope factor (Appendix B)	0.85			
	δ	Material angle of surcharge	20°			

4 Conclusion

In this work, a concept development process is provided to design the components of a LRR testing machine. The final design is based on the improvement of the existing test rig since it has all requirements to complete the task but the new one has been reduced in size considerably. Decision matrices have been used to justify the material selection. Due to cost, ease of manufacturing and strength, 300 XLERPLATE is selected for the structural supports and painting is considered as a suitable anti-corrosion solution to cover corrosivity level of C3. To ensure the quality, the system is designed based on the related Australian Standards, and justification is achieved through finite element analysis by investigating the deformation, stress and strain of each part. Physical specifications of the first concept is downscaled drastically to a compact, portable and desktop-sized model. Furthermore, a few adjustments are carried out for the variable hold down rollers, the tensioning method, frame geometry and the roller size. Under distinct loading conditions, necessary parameters including belt tensions, drive power, mass flow rate are obtained to compare the performance of the currently existing system operating in Newcastle, and the new downscaled version.

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SALES FORECAST FOR AGGREGATE PLANNING: CASE STUDY OF AN INDUSTRIAL PRODUCTS COMPANY IN MEXICO

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Keywords: demand planning, aggregate forecast, forecast accuracy, time series, SBC classification
Abstract: This case study presents the analysis through the use of sales estimation tools for planning demand for aggregate level as a finished product in a leading industrial products company in the market in Mexico. First, it aligned the demand plan and the supply plan, recommending the best execution scenario to increase operational efficiency and reduce the cost of operating the supply chain to increase the company's productivity and stay competitive. Then, after analysing the behaviour of the demand for selected products, the authors determined as the main affectation the inadequate precision of the method forecasting and the lack of an aggregate forecasting strategy that allows reducing the variation. Due to this, the most significant effort was concentrated on determining a better-forecasting model and the decision to aggregate the demand based on three relevant criteria: the demand pattern based on the Soft, Intermittent, Erratic or Irregular quadrant, the best method of the forecast for each product and the time in quarters. As a result, a reduction between 20% and 46% in the forecast variation can be obtained from the above.

1 Introduction

The correct alignment between the demand and supply plan is critical throughout the supply chain supplies in such a way that the entire value chain has visibility of customer demand and is synchronised to meet the customer service level and therefore achieve the strategic objectives of the company generate sales, profit margin and cash flow.

The correct balance of demand and supply helps the company to improve its level of service to customers, allows better visibility of supply requirements to suppliers to guarantee the availability of raw materials as well as operations to level the production plan for the best planning of resources and correct execution of the production plan, giving more certainty for the fulfilment of the business plan (Entringer & Ferreira, 2018).

The Sales and Operations plan is the mechanism that several companies have used to align the demand and supply plan to provide better customer service. It reduces delivery times, better control of inventory levels, provides visibility to both suppliers, such as company operations, stabilises production levels, takes better advantage of the productive capacity, and anticipates any imbalance between the demand and supply plan for the correct taking of actions to mitigate the impact on the company's business plan (Wallace & Stahal, 2014).

It is important to incorporate time series forecasting techniques for estimating sales to support the strategies and actions determined to satisfy demand, positioning the necessary resources, and reducing uncertainty in the processes that comprise the value chain (Contreras-Juarez, Atziry-Zuniga, Martinez-Flores, & Sanchez-Partida, 2016).

The scope of this case study is a 100% Mexican capital company, a market leader dedicated to the production and commercialisation of industrial products located in Mexico with ten manufacturing plants and three distribution centres with 800 employees.

This case study supports the company in integrating a formal sales estimation process into its Sales and Operations Plan through the support of time series to improve the accuracy of the forecast at the aggregate level by product family and at the catalogue level of the finished product.

2 Literary review

Every business plan in a company begins with the estimate and sales planning of its products, and based on this estimate, master plans are generated in the company, a financial plan to mention a few, so the quality of the

estimate has an impact on the quality and execution of these plans.

The company's management must consider several factors to maintain optimal inventory levels, such as the financial liquidity of the company, sales behaviour such as seasonality, reliability, and availability of suppliers, available financial resources. Furthermore, an adequate inventory level reduces the potential risks of loss of sales due to the lack of inventory availability and an increase in the company's cash flow, such as the release of warehouse capacity (Malindzakova & Zimon, 2019).

The variability of demand is due to different factors such as the heterogeneity of customers, external factors such as macroeconomics, market conditions, socio-cultural factors, and internal company factors such as service, price conditions, and promotional activities. In addition, distribution policies contribute to generating this variability. It is proposed first to understand the context in which the company operates regarding the number of products, the main problems it is facing, and the root flow analysis of demand variability. The structure of the supply chain and customer behaviour in order to collect process and analyse the data, which is known as data research and have a better reference for the correct selection of the estimation model and based on the results obtained by the model propose an action plan, implementation, and evaluation of countermeasures (Kalchschmidt, Verganti & Zotteri, 2006).

The client's different characteristics induce variability in the quality of the provision of a service: The needs and desires of a client are different. They can request the service at different times. The knowledge and experience of the product or service vary between clients, their willingness to support in the provision of the service may differ, they have different opinions about the provision of the service, the communication about the provision of the service may be ambiguous, so it is essential to consider these characteristics to understand the performance baseline, recognise the opportunity for improvement and implement an action plan to increase the quality of service and customer loyalty to the company (Yang, 2011).

It can be classified into two types to measure the performance of the estimate, 1) Bias or bias is the primary measure that evaluates the degree to which a forecast model generates an estimate above or below the current data if the bias is zero. Although the estimation model is good, if the bias is positive, the current values tend to be on average above the estimated, in the case of being the negative bias, the current value is below the estimated value, 2) There are three measurements to quantify the error in the forecasts: the mean absolute deviation error (MAD), the mean square error (MSE) and the mean absolute percentage error (MAPE) (Klimberg, Sillup & Tavva, 2010).

The estimate's accuracy is generally measured as the variation of the estimate compared to current performance. Usually, this variation is generated due to the incorrect use of estimation tools and processes. Therefore, four categories are proposed to increase the accuracy in the estimate, 1) Review of the statistical estimation method, 2) Hardware and software to increase the computing capacity of the information, 3) Preparation of the estimate requires tools, processes, experience, and training of personnel, and 4) Analysis of the time series and estimation methods to recognise patterns, structures, that allow predicting and improving the accuracy of the estimate (Rieg, 2010).

In some cases, it is recommended to consider the combination of estimation methods and evaluate the methods to quantify the bias and error of the estimate (Klindokmai, Neech, Wu Ojiako, Chipulu & Marshall, 2014).

A methodology (Syntetos, Boylan, & Croston, 2005) is considered to position the demand for the different catalogues of finished products within a category based on two parameters. First, the average demand interval (ADI) measures how steady the demand is in terms of time by calculating the average interval between two demands and the squared coefficient of variation (CV^2) that allows measuring the variation of the units.

It is described through four quadrants to locate each discrete category of demand considering the parameters of ADI and CV^2, as shown in Figure 1:

1. Erratic demand (ADI <1.32 and CV^2> = 0.49). Demand shows a high degree of variation between periods. For items located in this quadrant, the Syntetos and Boylan estimation method is recommended for forecasting demand.
2. Irregular Demand (ADI> = 1.32 and CV^2> = 0.49). The demand presents a high variation greater than or equal to 50%, and the average interval between demands is considered high; with this, we can deduce that there are some periods in which the demand is zero. Like items in the erratic quadrant, the Syntetos and Boylan method is recommended for forecasting demand.
3. Soft demand: (ADI <1.32 and CV^2 <0.49). Demand is at a constant level and the periods in which they are not for sale are scarce or nil. In this area of the quadrant, the Croston estimation method is recommended.
4. Intermittent Demand (ADI> = 1.32 and CV^2 <0.49). The demand shows low variation in units between the periods, but high variability in the time interval between two demands indicates zero demand periods. In this area of the quadrant, the estimation method Syntetos and Boylan is recommended.

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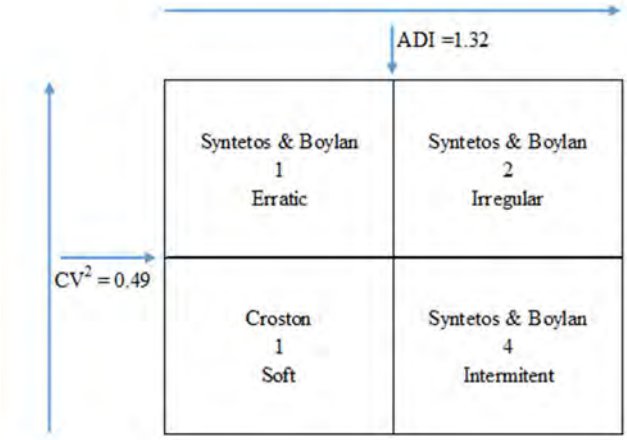

Figure 1 Illustration of intermittent demand categories (Syntetos, Boylan, & Croston, 2005)

It is essential to understand the demand pattern considering the different factors that influence its behaviour, then determine the category of intermittent demand according to the SBC classification in order to select the appropriate estimation methodology to reduce the error of the estimate (Van der Auweraer, Boute, & Syntetos 2017).

In the intermittent demand time series, demand is classified taking into account the average interval of demand and coefficient of variation according to the model of Syntetos, Boylan & Croston in their research Doszyń proposes instead of the average interval of demand recommends comparing the coefficient of variation concerning the frequency of the sale to understand better the nature of the demand behaviour (Doszyń, 2019).

Within the methodology for implementing the sales estimate, it is necessary to understand the structure of the company's supply chain, understand the characteristics of the demand, and validate the causes that generate this variability in demand. The next step is to understand the demand pattern and classify it according to the intermittent demand categories, select the correct estimation model, carry out a simulation and, based on the positive results, plan a pilot test for its subsequent implementation. This methodology was implemented in the retail sector (Balderas, Araiza, Peña & Villareal, 2019).

As part of the methodology for estimating consumable items such as spare parts where demand is intermittent or slow-moving, it is tough to forecast their consumption, so an analysis of the demand category is made in soft, erratic, intermittent, and irregular using estimation methodology according to the demand patterns for which a modification to the Croton method is proposed as an approximation method to maintain a required inventory level for a service level according to each of the demand patterns (Eaves, & Kingsman, 2004).

Once the inventory levels are established, we proceed with the levelling of the production in a period. It allows avoiding fluctuations to predict the consumption of raw materials, labour, and productive capacity to guarantee the product's availability, minimising inventories, working capital, and delivery time throughout the value chain (Narusawa & Shook, 2011).

Poor demand planning results in constant changes in production levels, so it is essential to smooth demand to optimise production resources using the double exponential smoothing methodology. Demand projections are generated as part of the evaluation of the estimate is quantified. The error in the forecasts through three measurements: MAD, MSE and MAPE, as the error does not decrease, it is decided to adjust the average demand instead of a monthly to quarterly basis, optimising the smoothing parameters α and β, it was possible to reduce the error in the estimate (Sánchez-Partida, Rodríguez-Méndez, Martínez-Flores & Caballero-Morales, 2018).

When obtaining the forecast of customer demand, it is essential to evaluate if it has the correct inventory levels through a correct inventory control policy using the EOQ to determine the optimal quantity to order with a reorder point to order when the target has reached a point in the inventory within the delivery time to meet the level of service desired by the client or if more inventory is required, evaluate the productive capacity to position inventory required to meet the client's demand (Alvarez-Socarras, Berrones, Moreno, Rodrıguez-Sarasty & Cabrera-Ríos, 2013).

ABC analysis in inventory management is a method of classifying inventories based on the book value (cost or acquisition) of the stored materials that consider using the item at its book value, classified from highest to lowest (Richards, Grinsted, 2016).

The inventory control of spare parts in an MRP system is essential to analyse the historical demand having the ABC classification in terms of inventory cost and the inventory replenishment through a point of order where the estimated demand for high-value parts A articles with a high coefficient of variation are manually validated with a criterion judgment. In this case, the articles classified as B, the criterion for selecting the estimator and its parameters are based on minimising the MAD. In articles classified as C, the demand pattern is studied to correct the estimation tool's correct selection (Syntetos, Keyes & Babai, 2009).

3 Current issue

The company is currently using a linear method estimation which implies considering current sales to date to project the sales estimate for the following month based on the average of the historical demand of the last three months, that is, a moving average of three months in addition to considering public tenders as requirements of the private sector for special projects. The Commercial area proposes the sales estimate by product family and at the finished product catalogue level by business unit. Only the sales estimate is calculated for items classified A, which represents the 80-20 of the income from the sale in monetary value, products B are produced in a

manufacturing environment "make to order," and the case of articles C that are special projects are produced as "design to order."

These sales estimated are used for the business's financial projection and are evaluated against the business plan to determine the month's sales and operation plan with their respective budgets for each of the company's functional areas. In addition, inventory goals and inventory maximums and minimums are determined for each of the finished products classified A for inventory control purposes.

The current environment that the company faces is very challenging when considering the market contraction, the more protectionist market policies that impose tariffs on critical raw materials for the production of its products, and the constant increases in the prices of materials premiums. Without neglecting a more significant presence of competition in the market, it has made the company rethink its strategic position to generate a competitive difference to stay and grow in the market with more innovative products, seeking efficiencies in operating and production costs and shorter response times to meet customer requirements.

As part of the efficiency in the operating, production, and distribution costs of its products, a formal method of estimating sales is required to reduce the error of the sales estimate to give more certainty to the business plan. It is also, reducing the uncertainty providing visibility of the demand both to the manufacturing plants and of the supply requirement to the raw material suppliers to ensure the availability of the material and logistics providers for the distribution of their products to determine the correct resource requirement of transportation to comply with the delivery plan committed by the commercial area.

The accuracy of the aggregate sales forecast on average is 71% as a performance baseline, highlighting a significant opportunity for the generation and execution of the Plan and Sales and Operations, as shown in Figure 2.

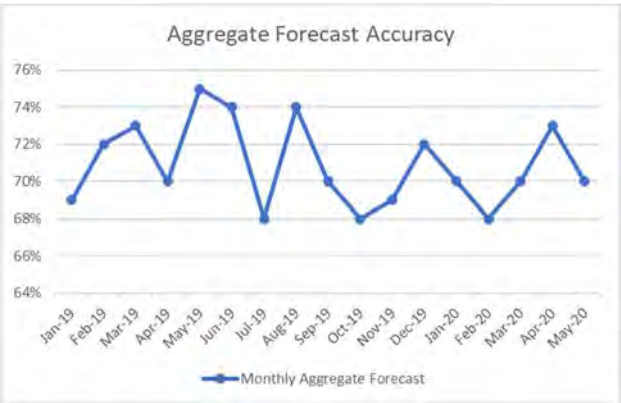

Figure 2 Accuracy of the aggregate forecast of the sale of the periods from January 2019 to April 2020

4 Methodology

The case study includes the analysis of the historical sales of the last two years of one of the manufacturing plants that generated the highest income for the company, for which historical sales were collected in terms of sales units by product family and at the level of a finished product for products classified as type A that represent 80-20 of the revenue received from the manufacturing plant.

Historical sales are stratified by product family with their respective finished products, and we proceed to understand the behaviour of sales to graph the time series to recognise patterns and structures.

The demand for the different catalogues of finished products is categorised based on the coefficients: Average demand interval (ADI) and the squared coefficient of variation (CV^2).

The demand for each of the finished product catalogues is classified into four categories considering these two coefficients: Soft, Intermittent, Irregular, and Erratic.

The finished product catalogues whose demand is Irregular and Erratic is not proposed as a method of estimating the sale, but an aggregate forecasting strategy that allows reducing the risk and the possibility that these catalogues are managed in a "make to order" environment.

For the catalogues classified in both Soft and Intermittent categories, the appropriate estimation method will thus be selected to generate the sale estimate that shows a reduction in the forecast error.

For the evaluation of the estimation method, bias is considered as the primary measure that evaluates the degree to which the forecast model generates an estimate above or below the current data, as well as the error of the estimate, will be quantified using three measurements: MAD error of the mean absolute deviation, MSE squared error and MAPE error of the mean absolute percentage.

Based on the estimate produced by the selected model with the most negligible bias and error of the estimate, the estimate of the recommended sale at the aggregate level by product family is the basis for the generation of the sales plan. In addition, the proposed sale estimate at the finished product level is updated in the manufacturing plant's production master plan to determine future production and production capacity requirements.

The net requirement proposed by the master production plan is the basis for the material requirement plan to generate the estimate of future purchase requirements for raw material suppliers, thus providing visibility to ensure the supply of raw materials. In addition, the results will be evaluated in the impact on the operational efficiency and reduction of the supply chain's operating cost to increase the company's productivity and become more competitive in the market.

5 Result and discussion

Considering the historical sales of the last two years, 2018 and 2019 of the finished product catalogues classified A of the manufacturing plant, and they are then plotted based on the Syntetos, Boylan, & Croston (SBC) matrix to identify the demand category, based on the average interval

coefficients of the demand (ADI) and the squared coefficient of variation (CV^2).

Table 1 Results of the ADI, CV2 coefficients and classification Syntetos, Boylan, & Croston

PRODUCT	J-1	J-5	H-6	D-7	S/F-11	D-12	H-13	G-14
2018 & 2019 Total Demand	11484	4645	3145	791	2618	949	2086	908
Periods without demand	0	0	1	1	0	1	0	0
Constant/Intermittent	C	C	I	I	C	I	C	C
Periods with demand	24	24	23	23	24	23	24	24
ADI	1.000	1.000	1.043	1.043	1.000	1.043	1.000	1.000
CV^2	0.171	0.406	0.350	0.170	0.234	0.085	0.228	0.143
CLASSIFICATION	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Soft

PRODUCT	A-15	H-18	S/F-20	A-23	F-24	S/F-25	D-26	F-28
2018 & 2019 Total Demand	3390	906	1056	2472	422	1566	332	428
Periods without demand	0	0	0	1	0	10	1	0
Constant/Intermittent	C	C	C	I	C	I	I	C
Periods with demand	24	24	24	23	24	14	23	24
ADI	1.000	1.000	1.000	1.043	1.000	1.071	1.043	1.000
CV^2	0.456	0.226	0.310	0.404	0.282	0.336	0.325	0.370
CLASSIFICATION	Soft	Soft	Soft	Soft	Soft	Soft	Soft	Soft

PRODUCT	D-37	D-29	D-35	B-38	B-21	F-22	K-27
2018 & 2019 Total Demand	2074	75	110	672	2068	320	228
Periods without demand	1	16	16	8	0	1	0
Constant/Intermittent	I	I	I	I	C	I	C
Periods with demand	23	8	8	16	24	23	24
ADI	1.043	3.000	3.000	1.500	1.000	1.043	1.000
CV^2	0.248	0.484	0.161	0.484	0.636	0.989	0.674
CLASSIFICATION	Soft	Intermittent	Intermittent	Intermittent	Erratic	Erratic	Erratic

PRODUCT	J-3	C-9	H-10	B-16	G-34	C-19	J-4	B-30
2018 & 2019 Total Demand	4953	159	2266	1927	121	76	2906	633
Periods without demand	0	5	1	0	3	7	12	11
Constant/Intermittent	C	I	I	C	I	I	I	I
Periods with demand	24	19	23	24	21	17	12	13
ADI	1.000	1.263	1.043	1.000	1.143	1.411	2.000	1.840
CV^2	0.698	1.474	0.903	0.695	0.882	0.726	0.837	3.579
CLASSIFICATION	Erratic	Erratic	Erratic	Erratic	Erratic	Irregular	Irregular	Irregular

From the results presented in Table 1, the proportion corresponding to each quadrant can be determined, being 54.84% of the finished product catalogues located in the soft quadrant, 9.68% with Irregular demand, 25.81% with Erratic demand, and 9.68% with Intermittent demand (see Figure 3).

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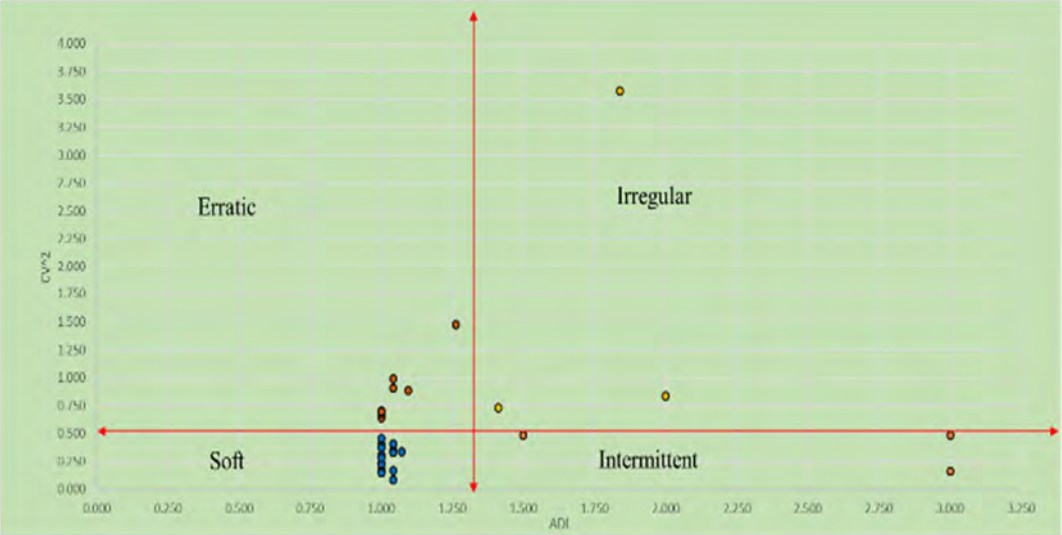

Figure 3 Classification of the Manufacturing Plant demand (Syntetos, Boylan, & Croston, 2005)

As described in the percentage and reflected in the graph, several products are located in the Erratic area and the same number of products in the Irregular and Intermittent areas. Once each item is located in its respective quadrant, we calculate a better forecasting method for each item. In Tables 2 and 3, the summary of the results of the demand estimate through the method used by the organisation and the proposal of a new method that allows reducing the forecast error is shown. The value of each value of the necessary softeners of the proposed method for each product.

Table 2 The proposed method for calculating the demand forecast for products classified in the Soft and Intermittent quadrant

PRODUCT	CURRENT FORECASTING METHOD	CV^2	ADI	MAD
J-1	Moving Average	0.171	1.000	162.143
J-5	Moving Average	0.406	1.000	121.556
H-6	Moving Average	0.350	1.043	88.175
D-7	Moving Average	0.218	1.043	13.206
S/F-11	Moving Average	0.234	1.000	45.889
D-12	Moving Average	0.085	1.043	9.651
H-13	Moving Average	0.228	1.000	29.937
G-14	Moving Average	0.143	1.000	12.381
A-15	Moving Average	0.456	1.000	78.810
H-18	Moving Average	0.226	1.000	15.476
S/F-20	Moving Average	0.310	1.000	18.630
A-23	Moving Average	0.404	1.043	79.048
F-24	Moving Average	0.282	1.000	6.730
S/F-25	Moving Average	0.336	1.071	50.980
PRODUCT	CURRENT FORECASTING METHOD	CV^2	ADI	MAD
D-26	Moving Average	0.354	1.043	6.860
F-28	Moving Average	0.370	1.000	9.380
D-37	Moving Average	0.270	1.043	41.390
D-29	Moving Average	4.357	3.000	1.587
D-35	Moving Average	1.452	3.000	2.540
B-38	Moving Average	1.089	1.500	30.300

PRODUCT	SBC CLASSIFICATION	BEST FORECASTING METHOD	ALFA PARAMETER	BETA PARAMETER	MAD
J-1	Soft	Brown	0.0001		159.841
J-5	Soft	Brown	0.0001		102.767

H-6	Soft	Brown	0.0001		63.194
D-7	Soft	Holt	0.0977	0.1867	12.166
S/F-11	Soft	Holt	0.0001	0.0001	42.671
D-12	Soft	Brown	0.5545		10.793
H-13	Soft	Brown	29.1300		31.074
G-14	Soft	Brown	0.0004		10.414
A-15	Soft	Holt	0.5310	0.1090	59.301
H-18	Soft	Brown	0.0020		13.821
S/F-20	Soft	Moving Average			18.630
A-23	Soft	Brown	0.0004		61.696
F-24	Soft	Brown	0.3989		6.470
S/F-25	Soft	Holt	0.5740	0.0040	47.580
D-26	Soft	Brown	0.3091		6.080
F-28	Soft	Holt	0.3240	0.0200	8.770
D-37	Soft	Brown	0.0004		38.590
D-29	Intermittent	Holt	0.3420	0.0470	1.220
D-35	Intermittent	Holt	0.3990	0.0510	2.190
B-38	Intermittent	Brown	0.9999		18.700

Table 3 A proposed method for calculating the demand forecast for products classified in the Erratic and Irregular quadrant

PRODUCT	CURRENT FORECASTING METHOD	CV^2	ADI	MAD	SBC CLASSIFICATION
J-3	Moving Average	0.698	1.000	144.905	Erratic
C-9	Moving Average	1.474	1.263	6.238	Erratic
H-10	Moving Average	0.903	1.043	70.079	Erratic
B-16	Moving Average	0.695	1.000	52.492	Erratic
B-21	Moving Average	0.636	1.000	62.206	Erratic
F-22	Moving Average	0.989	1.043	9.476	Erratic
K-27	Moving Average	0.674	1.000	6.220	Erratic
G-34	Moving Average	1.152	1.095	3.680	Erratic
J-4	Moving Average	0.837	2.000	70.095	Irregular
C-19	Moving Average	0.726	1.411	3.476	Irregular
B-30	Moving Average	12.199	1.840	46.380	Irregular

PRODUCT	BEST FORECASTING METHOD	ALFA PARAMETER	BETA PARAMETER	MAD
J-3	Holt	0.3409	0.0001	134.321
C-9	Holt	0.0233	0.9999	4.743
H-10	Holt	0.0206	0.8819	63.331
B-16	Holt	0.5150	0.0210	45.712
B-21	Holt	0.0650	0.2490	47.281
F-22	Brown	0.0004		8.428
K-27	Brown	0.0004		5.330
G-34	Holt	0.3390	0.0001	3.570
J-4	Holt	0.4568	0.2287	69.297
C-19	Holt	0.0471	0.0001	2.660
B-30	Brown	0.0004		35.900

In 90.3% of the cases, a better method was found to reduce the demand forecast error; 41.94% of the products are better forecast through the Brown method, which allows us only to have an alpha smoother (α). In this case, the same percentage of 48.3% of the products improves their prognosis by Holt's method, using the alpha and beta (α, β) softeners. Once the best forecasting method for each product was identified, they were classified by quadrant of the SBC method, it is the best forecasting method to use the strategy of an aggregate forecast that allows reducing

the relative variability further increase the forecast precision, and that allows reducing the requirements of the safety stock in inventories.

Table 4 describes the demand for each period of 2018 and 2019 of the items located in the Irregular quadrant and Holt's method and the total aggregate demand for each period of the items classified according to their quadrant and their best method.

Table 4 Irregular classification and Holt's forecasting method

	PRODUCT	J-3	C-9	H-10	B-16	B-21	G-34	AGGREGATE
2018	January	153	2	43	79	35	13	325
	February	21	1	9	78	11	5	125
	March	169	2	17	56	88	1	333
	April	487	1	0	30	42	1	561
	May	77	4	38	146	73	0	338
	June	154	0	144	75	42	1	416
	July	109	5	96	41	26	4	281
	August	69	0	130	78	102	4	383
	September	426	6	11	52	82	2	579
	October	219	10	121	103	95	1	549
	November	254	3	16	102	134	2	511
	December	639	23	79	31	53	4	829
2019	January	373	2	134	144	72	4	729
	February	409	0	9	73	18	0	509
	March	201	5	161	29	301	2	699
	April	16	0	62	15	1	4	98
	May	487	0	2	13	52	6	560
	June	89	3	1	7	41	4	145
	July	56	7	107	18	109	14	311
	August	111	14	144	160	135	6	570
	September	138	8	84	106	203	22	561
	October	189	9	225	118	178	12	731
	November	47	44	373	317	53	9	843
	December	60	10	260	56	122	0	508

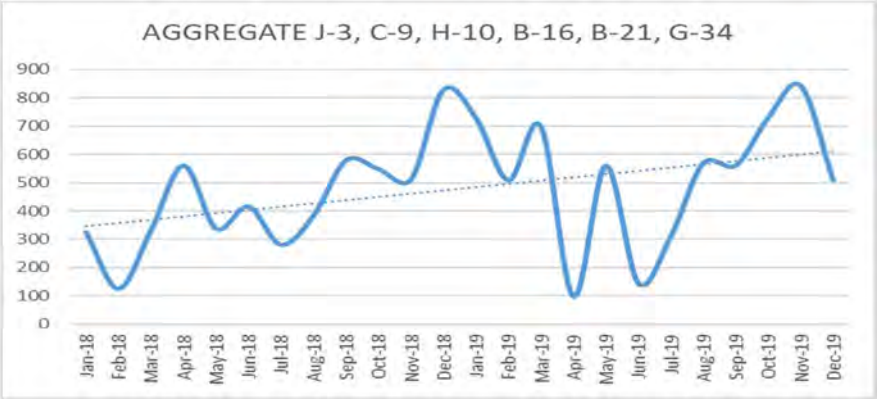

Figure 4 Graph of the aggregate demand of Irregular products and Holt's forecasting method

Subsequently, the estimation of the demand forecast for the aggregated data was carried out to contrast if there is an improvement in the variation and the forecast precision. Table 5 shows the primary statistic of the aggregated data, and Table 6 details the results of the forecast estimation calculation.

The graph of the values of the aggregate demand is made, allowing us to visualise its behaviour and pattern. It can be seen that it still presents a vital variation and a positive linear trend, as shown in Figure 4.

Table 5 The average value, standard deviation, CV and CV^2

Mean	478.917
Deviation	208.818
CV	0.436
CV^2	0.190

Table 6 Results of the aggregate forecast for the Erratic classification and Holt's method, values of the softeners, and their MAD

Product	SBC Classification	Best Forecasting Method	Alfa Parameter	MAD Disaggregated	MAD Aggregated
J-3	Erratic	Holt	0.074	298.958	158.376
C-9	Erratic	Holt			
H-10	Erratic	Holt			
B-16	Erratic	Holt			
B-21	Erratic	Holt			
G-34	Erratic	Holt			

From the result obtained using the aggregate demand forecast, a MAD error of the forecast can be determined with a value of 158,376; this can be described as an improvement of 47% concerning the MAD error of 298.958 treating disaggregated demands.

It was also considered to evaluate a strategy of adding the SBC classification, the best forecasting method, and quarters. Figure 5 shows only the results of the basic statistics of the proposal to consider adding the demands in quarterly periods.

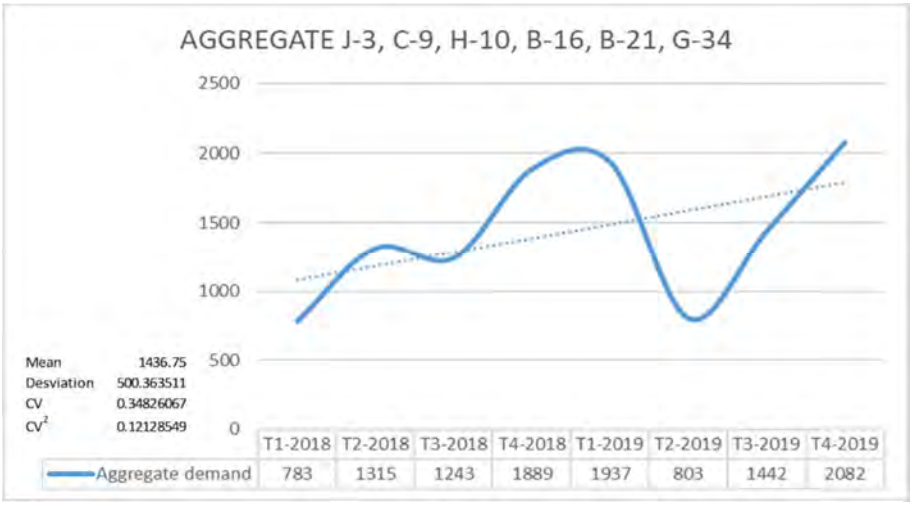

Figure 5 Aggregate demand considering the SBC classification, best forecasting method, and the periods in quarters

It can be seen in the graph how the variation reduces considerably, allowing the variation to be reduced by 20.18% concerning the strategy of adding only the SBC classification and the best forecasting method, from 0.436 to 0.348 in the variation coefficient.

Figure 6, based on data from Table 7 and Figure 7, based on data from Table 8, show the results of the aggregate demand for products in the Soft classification with the Brown method and the periods in quarters, as well as for the products with Soft and Intermittent classification, with the Holt method and the periods quarterly.

Table 7 Trimestral aggregate demand

Product	SBC Classification	Best Forecasting Method	Alfa Parameter	MAD Disaggregated	MAD Aggregated
J-1	Soft	Brown	0.806	504.741	393.93
J-5	Soft	Brown			
H-6	Soft	Brown			
D-12	Soft	Brown			
G-14	Soft	Brown			
H-13	Soft	Brown			
H-18	Soft	Brown			
A-23	Soft	Brown			
F-24	Soft	Brown			
D-26	Soft	Brown			
D-37	Soft	Brown			

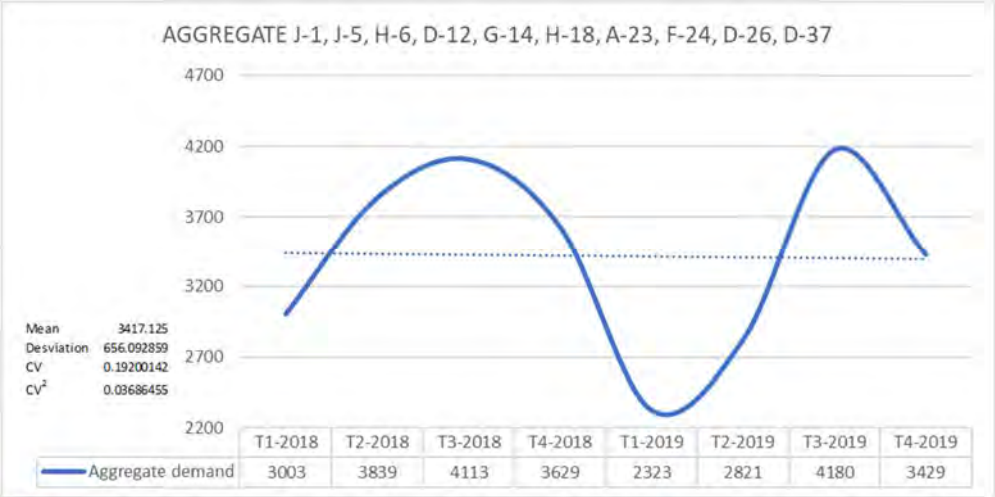

Figure 6 Aggregate demand considering the Soft SBC classification, Brown forecasting method, and the periods in quarters

Table 8 Trimestral aggregate demand

Product	SBC classification	Best Forecasting Method	Alfa Parameter	Mad Disaggregated	Mad Aggregated
D-7	Soft	Holt	0.515	173.898	104.416
S/F-11	Soft	Holt			
A-15	Soft	Holt			
S/F-25	Soft	Holt			
F-28	Soft	Holt			
D-29	Intermittent	Holt			
D-35	Intermittent	Holt			

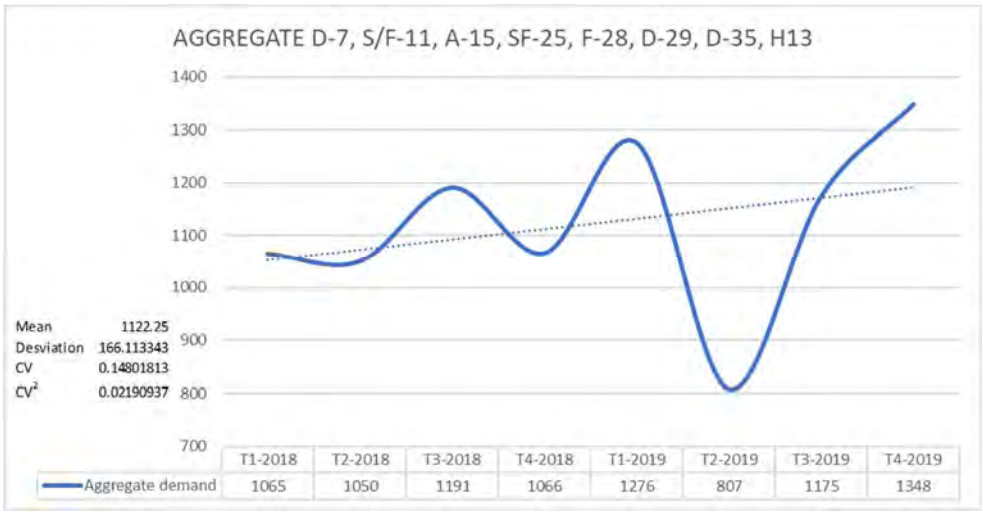

Figure 7 Aggregate demand considering the Soft and Intermittent SBC classification, Holt forecasting method, and the periods in quarters

The results of the proposal to classify the products according to their demand pattern, find a better forecasting method that allows pursuing the demand pattern, add the demand by the classification proposed by Syntetos, Boylan, and Croston. Moreover, their best method, forecasting and for quarterly periods, allow reducing the relative variability, an essential increase in the forecast precision that will reduce the requirements of the safety stocks for the raw materials, which in our case are the same for the majority of the products.

6 Conclusions

The importance of maintaining optimal inventory levels that allow the company to satisfy the needs of its

customers at the lowest cost requires an understanding of the key factors that describe the behaviour of demand patterns. In these circumstances, the effectiveness of forecasting and inventory management schemes becomes essential.

The case study described in this document seeks to improve the demand forecast level for a sample of representative items from the production plant of industrial products, limited under this study. The organisation was dealing with having an excessive level of variability in the consumption of raw materials given the lack of a forecasting method, with greater assertiveness; this caused high inventory management, which allowed the continuity of production at a high cost to avoid stoppages due to lack of supplies.

An in-depth analysis of the contribution to this excess variance was conducted and found that forecasting performance could be improved to improve inventory levels. The analysis results made it possible to implement a classification based on the methodology of Syntetos, Boylan, and Croston, to group the analysed products under affinity and a change in the method for calculating the forecast to reduce the error. Once the classification and forecasting method was defined for each product, an aggregate forecasting strategy was implemented for the products found in each classification with each forecasting method, obtaining a variation reduction between 20% and 46% in each estimated case.

Based on the results found in this study, the organisation will gradually implement the changes in its management system, the modifications required to establish the methods and parameters suggested in this document, as well as include the rest of the articles produced by the plant at the same treatment—moreover, experimentation to analyse your results. The description of the methodology used in this case study has been satisfactory and shows evidence of improving the precision of the forecasts.

Further research should involve the interaction with finished good inventory forecasting based on the forecasting model proposed in this study in order to notably reduce the uncertainty presented in the use of forecasts as inventories are the support that the forecast model has in the face of significant changes by the demand. Under these circumstances, the effectiveness of the forecasting and inventory management schemes becomes important in an industrial environment, which may lead to significant inventory and production cost reductions and improve customer service levels.

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VALUE STREAM MAPPING OF OCEAN IMPORT CONTAINERS: A PROCESS CYCLE EFFICIENCY PERSPECTIVE

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Keywords: shipping port, container terminal, value stream mapping, lean six sigma, process management
Abstract: International cargo transportation is majorly dependent on marine transport, which moves 80% of the international cargo. With the increase in vessel size and the same yard area available for container transportation, it is important to study the processes and understand the efficiency of the container operations process. This research paper aims to review the import container transportation process and understand the process cycle efficiency through lean six sigma concepts. The process is evaluated from the operations process perspective and documentation process at one of the ports of India. The research has been designed by conducting an industry expert review on the process of container transportation from vessel berthing to gate out for import containers, utilising lean six sigma principles such as value stream mapping (VSM) and process cycle efficiency. The results have contributed to the existing knowledge in identifying the waste in the container handling process and demonstrated the inefficiency in the system from the perspective of waiting time of containers due to customs examination, scanning, and inter-terminal handling and movement. The process cycle efficiency of 40% is calculated by analysing the detailed time of handling containers from vessel berthing to gate out. A new future value stream mapping is proposed considering the process cycle efficiency. Future studies will focus on studying this process for export containers and benchmarking the results with the top-performing ocean ports globally.

1 Introduction

The increasing role of globalisation, together with the increasing speed of all the processes, have led to the fact that in the contemporary world, supply chains have to be changed towards more effective and sustainable systems. Considering that the ports are an important part of the supply chain processes, the influence of the change in the environment could also be seen. An essential role in delivery services is given to marine ports as approximately 80% of products is carried by sea transport [1] and thus inevitably goes via seaports.

International trade largely relies on a marine mode of cargo transportation. The container shipping sector is predominantly constituted by multiple stakeholders that act as individual entities and operate on a silo basis. These independent stakeholders are expected to collaborate in order to transact by coordinating their information exchange. In order to integrate and ensure the collaboration between operations, reliable exchange of information is important to integrate with along with digital technologies. This will enable them to exchange data on a regional and global level, which can increase efficiency and deliver environmental benefits through waiting for time reduction and optimal use of energy and resources [2].

The relationship between vessel size and the companies owning the vessel is illustrated in Figure 1. It can be observed that companies owning vessels is decreasing; however, the size of each vessel is increasing. Thus, a container port terminal has to adopt optimising practices to ensure and manage continuous efficient operations. This can be performed by optimising the current space, processes and standard operating procedures, considering the below factors:

1. Port infrastructure, such as berth areas, cranes, technology.
2. Lean efficient processes and space optimisation.
3. High Investment.
4. Environmental Impact.

VALUE STREAM MAPPING OF OCEAN IMPORT CONTAINERS: A PROCESS CYCLE EFFICIENCY PERSPECTIVE

Mohan Saini; Anastasia Efimova; Felicita Chromjaková

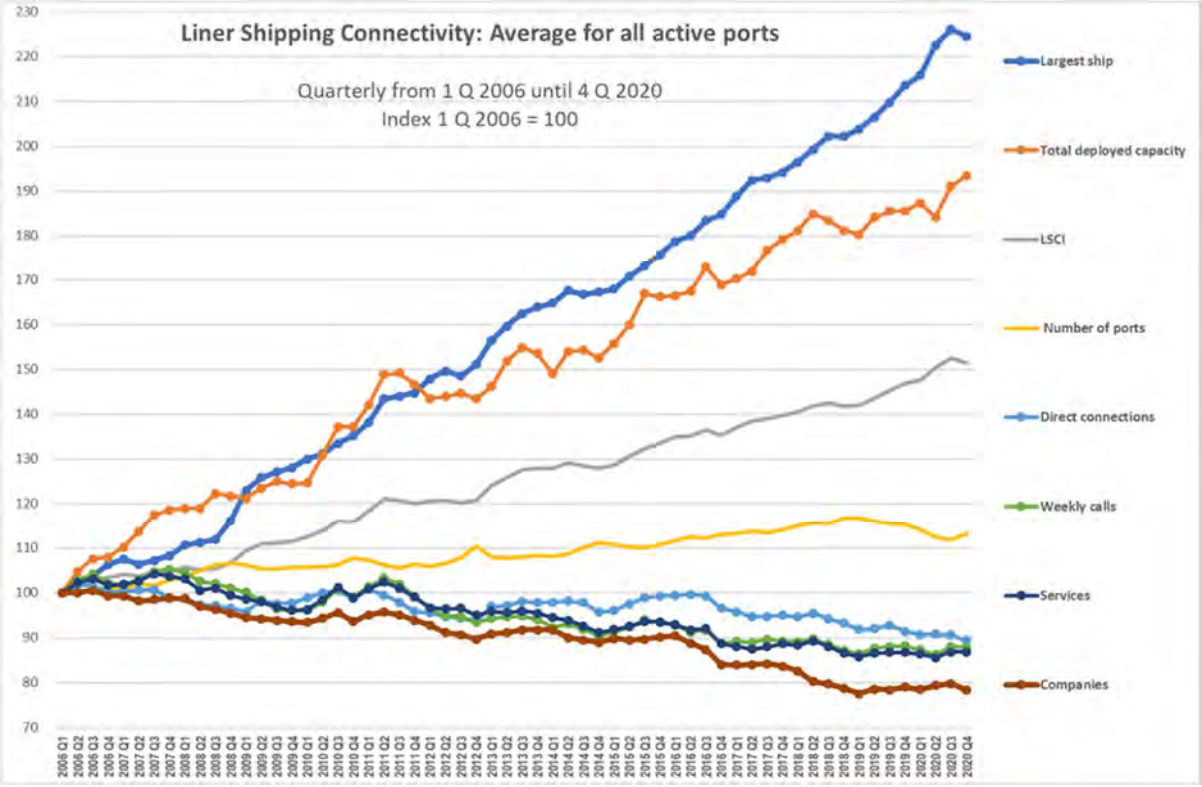


Figure 1 Relationship between vessel size and vessel per country [3]

The container and shipping sectors are important for economic development and influence various segments such as transport infrastructure, warehousing, information and communication in supply chain management. Evolution in the logistics sector may benefit logistical investments, which changes the traditional way of company functioning. In many countries, economic advancement was influenced by expanding export production. Export performance is important, especially for small economies or developing countries [4]. [5] also, highlight that economic growth is positively influenced by trade openness while studying selected Asia countries.

There has been a strong push for information communication technologies in the container logistics sector, along with the introduction of smart port 4.0. Many global and European organisations such as United Nations Economic Commission for Europe (UNECE) and United Nations Center for Trade Facilitation and Electronic Business (UN/CEFACT) are researching smart container technologies for data exchange transactions to build efficient and cost-effective processes.

The ongoing change towards the digitalisation of processes, also known as the fourth Industrial Revolution or Industry 4.0, provided new opportunities for the delivery and supply chains. However, new opportunities are always connected with new challenges that could arise in port management systems. The rising opportunities influence the competition on the market, and the necessity of the change might provide the competitive advantage against road, rail and air. Considering the complexity of ports processes, the process improvement could serve as an advantage in the contemporary world, allowing services to be provided faster, better and/or at a lower price.

They are identifying the role of container terminals in modern supply chain strategies and further integration of container transportation. There is significant scope for research since globalisation demand effective and secure supply strategies [6]. The ports serve as gates for goods and products to enter or to leave the country. Ocean freight greatly depends on port efficiency [7]. Thus, the process optimisation in ports might provide a new perspective for a country. India has twelve major Ocean ports for trading at the global level. Though there have already been attempts to optimise the processes in Indian ports, the key indicators of Indian ports are not effective in comparison with European or Singapore systems.

As many ports in India are struggling nowadays to improve the processes by implementing advanced technologies, the proper analysis might be beneficial to identify the steps that could be removed prior to being digitalised. Several methods have already been used to optimise port processes, such as standardisation [2], SMEA [8] or JIT [9,10]. To better analyse the challenges, the process should be divided into its constituents and then assessed. One of the qualified tools to analyse the actual process efficiency is value stream mapping as a method that opens more horizons for the identification of wastes, non-productive process activities, value-added processes. Many port types of research have been conducted from various aspects, but the approach when VSM is proposed

for ports process improvement is not much studied so far [8]. In connection with the Six Sigma methodology that could be applied to monitor and assess statistical indicators of the processes and use the to improve the existing process, it opens new and innovative potentials for setting up a system solution for internal processes in the area of container import by ocean ports in the whole world.

In this research study, an attempt is made to analyse the existing processes in ports in India from the point of view of value-adding and non-value-adding activities and to calculate the process cycle efficiency with the purpose to propose possible optimisation of existing processes. The novelty of this research is the application of VSM in Indian ports based on the information gathered from the port managers. The study comprises the information gathered from port managers by specially developed questionnaires and application of Lean tools, namely VSM, for analysis. The research was conducted in the southern Indian ocean port, and import cycle data for containers were collected for the period of one year to understand the dwell time and the time taken by sub-processes were discussed in detail with the port operations managers to better understand the pattern existing in the given ports.

The paper is structured as per the following details: The first section provided the theoretical background for container logistics, lean six sigma, value stream mapping (VSM) and VSM in container logistics in research studies. The methodology section presents data analysis along with VSM calculation and waste management. The results section illustrates the investigative relationship, data analysis and empirical results. The discussion sections highlight the findings of VSM mapping. The last section presents the concluding results along with limitations and future research scope.

2 Literature review

2.1 Container logistics in research studies

Containers are traditional cargo movement and storage units classified as general-purpose, refrigerated, dry or tank containers. For such a cargo movement in international trade, a crucial role is played by marine transportation. Nearly 80% of the international trade in volume and approximately 70% of the international trade-in value is transported by marine transport and is operated in maritime ports [11,12]. For the majority of the developing countries, the amount is even higher. With expanding economies and advancing globalisation, containerisation is further staged to grow and remain as a preferable mode of cross border cargo movement [13].

With the increase in global trade and container volume, yard managers have to manage the yard operations to ensure terminal efficiency [14]. With such large expansion and increase in the volume of cargo, the limited possibilities include increasing the land area, which is a larger investment of procuring land or optimising operations in an efficient manner to reduce dwell time. Terminal operators operationally plan to reduce the dwell time of the container by determining factors that affect the container time spent at the container terminal operator. A research study conducted by Pekarčíková et al. (2020) emphasised strategic long term planning utilising DDMRP (demand-driven material requirement planning) to explain the location and sizing of shipping containers [15].

Merckx [16] designed a framework to assist the container terminal operators on the pricing scheme for container time spent in the terminal based on the dwell time. Logistics and freight forwarding companies intend to store and stock their containers in a terminal operator or container freight station till their requirement arises in the production [17].

With the advent of technological advancement in e-commerce and road transportation, there is a major thrust towards automation and digitising platforms in container logistics management. For a developed and a developing economy, the port plays an important role in cross trading between economies. For the last decade, there has been a continuous increase in the global trading of containers. This is primarily due to the increase in the global movement of container and trading numbers globally [11,12]. Thus, in a competitive scenario, port terminal operators are under immense competitor to make the container handling process more efficient and a lean process. This research study will include analysing the process of container movement from vessel manifestation to gate out operations utilising lean six sigma and value stream principles. Figure 2 depicts the process of the movement of the container terminal in marine ports, including physical movement and document moving from the supplier (which is a ship) to the customer (which is the delivery company).

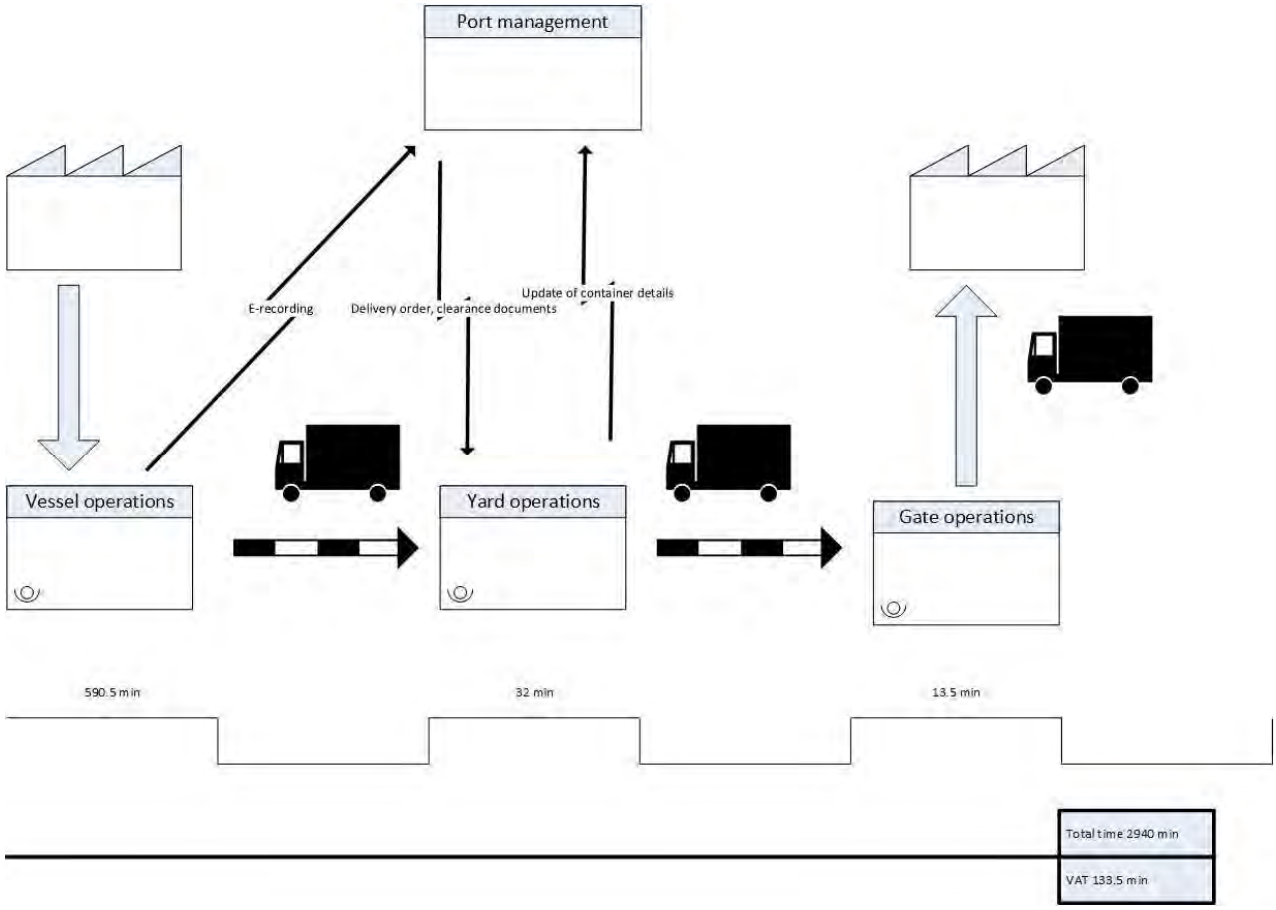


Figure 2 Container movement from vessel berthing to gate out (Source: Own research)

2.2 *Lean and value stream mapping in research studies*

Lean methodology has already been used in ports and has proved itself to be beneficial from the point of view of process analysis [1,7,18]. VSM allows to better understand the port processes and thus could influence port management and influence flow. Lean ports are able to identify wastes and bottlenecks of any process together with defects [7]. The proper understanding of the initial process could also increase the output of investment as the core stages could be defined, and the attention could be shifted from non-value-added processes. As in this study, the VSM is the main tool that is used to calculate process cycle efficiency, the thorough understanding of port processes and the understanding of the Lean VSM tool are required for the research success.

Lean methodology has been applied in many companies worldwide and has proved its positive impact on industrial processes, non-industrial processes and services. However, despite its great success, many companies deny implementing this methodology as they consider lean to be costly in implementation, and they are uncertain about its application in their company [1]. Regardless of this fact, many ports have advantageous experience in implementing lean [1,7,8,18].

As a methodology, Lean appeared in Toyota, and it was developed by Taichii Ohno. It received attention in economically challenged periods as Toyota managed to increase income [19]. Lean followed the principles of Toyota Production System, the basic principle of which was to eliminate seven kinds of wastes, thus creating a more effective production system. In the work of [11] the enhancement of the company competitiveness by the implementation of waste reduction and continuous improvement tools for JIT was indicated. And JIT was considered to be the crucial strategy for competitive advantage.

"Lean management thinking is used to differentiates between waste and value within an organisation" [20]. In lean, the waste (also called "muda") is connected with activities that take time without adding value to the product. "Anything in production that does not add value is considered to be a form of waste" [21]. In connection with the setting up of lean processes at the ocean port, we can identify according to the 7 types of losses the following attributes:

- Overproduction – Containers imported by port terminal with limited real time schedule and unavailability of storage place causing planning errors and congestion.
- Waiting – Planning errors and rehandling causing delay due to custom examination.

- Transportation – Truck scheduling and multiple handling at the yard.
- Over processing – Scanning and examination due to customs risk management system.
- Inventory – Handling at empty yards, freight stations and their maintenance.
- Unnecessary motion – Reshuffle and rehandle of the container at the yard.
- Defects – Container delivery on account of a truck appointment system.

To create a lean port, it is important to create a system where the bottlenecks, defects, and other wastes are identified [7]. To identify the wastes, the tool called VSM that depicts the order of all steps of the process (including information flow and materials flow) is used [1]. The purpose of this tool is to determine value-added activities [22,23] and to identify the "potentials for improvement" [24]. Although transportation is a value-added activity in general [22], the understanding that some of the activities within the process are wastes is crucial. [25] performed a study where they indicated that for operational performance, the most important tools are Just in Time and Automation, while TPM, VSM and Kaizen could lead to less effective or even negative results. The successful results from the implementation of lean and VSM across industries have also been demonstrated [26].

All the activities within a process in VSM are divided into 3 groups: value-added, non-value-added but indispensable and purely non-value-added [27]. Value-added activities are important for our customers from the point of view of creating the final product. Non-value added are activities that are unnecessary in the process and could be eliminated fully [27]. Non-value-added but indispensable are the steps in the process that, although they do not improve our product from the consumer point of view, are compulsory for the completion of value-added activities [7].

VSM is used not only to understand the current process but also to plan the process improvement. Thus, two types of VSM exists – current state VSM and future state mapping. The current state VSM depicts the existing process with its value-adding activities and non-value-adding activities, and it helps to understand the most important problems [28]. The future state VSM represents the situation when the non-added-processes (or wastes) are eliminated [1]. The collection of the initial data, its analysis and transition into future state maps is an essential part of VSM. The optimisation of the value stream map is managed by a key indicator – the value-added index. It represents the ratio between productive and unproductive lead times in the complex process flow.

Considering the above mentioned, VSM could provide sufficient information about the process from the point of view of its analysis, of its further usage and planning and also for measuring the process cycle efficiency.

Value stream mapping – research literature review in the container and port logistics

The research on value stream application in container and port logistics is very limited. The research studies have been performed from the perspective of lean principles, agility, waste evaluation. A detailed illustration of research studies on value stream mapping and container logistics is detailed in Table 1.

The main objective of this research study is to understand and analyse the import process of container handling in a port terminal and then evaluate the detailed time taken for each of the processes as detailed in Figure 2. Adequate diagnostics of the causes of efficiency losses will be the basis for the setting of a future value stream map. Subsequently, performance parameters in the form of process efficiency along with value stream mapping and waste calculation are performed by analysing the data collected from the container terminal. The main theoretical and practical contribution of this research study is in better understanding of container port terminal process for handling import containers utilising lean six sigma principles. As the research conducted for value stream mapping in a container terminal is very limited, the results have provided various directions for future research.

Table 1 Research studies on container logistics and value stream mapping (Source: Own research)

Author	*Methodology*	*Sample and period of study*	*Independent variable*	*Dependent variable*	*Outcome/Suggestion*
Marlow and Paixão Casaca (2003) [7]	*Performance measuring*		*Knowledge*	*Port agility*	*Proposed framework for agile ports*
Paixão and Marlow (2003) [18]	*Literature review*	*Other industries*	*Lean and agility*	*ports, logistics*	*Proposed methodology based on internal and external integration*
Taylor(2008) [29]	*Action research methodology*	*Texton company*	*Current state map: product and information flows*	*KPI*	*Future state map was developed, KPI improvement*
Chen, Cheng and Huang (2013) [30]	*Value stream mapping of material flow,*	*Storage and retrieval SKU's in a warehouse.*	*Value stream mapping*	*Inter logistics warehouse operations*	*Operations time handling made efficient by the*

	information flow and process flow				*implementation of RFID through the insights from value stream mapping.*
Olesen, Powell, Hvolby and Fraser(2015) [31]	*a theory-building approach combining aspects of lean- and intermodal transport theory with practical insights*	*container facilities within the Scandinavian region*	*Lean principles*	*Material flow in container facilities*	*Proposed framework*
Sánchez, Buiza, Beltran, Stanley, Veloqui, Cerbán and Turias (2015) [1]	*Combination of VSM and numerical modelling by using MATLAB*	*Mediterranean Ports and logistics areas (Algeciras and Naples)*	*VSM and MATLAB*	*Post efficiency*	*Improvement's proposals, simulation model*
Kusrini and Parmasari (2020) [8]	*Waste Assessment Model for VSM, improvement using SMED and 5S*	*Port Companies in Indonesia*	*Wastes*	*internal setup time, efficiency of the goods procurement process*	*Reduction of internal setup time of 57,33%, increase in efficiency from 60,81% to 70,20%*
Dewi (2021) [32]	*Statistical method in the form of lean six sigma for exception containers.*	*Containers entering port and excepted by gate automation system*	*Lean Six Sigma*	*Gate automation system containers*	*Identification of low efficiency of gate automation system operations*
Wang, Yin, Khan, Wang and Zheng(2021) [10]	*Logistics system model on JIT and linear modelling for lean production*	*Cruise shipping*	*Modelling on lean production methods utilising JIT and linear modelling*	*Cruise shipping logistics*	*Variations of optimal inbound logistics mode over three different kinds of cruise parts*

3 Research methodology

The given research is based on both qualitative and quantitative research approaches. As the quantitative part, it considers results and data of real-time operations data that is collected from the secondary reports of DMICDC logistics data services through their portal www.ldb.co.in and discussion with the port operations managers to identify the import transaction process along with average time handled per container. This provides the quantitative information connected with the process being analysed with detailed information about time spent on every step of the process. The qualitative part is related to the analysis of the gathered data and the interpretation of the results by the specialists. The research also comprises a literature review part as an attempt to better systemise and analyse the information already available on the topic of the research.

The gathered data is analysed with the usage of one of the tools connected with Lean and/or Lean Six Sigma, which is called Value Stream Mapping (VSM). The data of the process that occurs in the port was divided into three major parts -Vessel Operations, Yard Operations and Gate Operations - and then each of the mentioned parts was analysed separately for the process efficiency. Conclusively, the common pattern was also developed where all three-part were analysed as one process.

As the availability of the data for the sub-processes of container handling from vessel berthing to gate out operations is limited, port managers were asked to analyse the processes for the wastes appearing in the course of the process. For this purpose, a table comprising the explanation of the wastes type was developed by authors and delivered to port managers. In this work, the port managers were also asked to analyse the amount of time connected with those wastes and if the mentioned wastes could be avoided or limited in the process. Based on this data, the VSM was developed where the efficiency of the processes was shown and, consequently, the process cycle efficiency was calculated. A general representation of the steps of the analysis used for the research is depicted in Figure 3 for detailed understanding. As it is illustrated in Figure 3, the research consisted of 7 steps starting with the development of the table for waiting time analysis and finishing at the propositions to evaluate the waste in the Process Cycle efficiency in ports of India.

VALUE STREAM MAPPING OF OCEAN IMPORT CONTAINERS: A PROCESS CYCLE EFFICIENCY PERSPECTIVE

Mohan Saini; Anastasia Efimova; Felicita Chromjaková

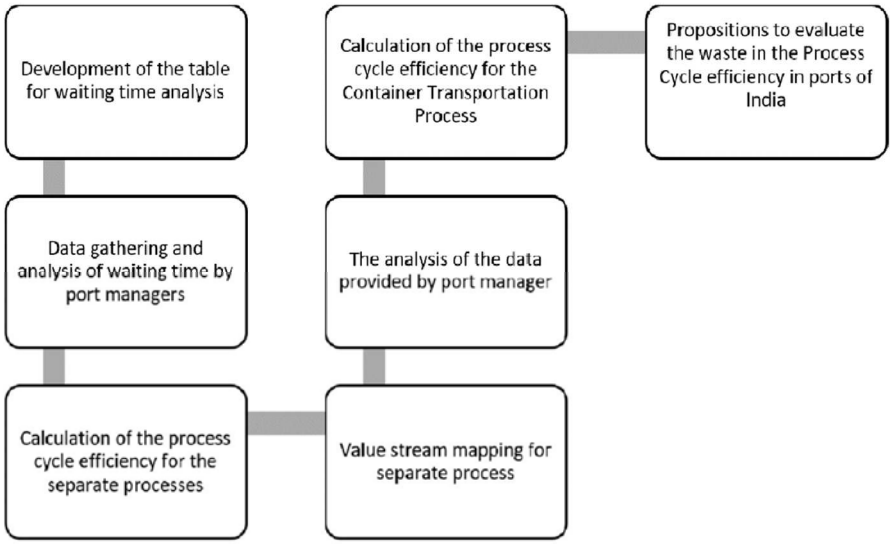
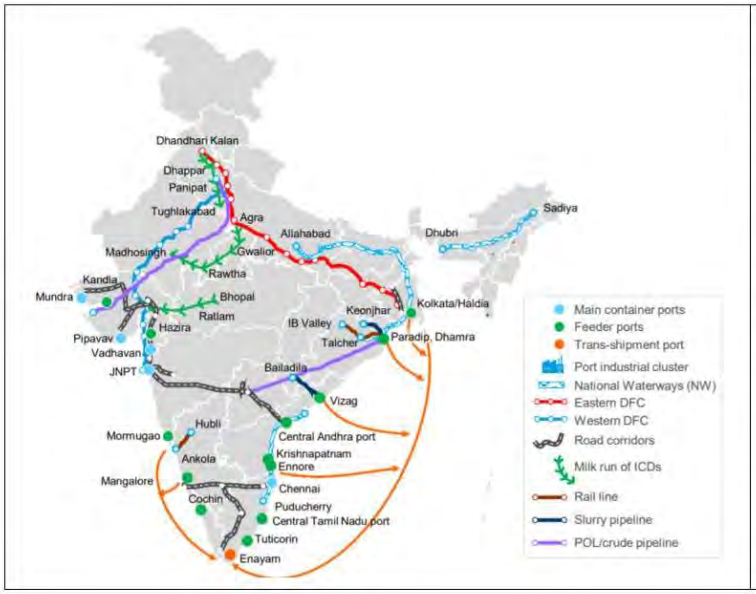


Figure 3 Process of the research analysis

3.1 Process information, data analysis and results

The detailed process for import container handling from vessel berthing to gate out was discussed in detail with the port operations manager. The discussion provided details of every micromanagement which is performed by the container terminal operator for the handling of the container cargo. This process is a complex handling operation and requires material handling equipment which is heavy duty and have to be managed by skilled manpower. Right from the starting of handling vessel berthing to quay cranes handling, this handling of the container during import transactions passes through various sub-operations processes. These sub-activities have been discussed in this paper along with the comparison for the overall dwell time of container spend in the container terminal operations. We have identified that most of the time of the container is spent in the terminal yard either waiting for inspection, scanning, examination, further connection to the next operator, which causes the dwell time to be as high as 24 – 72 hours for the truck and train bound containers. Figure 4 illustrates the dwell time at all the major ocean ports of India. We can understand from the data of December 2020, January 2021, and February 2021 that dwell time varies from as low as 17 hours to as high as 93 hours. Such a high gap in dwell time calls for a study to understand the subprocess and identify the reasons for such a variation in the inefficiency of container handling.



Port	Avg. Dwell time (In hours)
Kandla	39
Mundra	27
Hazira	28
JNPT	26
Mangalore	73
Cochin	56
Tuticorin	23
Chennai	64
Ennore	84
Krishnapatnam	58
Vizag	44
Haldia	90
Kolkata	32

Figure 4 Dwell time comparison at India Ocean ports (Source: [33])

As it is illustrated in Figure 4, the dwell time in different ports in India may vary greatly from 23 hours in Tuticorin to 90 hours in Haldia. As we understood this variation in dwell time of import containers across the ocean ports of India, we carried out a study to understand the detailed process of import container handling at ocean ports and find out the time taken by each process from vessel berthing to gate out and calculate the process efficiency and draw a future value stream mapping for the container handling. The process timelines as defined by the port managers are detailed in Table 2.

Table 2 Summary of handling time, value-added time, waste time and total dwell time (Source: Own research)

Process	*Net Process handling time (In minutes)*	*Value-added time (In minutes)*	*Wastage time (In minutes)*	*Dwell time across ports (In minutes)*
Vessel Operations + Yard Operations + Gate out operations	*636*	*133.5*	*502.5*	*2940*

As we can observe from Table 2, there is a wastage in container handling across terminals due to various factors. Actual handling time (average time obtained via practical data gathering) without any delay for the container is equivalent to 335 minutes; however, due to waiting delay and other complexity associated with handling bulky containers increases the overall container handling time to 2640 minutes (average time based on the discussion with port managers).

To understand how efficient the process is, the process cycle efficiency (1) was calculated according to the formula [34]:

$$Process\ cycle\ efficiency = \frac{Value\ added\ time}{Total\ lead\ time} \quad (1)$$

In our case, total cycle time is taken as Net Process Handling time as the net process could be influenced (2).

$$Process\ cycle\ efficiency = \frac{133.5}{636} = 0.21 * 100\% = 21\%. \quad (2)$$

Thus, in general, the process is not efficient. According to the opinion of specialists that participated in the research, the major reason for the inefficiency is waiting at the gate as the number of containers does not correlate with the number of gates. There is congestion connected with the smooth flow of the process. Although there are variations in Net Process Handling time, the process needs amelioration.

3.2 *Future value stream map*

Based on the information that was gathered from port managers along with data analysis, future value stream mapping was proposed, where the process is depicted without unnecessary wastes but with the usage of the technologies that are already present in ports. The process cycle efficiency (3) increases from 16% to almost 40% for the improved process, as could be seen in Appendix II, where the value stream map of the improved process is presented.

$$Process\ cycle\ efficiency = \frac{133.5}{335} = 0.40 * 100\% = 40\% \quad (3)$$

This illustrates the process cycle efficiency of 40% and thus examines the importance of technologies for industry 4.0 for identifying this waste and improving upon it. Various types of delay reasons as briefed by port managers are illustrated in Table 3.

Table 3 Major challenges identified for waiting and waste (Source: Own research)

Import container delivery		
Direct Importer	***Container Freight station***	***Inland Container depot***
Customs readiness	*Statutory clearance*	*Container scanners*
Custom duty unpaid	*Readiness or availability of transportation*	*Manual scanners*
Storage capacity with the consignee	*CFS Availability*	

4 Discussion

Technological change is influencing the environment from many perspectives, including the port systems. To be able to respond to market demand, the port should be proactive rather than reactive [18]. One of the ways to achieve it is to use existing process optimisation tools such as VSM, the usage of which was applied in this analysis. The usage of VSM helps to visualise the process and propose a more fitting amelioration. As visibility increases, the connectivity of supply chain elements [7] this paper proves that even complex port processes can be operated more efficiently.

The data analysis and discussion with port operation managers illustrated the challenges of higher dwell time at container terminals. Figure 6, depicts the value stream mapping as a visual representation where the comparison of time for the time taken, value-added, and wastage is illustrated. The green bar depicts the value-added time and the grey one's wastage time. Import containers that are handled from the vessel berthing to gate out operations generally take 335 minutes of handling time, including wastage identified due to customs examination. However, the challenges of rail connectivity and schedule, customs

examination, automated scanners, which are expected to cause a delay from 8 hours to 36 hours on account of peak volume, contributes to the median dwell time of 44 hours in handling a container import operation.

A research study evaluated the truck congestion time and reducing waiting time at the terminal for improving efficiency, a part of the complete process was studied to evaluate the efficiency [35]. Another research on six sigma approaches for straddle carrier routing problems utilising VSM to understand the process in detail [36]. This research study has evaluated the process from container berthing to gate out and thus developing a future value stream mapping with improved process cycle efficiency. Research on unit container terminal productivity [8] suggested that the major wastes are unnecessary motion and transport of documents in-unit terminal containers. In this paper, the major waste was identified as waiting, which can contribute to the ports wastes understanding. A research study based upon decision making demonstrated that digital platforms could bring significant changes in inspects and detention charges which are on account of delayed processing such as customs and examination [37].

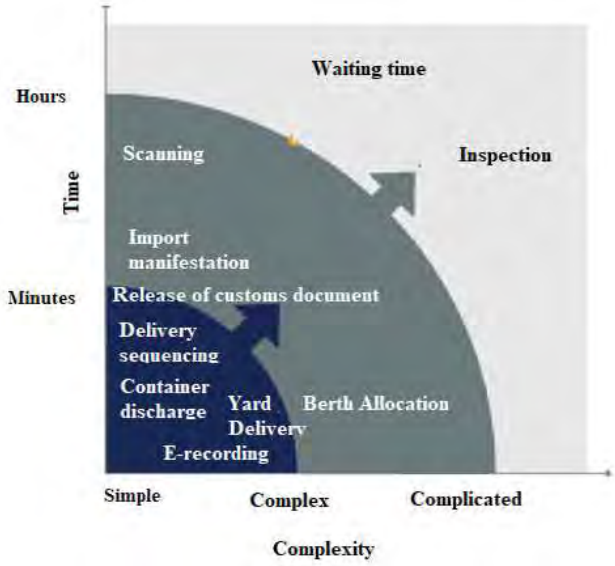


Figure 5 Process complexity model (Source: Author)

Figure 5 illustrates the process-wise complexity model, which is related to the process efficiency from a time and complexity perspective. This model might complement the understanding of the process timing and complexity. Various processes of container handling have been depicted in Figure 5, representing the simple to complicated from the time of operations taken. As we can see, the processes such as inspection and waiting time due to dealing are the most contributed processes for wastage. The port managers illustrated upon challenges of the throughput capacity of quay cranes which can manage 30-32 moves per hour for the unloading of containers to RTG (rubber tyre gantry cranes), which can perform 20 movers per hour are affected during traffic congestion. The operational strategies of twin lift mover are performed to ensure the efficiency of container handling. However, due to the complexity of handling and unavoidable delay, the gross crane rate was reduced, causing a severe impediment on the container handling efficiency. The manager performs various advance planning strategies for the bay plan, vessel stowage plan, considering total stack weight, loading sequence and weight factor. However, various complex handling due to multi-stakeholder causes the operations inefficient.

The confluence of Lean and Industry 4.0 improves the quality, efficiency and flexibility [38]. For marine ports, Industry 4.0 technologies in the form of gate automation, yard automation, and mobile scanners are getting the attention of the container terminal operators, contributing to performing measures that can improve the efficiency and reduce the handling time of containers.

5 Conclusion

This study incorporated a mixed research study in which the process of import containers data is collected from one of the visibility projects in India, logistics data bank, and the respective port managers are discussed for understanding the process cycle efficiency of each subprocess. A detailed data analysis of logistics data bank project along with data collection from port managers for subprocess and detailed value stream mapping understanding for process cycle efficiency was calculated (Appendix I).

The process cycle efficiency of 40 % was evaluated for the import handling containers in which the actual time of handling container with the continuous process is 335 minutes; however, due to the complexity of container handling and other challenging process and delay, the total handling time reaches 2640 minutes A time window equivalent to 335 minutes of handling time which includes wastage or delay on account of delayed customs examination, rail connectivity and schedule, customs examination, automated scanners increase the total dwell time to 44 hours. The results are important for the study from the perspective of mapping industry 4.0 technologies which can assist in reducing this waste and thus increasing the efficiency of container terminals. The future study will focus on understanding the export and transhipment process through a similar process and benchmarking the results with the other high performing ports at the global level. The limitation of this study is the regional level study at the level of India and specific ports for the data and discuss availability.

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Review process
Single-blind peer review process.

Appendix I

Table 4 Subprocess and time took while handling each activity

Process Type	Process	Type of Process	Average Handling Time	Average Handling Time (Future VSM)	Average Dwell Time (in hours)
Vessel Operations	Vessel Import manifestation	Major	75 minutes	75 minutes	**49**
	Berth allocation to the vessel	Major	30 minutes	30 minutes	
	Container discharge to the quay	Supporting	2.5 minutes	2.5 minutes	
	Inspection of the containers	Supporting	480 minutes	180 minutes	
	E-recording	Others	1 minute	1 minute	
	Delivery sequencing generation	Supporting	2 minutes	2 minutes	
Yard Operations	Delivery to the yard	Supporting	4 minutes	3 minutes	
	Receipt of delivery order of sealed container customs for the release and container is delivered to the Port Authority	Others	3 minutes	3 minutes	
	Release of clearance document by terminal	Supporting	5 minutes	5 minutes	
	Update of container details along with Bill of Lading details in system and releases delivery request form (DRF) to CFS agent	Supporting	10 minutes	10 minutes	
	The yard dispatcher dispatches equipment to load the import container onto the truck	Supporting	10 minutes	10 minutes	
Gate Operations	Weight and other truck-related processes at gate operations	Supporting	5 minutes	5 minutes	
	Verification by In-Gate staff on the consistency of the documentation details	Supporting	1.5 minutes	1.5 minute	
	Verification by Out-gate staff on the consistency of the documentation details	Others	2 minutes	2 minutes	
	Verification of truck loading weights	Others	5 minutes	5 minutes	

Appendix II

Figure 5 Future Value stream map (Source: Author)

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CONCEPTUAL FRAMEWORK FOR HEAVY-DUTY VEHICLE PLATOONING IN PHYSICAL INTERNET SYSTEMS
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Abstract: One of today's most significant challenges is sustainability, which is closely linked to environmentally friendly solutions and resource efficiency. As a solution to these goals, the concept of the Physical Internet emerged, defining the logistics network of the future as a global, open, and interconnected system. Concerning the conditions of vehicles based on Physical Internet-based systems, we cannot ignore the latest vehicle technology innovations that appear more and more intensively in parallel. The framework proposes planning at the strategic, tactical, and operational levels. Different levels of coordination implement different approaches to platoon coordination in line with the network architecture of PI-based logistics systems. We recommend the highest level of offline design in fixed π-hubs. The tactical level involves designing π-hubs online. We propose the implementation of speed-based solutions at the operational planning level.

1 Introduction

One of today's most significant challenges is sustainability, which is closely linked to environmentally friendly solutions and resource efficiency. As a solution to these goals, the concept of the Physical Internet (PI, π) emerged, defining the future logistics network as a global, open, and interconnected system. The most significant breakthrough comes from the new mindset that the operation of Physical Internet-based systems breaks with traditional storage, movement, and transportation solutions. The Digital Internet inspired methodological solutions based on new principles. The Physical Internet transfers the flexibility and standardization that comes from the Digital Internet to the physical world. The global vision requires functioning within a single cross-border system, the foundations, principles, and requirements that anyone can openly access [1]. By sharing resources, data, and designing centres for seamless interoperability, freight transport is optimized in cost, speed, efficiency, and sustainability. In order to achieve better logistics efficiency and sustainability, PI is evolving extraordinarily, found in all elements of technological innovation [2]. Given the growing number of PI publications and the growing global investment in PI-related projects, PI is becoming increasingly important in scientific and practical.

Concerning the conditions of vehicles in the Physical Internet systems, we cannot ignore the newer vehicle technology innovations that appear more and more intensively. Modularity and flexibility, which vehicles must also meet, will be central to the future logistics network. This article reviews the impact of autonomous-, electric-, shared-, connected-vehicles, and platooning concept on the PI system among the emerging automotive trends [3].

Based on our research, one of the promise innovation areas is platooning concept. The implementation of platoons in a natural environment is expected to get closer, so there is a growing need to define concepts for organizing platoons. There are several publications about platoon coordination. To our knowledge, this work is the first to provide a general framework for the coordination of platoons in a PI-based logistics network.

In this paper, following the introduction, we first review the impact of automotive trends on the Physical Internet, and then in Section 3 we summarize the relevant literature solutions for the coordination of platoons. Section 4 presents the conceptual framework, which is detailed in Section 5. In Section 6, we summarize the main findings of the article and also discuss future research plans.

2 Impact of automotive trends on the Physical Internet

In the history of humanity, we can say that vehicles have radically changed the earth's natural environment [4]. In recent years, the automotive industry has undergone significant transformations, which is perhaps the main reason for the rapid emergence and integration of innovative information and communications technology solutions in this area as well [5]. Physical Internet is also a paradigm shift in terms of transport, as according to the concept built on the Digital Internet metaphor, freight

would be exchanged as seamlessly as data over the Internet. In examining the concept of the Physical Internet, it would be impossible to separate it from the automotive aspects of the system. By imagining an ideal system, vehicles as modular units of the PI-based logistics network operate energy-efficiently, are interconnected, and have maximum utilization while reducing noise pollution and environmental and air pollution [4].

In the automotive industry, various development guidelines can be defined entirely independently of the field of logistics, of which the most important trends for the Physical Internet will be reviewed in the following: autonomous vehicles, shared vehicles, electric vehicles, connected vehicles, and platooning systems. The increasing sharing of vehicles and the spread of emerging autonomous and electric vehicle technology can disturb the functioning of transport systems, especially when combined with platooning transport. Much of the recent research has focused on improving the quality of existing transport systems and services and designing new methodologies that offer a more sustainable ecological approach and address the challenges generated by growing demand. Cross-sectoral cooperation offers an excellent opportunity to improve the quality of transport services [6].

Autonomous vehicles, especially their partially automated versions, are increasing focus in industrial and research areas [7]. Automated technology is considered an innovation to introduce eco-driving and energy-saving features, more stringent safety and security standards in the future [4]. However, despite its current popularity, there are still several unanswered questions associated with it. Fully autonomous vehicles are of enormous importance for future logistics and are expected to transform the practices known for decades.

Research on **shared mobility** is one of the automotive trends [6]. The advent of the Physical Internet will allow shared transportation by creating a dynamic and flexible network. Companies can gain a competitive advantage by not only using access to their resources efficiently. Thus, in the Physical Internet, the idea of sharing is by no means an unknown or new concept. It can be said that the idea of sharing is part of the Physical Internet [3]. Sharing maximizes resource utilization.

Research into the use of **electric vehicles** is more common within the city due to shorter distance requirements [7]. In a Physical Internet-based network, the goal is for drivers to stay as close to home as possible, so they only need to travel short distances. With this goal in mind, electric vehicles can be considered a highly relevant area, as their benefits are well integrated into the planned open, global hub-and-spoke system [3].

Nowadays, the essential feature of a **connected vehicle** is that it can communicate via the Internet and thus interact with other intelligent objects, which may extend to other vehicles, traffic signs, or other infrastructure elements [4]. Modularity and flexibility, which vehicles must also meet, will be central to the future PI-based logistics network. Development guidelines for coupled vehicles are of paramount importance in PI-based logistics networks. The PI concept embodies the idea of a global interconnected network. The innovation of connected vehicles based on a similar theory is, therefore, a well-integrated system. In such a system, the entities within it (people, machines, and even infrastructural elements) can continuously communicate. The aim is to strive for a constant optimum while resolving a current situation. Figure 1 illustrates the connection system of interconnected vehicles in a network of Physical Internet π-hubs.

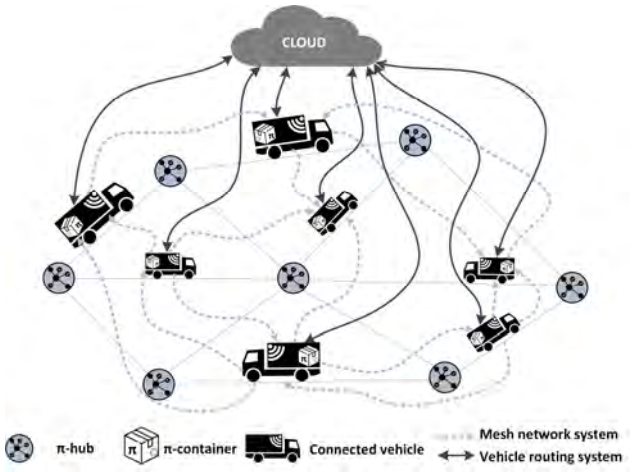

Figure 1 Cloud-based connection system of interconnected vehicles in a network of Physical Internet π-hubs based on [8]

Reducing extralogistics shipments, which has increased significantly over the past decade, has become key for environmental and economic reasons. According to studies, fuel costs account for about 30% of the life cycle costs of trucks [9]. Furthermore, a quarter of the significant 20% of CO2 emissions from vehicles can be attributed to trucks [10]. In general, 82% of roads are unoccupied due to traffic density, which is due, among other things, to compliance with the mandatory distance required by the rule [11]. A promising approach to reducing fuel consumption is to drive **vehicles in a platoon**, which is a kind of transition between autonomous and conventional transport. The essence of the technology is that the trucks move in close succession, in parallel with which they increase energy efficiency and reduce road occupancy [12]. The PI-based open, global logistics network creates the common platform needed to organize vehicles, even in cross-company collaboration.

Vehicles travelling between PI terminals can also communicate within specific scope through communication, resulting from which they can take into account each other's goals. Depending on the platoons' capacity (the number of vehicles in a platoon), it would even be possible to connect on the road. This would even admit dynamic and flexible modification of preliminary plans. By defining virtual transhipment points (virtual π-hubs) between fixed π-hubs, platoons can change their

vehicles. This allows platoons to reconfigure their composition as they make their way. Recombination of platoons can further increase the flexibility of the system [13,14].

3 Literature review

The whole platoon problem consists of many different layers: global, regional, and local control. Figure 2 provides a general graphical overview of the characteristics and main properties of the layers. This figure illustrates the three main problem areas, which, although very different, are all necessary to take full advantage of the concept of teams. The local layer deals with the actual control of each vehicle. In the regional layer, we interpret the coordination of platoons by dynamic route planning or speed change. The top global layer deals with general scheduling and allocation tasks.

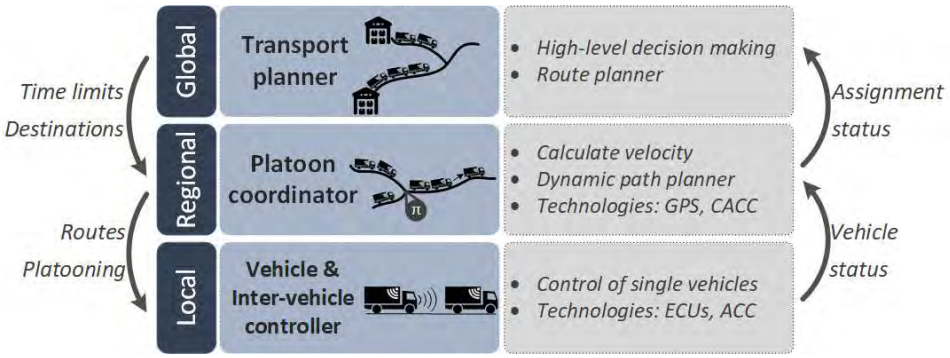

Figure 2 Layers of the control structure of platoons

There are several publications on platoon organization solutions, of which a summary table is in [15]. Among the related works presented in our article, our goal is to show the achieved results and methodologies through the diversity of solutions. It can be said that most publications deal with online organizations, and there are fewer offline operation algorithms. There are two groups of online solutions, which are hub-, and velocity-based approaches.

An example of a hub-based solution can be seen in C. Kammer publication [9], where the main idea behind the methodology is to divide the problem into several smaller sub-problems, as the original solutions have an unmanageably long runtime when handling a large number of cases. An example of the basis of their solution is shown in Figure 3, where a local controller (green dashed square) controls the arriving heavy-duty vehicles (HDVs). The local manager decides which truck to go to and where to catch another truck. There are different ways to set up a local controller problem [9].

In publication [16], the authors examined the problem of vehicles waiting at nodes in a transport network to travel with others on a platoon. They develop two models: one with deterministic and one with stochastic travel time. The simulation study showed that the uncertainty of travel times significantly impacted grouping speed and that clustering can bring notable benefits at the societal level, even if vehicles design to optimize their profits.

The other standard solution structure is to change the vehicles' speed to get close enough to each other to create a platoon. In publication [17], they present a coordinated model with multiple speed options that integrate scheduling, routing, speed selection, and section design/resolution. For problems with many vehicles, they propose a heuristic decomposition solution, in which the algorithm breaks the vehicles into a smaller set. They evaluate that if the set of the vehicle is large and the available computation time is small, the decomposed approach will find significantly better solutions [17]. In publication [18], they suggest allowing the following vehicle to drive faster to catch up with the leading vehicle. This approach can increase the frequency of creating platoons, as many HDVs do not have the exact origin and destination with the same time window. The algorithm provides the fuel recovery required to control catching up by defining a range. They define the scope derived from the route length, within which the methodology examines the connection to the platoon, as illustrated in Figure 4 [18].

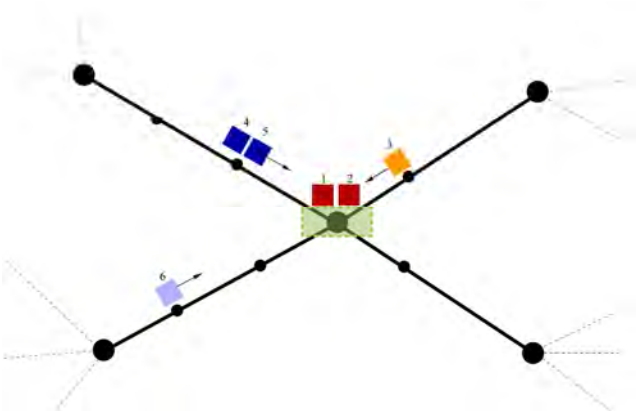

Figure 3 An example of HDVs driving towards a junction with a local controller node [9]

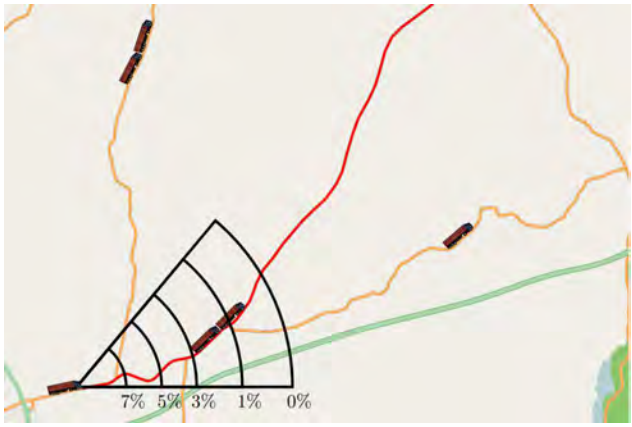

Figure 4 Cones (for illustrative purpose) of fuel-saving potentials if the HDV decides to catch up and form platoon [18]

Given the apparent complexity of platoon organization, it is not surprising that some artificial intelligence-based approaches have also emerged. The problem is very complex and has proven to be NP-difficult in different versions [11]. In publication [14], authors use a reinforcement learning methodology to facilitate collaboration between platoons. There is also a proposal for a local-, ant colony-based solution in the literature, where individual vehicles are independent and able to make decisions based on their speed and orientation [10].

Most publications approach the coordination of platoons with one type of solution, besides only a few papers setting up the framework for management. A framework presented in [15] consists of a platooning-enabled vehicle (operational level), a platoon manager (tactical level), a coordinator (strategic level), and a fleet management system and transport management system (service layer). The level of abstraction, geographical size, and time scale increase from bottom to top [15].

We can see several solutions for organizing platoons, which have in common that, due to the complexity of the task, they are looking for local solutions to achieve a globally sustainable system. Considering the presented solutions and the main features of the framework proposed in reference [15], a comprehensive, conceptual framework is presented in the next chapter, considering the structure of the Physical Internet-based logistics network.

4 The conceptual framework

In this chapter, we present the conceptual framework, which is detailed in Section 5. When defining the framework, we take the structure of the logistics network provided by the Physical Internet and provide a theoretical structure for the organization using the possibilities provided for the coordination of the platoons.

The Physical Internet logistics network consists of connected fixed and virtual π-hubs. For sustainability, defined as a goal in the future, the Physical Internet proposes hub-based operation to achieve a flexible and efficient operation. An essential consequence of hub-based operation is that transports by HDVs are interpreted exclusively between π-hubs. Thanks to the global cooperation available through the open and global logistics network, the sharing and interconnection of vehicles as resources can be achieved by applying the expected unified management system. The establishment of platoons contributes to resource-efficient operation, which can reduce fuel emissions and thus pollution. Virtual π-hubs that complement fixed π-hubs have no setup cost, no infrastructure, and can be interpreted dynamically on any node in the network. The Physical Internet system places particular emphasis on the alternative routing issue. Routes that exist in the world of the Digital Internet can be static or dynamic [8]. In the case of static routing, the nodes forward data through predefined nodes. Dynamic routing means that the nodes in the network are responsible for finding the best route. PI centers can be mapped as Digital Internet nodes (routers). These transit points do not necessarily have to be static. Virtual π-hubs can provide a possible design solution [8].

Platoon coordination options can be divided into two main groups: off-board and on-board. The former provides a statically defined load schedule from the platoons formed from vehicles starting from one place. There are no predefined platoons for the latter type but use real-time data to create new, unplanned platoons for a more sustainable system to operate. Based on the publications, we distinguish two main options for the on-board case: catching up with a truck or waiting for a truck [19]. In the former case, HDVs change their speed to get close enough to each other to form a platoon. In the latter case, the vehicles are waiting to form a platoon with oncoming vehicles. The advantage of this is that it is possible to form platoons more predictable and safer than the velocity-based case, where traffic disruptions can prevent the planned speed changes [20].

For the defined platoon organization solutions, we represent the road network as a directed graph $R = (i, \varepsilon)$ where i represents the nodes and $\varepsilon \in i \times i$ corresponds to the edges. The graph's nodes represent the intersections or endpoints of the road network, and the edges represent the road sections connecting these points. The function $L(e)$ maps the lengths of all edges ε. The location of the vehicles is determined by the pair $(e, x) \in \varepsilon \times [0, L(e)]$, where e is the current road section and x is the distance the vehicle has already travelled within the given segment. The set of vehicles is denoted by N, in which the index n illustrates the parameters for each vehicle. The graph representation is illustrated in Figure 5 [15].

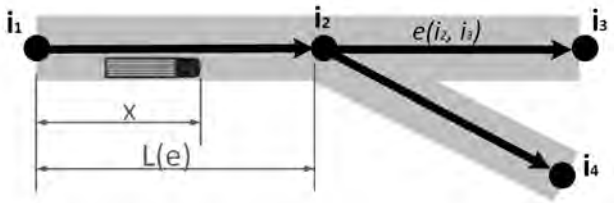

Figure 5 The road network represented as a directed graph [15]

The amount of weight assigned to the graph's edges represents the objective function. For each of the platoon coordination solutions, we want to achieve a minimum of the objective function, which is formulated as follows based on the [14] publication:

$$\min \mathrm{C}(\theta) = \mathrm{C_f}(\theta) + \mathrm{C_t}(\theta) + \mathrm{C_p}(\theta) \qquad (1)$$

where $\mathrm{C_f}(\theta)$represents the fuel cost, $\mathrm{C_t}(\theta)$ is the cost of the waiting, and $\mathrm{C_p}(\theta)$ represents the driver labour cost of the platoon leader and θ represents a set of decision variables. Taking into account the formulated coordination grouping and objective function, Figure 6 illustrates the framework for the coordination of platoons in the Physical Internet-based logistics network.

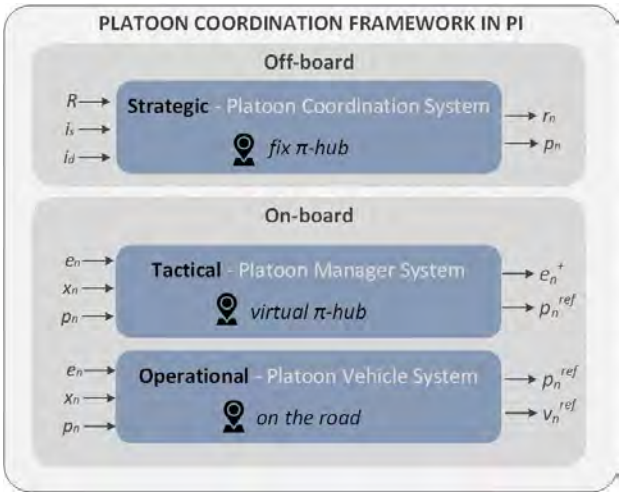

Figure 6 Platoon coordination framework in Physical Internet system

The framework divides the coordination of platoons into two main groups: off-board and on-board. In the case of off-board, we interpret the strategic-level planning performed by the Platoon Coordination System in fixed π-hubs. Graph R representing the network, and the starting stations i_s and end stations i_d belonging to the vehicles are the inputs for control. From these data, the system creates a static plan for the vehicles departing from the fixed π-hub. The solution consists of a p_n platoon plan and a r_n planned route $r_n \in R(i, \varepsilon)$. This planned route is an introductory guide to the vehicles with the expected arrival times, which can be modified later to minimize the target defined in the objective function.

This modify is conceivable by the on-board options defined in the framework. In the case of on-board, we distinguish two levels. On-board coordination requires a continuous, real-time data service provided by a cloud-based data service in the Physical Internet system. The information required for control comes from the connected vehicles in the system. If the vehicle does not have such a connection, the driver sitting in it can easily connect to the Internet on his personal mobile device. In this way, vehicles on the road play a role in decentralized, real-time decision-making. Based on the result of the paper [8], the most appropriate solution may be the information provided by the vehicles, as the vehicles already have a primary on-board computer. The data collected is beneficial to programmers if it is in one place where a cloud-based solution seems appropriate. This would create a virtual marketplace for PI users.

The length of the platoon defines how many vehicles connect in a group. If the platoon value is 1, the vehicle is moving independently. If the platoon value is greater than 1, then in the case of on-board coordination, the lead vehicle decides on the rest, taking into account the other vehicles' goals in the group.

The first on-board case is the tactical planning that the Platoon Manager System performs on virtual π-hubs. To do this, the Platoon Manager System uses vehicle information, which is the edge represented by $e_n$where the vehicle is travelling, the distance x_n travelled on the road section, and the platoon p_n that contains the vehicle. Based on the input information, a modified path segment (e_n^+) and the new platoon ID (p_n^{ref}) are determined if there is cooperation with another platoon in the virtual π-hub.

The other on-board option is a platoon merger on the road accessible by speed change by the Platoon Vehicle System at the operational level. Its input parameters are the same as those of the Platoon Manager System at the tactical planning level. On the other hand, its output is a modified speed (v_n^{ref}) due to the possibility of changing the speed, which is necessary to connect to the other platoon and the new platoon ID (p_n^{ref}). The strategic, tactical, and operational levels are described in more detail in the following section.

5 Discussion

5.1 Platoon coordination system

Fixed π-centres organize platoons solely by considering the vehicles arriving there. The goal is to create an optimal platoon design that considers the objective function defined in Equation (1). It means it deals with the amount of detour required by the platoon members, the waiting times, and the platoon lengths as well. The platoon lengths impact the driver labour cost because if the platoon is longer, then it needs fewer drivers.

The control panels detect approaching vehicles through the flow of cloud-based information, which allows vehicles that are not yet physically in the center but already have a predictable arrival time with less uncertainty to be considered in the design. Accordingly, as part of strategic-level planning, platoon plans are prepared in a time zone per shift or day. The information used as input to the system is the graph representing the road network and the vehicles' locations of departure and destination. The algorithm required for platoon coordination is a future research direction, which determines the maximum waiting

time and the amount of detour in each vehicle, keeping in mind the objective function.

The benefit available depends on the platoon leader or follower status. In the case of a follower vehicle, we can expect savings of 5-15%, and in the case of a leader, it is not so recommended to calculate savings [11]. Building on cooperation and trust, PI's system creates an organization independent of the manufacturer and owner of the vehicles arriving at the center, which, according to the publication [20], can even double the benefits of the platooning concept. An example of a platoon organization between fixed π-hubs is illustrated in Figure 7 [21].

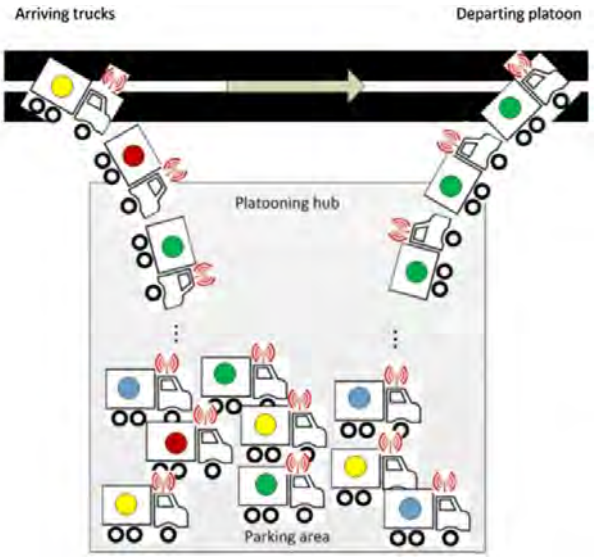

Figure 7 Fix π-hub based platoon coordination [21]

The independent operation of fixed π-centers, i.e., the absence of cooperation with other centers, is due mainly to the complexity of the task with a high degree of uncertainty induced by congestion, weather conditions, and other factors [11]. It has been investigated in several publications that the runtime of the constructed algorithm extends beyond the manageable extent, increasing the complexity of the task. Therefore, considering the results summarized based on publication [9], we propose local optimization to achieve the global goals in the operation of this framework.

5.2 Platoon manager system

In addition to the fixed π-hubs, the PI system consists of a system of virtual π-hubs, which can be defined, for example, at road junctions. This makes the logistics network a more flexible system, as it can increase the number of nodes, allowing for reorganization to reduce costs and achieve a more sustainable system.

Thus, virtual π-hubs provide an opportunity to connect platoons and reduce the detour by reconfiguring the vehicles [13,14]. In the case of virtual π-hubs, waiting is required for platoons to connect and reconfigure. With a continuous navigation system, the vehicles follow a constantly updated route plan. The basic algorithms used for route planning are time-consuming, so we propose the Dijkstra algorithm for this based on the publication [22]. Using the Dijkstra algorithm, we propose to design the dynamic route of the platoons. The objective function at the edges considers the cost reduction induced by the possibility of connection with the existence of the platoons on it. To this end, by [18], vehicles would consider other platoons within a predetermined radius only to avoid excessive waiting times.

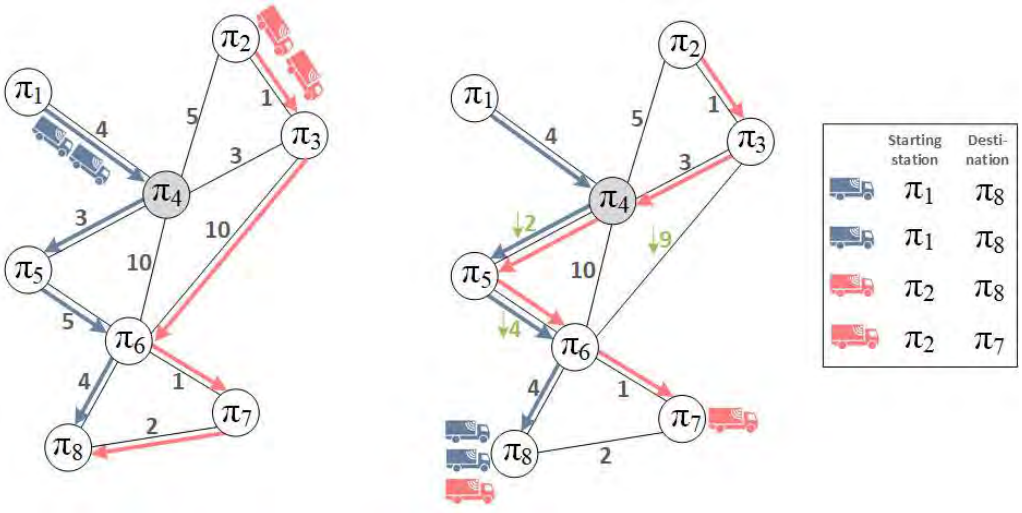

Figure 8 Platoon manager system at virtual π-hub using Dijkstra algorithm

Figure 8 shows an example using the Dijkstra algorithm. The figure's left is a separate strategic plan for the two platoons (blue and red) based on the Platoon Coordination System. The destination of the vehicles of the blue platoon is center π8, while the red platoon must also visit two destinations, which are nodes π7 and π8. The weights on the graph's edges on the right show the modified weights in green, which already considers that another platoon is moving on it. The value of the modified weights in the sample example decreased by 1 unit, indicating a

decrease in the value of the objective function by the platoon merger. Modifications to the Platooning Manager System shown on the right relative to the Platooning Coordination System plan are as follows:

- the red platoon merges with the blue platoon in virtual π-hub π_4 and then continues on its blue route,
- in the π_4 virtual π-hub, the platoons are also reconfigured. One of the vehicles in the red platoon continues its route with the blue platoon (which has the same destination), so the red platoon does not have to continue its journey to π_7.

With this, the Platooning Manager System reduces the total cost per platoon and detours the configuration.

5.3 Platoon vehicle system

Online options for organizing platoons include connecting on the road accessible by changing the speed of vehicles. It can be seen in the previous chapter that in the case of virtual π-hubs, the vehicles only detect the platoons around them in a predetermined radius. As a result, they may not have been close to each other in the case of a virtual π-hub taken into account in tactical planning due to traffic uncertainties (weather, congestion) or other reasons, but they become close to each other along the way. The proposed platoon control framework will allow connection on the road by changing the speed of vehicles at the operational level.

Figure 9 Three vehicles form a by small speed adaptions [15]

There are many examples of this type of opportunistic connection in the literature that provides different solutions for implementing a connection that can be achieved by changing speed profiles. Figure 9 illustrates an example of realizing progress in a platoon for three vehicles by changing speed profiles. The authors have shown that platoon creating can be implemented by the Platoon Vehicle System for more than 40% of the journey, resulting in a high platoon ratio. In states where the speed limit is higher (e.g., the US), even higher benefits can be achieved. In addition to the environmental impact of fuel reduction, there is an additional benefit to the platoon. This may be the case, for example, that future legislation may consider that the following position in the platoon may be equivalent to rest time [17,18].

6 Conclusion

In response to the goals of social, economic, and environmental sustainability globally, the concept of the Physical Internet has emerged, defining the logistics network of the future as a global, open, and interconnected system. In our opinion, one of the most defining concepts of the constantly evolving vehicle technology innovations is platoon-based transport. There are several solutions to the issue of coordinating platoons.

We propose a conceptual framework in Physical Internet-based logistics networks that can be defined as a research gap based on literature review. The concept organizes the off-board and on-board management structures into three layers. Strategic, tactical, and operational-level planning was placed in the Physical Internet network. We recommend the highest level of offline design in fixed π-hubs. The tactical level includes online-based design by PI hubs, while road-based implementation of speed-based solutions as an operational plan. We propose local optimization to achieve the global goals in the operation of this framework.

In conclusion, platooning transportation planning requires further research. Our conceptual framework is also a kind of guide, which requires specific solution proposals and algorithms in the future. In order to help practical applications, detailed algorithms are needed to achieve greater efficiency through platoon collaboration. At the same time, there is a need to increase cooperation between companies for a more sustainable future logistics system to work.

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INTERNAL FACTORS THAT DETERMINE THE SUCCESS OF PERUVIAN EXPORTS OF GINGER TO THE UNITED STATES IN THE PERIOD 2006 – 2020

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Abstract: This study analyzed the internal determining factors in ginger exports to the United States, being a controversial issue at the international level, due to the demand for exports of multiple products; to describe the internal factors that influence the success of ginger exports and making known the relationship with each of these, concerning the exported quantity, whether the result is favorable or not. The focus of this study is quantitative; it was based on the multiple linear regression model applied to our sample, which is the United States. Numerical data of ginger exports, export price, production volume, Investment in technology and innovation in trade, and exported value of Trademap during the period 2006 - 2020 were obtained. Through the econometric model, it was obtain that there is a direct relationship significant between the export price and the exported quantity ($p < 0.05$), that is; the greater the quantity of ginger exported, the lower the export price, and the higher the production volume, the greater the quantity of ginger exported ($p < 0.05$), the greater the investment in technology and innovation in trade, the greater the quantity exported ($p < 0.05$). These results provide accurate information for medium and large exporting companies of agricultural products, farmers, producers; the results show the key factors that lead to the success of Peruvian ginger exports.

1 Introduction

In recent years, trade interactions between countries in recent years, trade interactions between countries have been increasing and strengthening, thus achieving a significant increase in exports and imports. These merchandise exchange activities generated a high level of competition between the parties, whether it affects them positively or negatively, that will depend on the resources and competitive advantages they possess to take advantage of them.

International trade is currently an attractive topic in research, studies, and reports; since its contribution to economic and social development has been of great advantage, this process involves a series of factors that induce and interfere in the final result. Current leaders make the decisions of companies that want to internationalize based on different internal and external scenarios [1]. Likewise, [2] developed an investigation about the determining factors of export success, in which they explain the great importance of export activity from economic and business perspectives.

Ginger exports at the international level show that China, the Netherlands, Peru, and India are the major exporting countries for 2020. Likewise, the growth of ginger exports was due to national production and distribution and factors such as the domestic price, world prices, exchange rates, and inflation rates for the world market. Likewise, [3] indicates that the most relevant factors such as price, volume, and quantity are the primary and most relevant factors when exporting to the destination country. It was also determined that the factors influence the international demand when exporting to different global markets.

In the case of Peru, exports have benefited, making it grow economically and positioning it as one of the most important suppliers of agricultural products worldwide. The main factors that have influenced the improvement in export performance have been the increase in world demand for food, trade openness, the expansion of agricultural areas destined for export, and comparative advantages in food production [4]. A clear example with Peru are agrarian export companies, climate as factor inside volume of production, variance of the price according season, or the exchange rate, the different prices for needs of each country, the current technological development inside production processes of these companies, and other factors intervene in internationalization..

Regarding the export of ginger, it has become more valued by foreign countries, with Peru being the leading

exporter of ginger, becoming the main supplier to the United States, this being the market with the highest demand for this product. Likewise, it has been made known that the United States is one of the countries that value Peruvian ginger more than other countries; this is due to its organoleptic characteristics, for which they are willing to pay a very high price [24]. Despite all this, the demand in the US market is still very high and must be satisfied at the lowest possible price; It should be noted that China continues to be its leading supplier since they have very competitive prices, with a global market position of 50% and sales of over 800 million [5].

The main objective of this study is to reveal and find the relationship of the internal factors that have been determining factors in Peruvian ginger exports to the United States in the period 2006 to 2020.

2 Literary reviews

2.1 Internal factors

According to [6], internal factors are those agents that can generate a positive or negative impact; they are generally factors that can be exercised with a high degree of control; it is also essential to identify which are these factors to strengthen them and to contribute good performance and eliminate or reduce those that negatively affect it. The dimensions referred to the internal export factors that are applied in every organization are financial resources, human resources, technological resources, internal systems, and internal relationships. All of these together work to reach the objective. [7] considers that internal or external factors determine not only the possibility of access to new markets but also the quantities, values, export prices, and also explains that strategies, competencies, and even demand depend a lot on the characteristics of internal factors.

2.2 Exported value

It is the most significant characteristic of all exports; it expresses the exported product or services in monetary values, it is also the magnitude used to measure the goods, products or services, compared to the quantity, you can refer to the amount in which the price is calculated or money costs in the market. According to [8], exporting activity is desirable for most companies and producers since the exported value is compared in price and profit margins with those who sell in the national market. Furthermore, if a product can be sold in a foreign market, this favors to the exporting country, these operations benefits the economy; in the other words, even when you have to consider costs, you earn more than you invest in exportations, and the profit is greater when an optimal sale price is placed, the profitability of the exporting companies depends on it, taking into account that the objective is that the profits are always above those projected. [8] also indicates that the exported value in real examples, countries that export agricultural products such as Mexico that exported in 2008 obtained a price that on average was paid for these products at rural prices in the national territory. On the other, an implicit price of the exports of their agricultural products was estimated, concluding that the value exported to that country generated significant profits for those companies that export agricultural products.

2.3 Exported quantity

The quantity exported is another essential factor for all countries when making an export, since based on the quantity, the monetary value will be higher or lower, this factor is associated with the volume of production in the exporting country expressed in tons.

On the other hand, foreign countries that export non-traditional products analyze more the quantity and quality of the products they harvest. According to [9], indicate that the quantity exported is the growth of exports in quantity since each country produces more and more variety in each category of its products that it offers. For an individual country, the production of each type of its products is more excellent so that the most significant economies export greater value and volume. Likewise, [10] mentions that the amount exported is significantly more critical for developing countries since agriculture generates income for its inhabitants. This reflects a flow positively for the population since their jobs will be remunerated. In this way, the population can cover their basic needs and gradually use their disposable income in another variety of products. That is why countries are betting on investing more in agricultural products.

2.4 Export price

It is the monetary value requested from the importer in exchange for a product that will be exported. Therefore, certain factors that involve producing and taking the product as far as the customer requires must be considered when determining the export price. The importance of designating a price is based on determining the profitability and sustainability of the company. Likewise, the export price is the sale price that allows recovering the costs plus the profit that includes a return related to the business effort made and the risk based on the committed capital. To determine the export price, the costs of production are first identified; These costs are those that are generated in the process of transforming raw materials to finished products, and these are classified into, direct labor, indirect costs manufacturing, these are the main factors to be able to identify the export price. Also, the export costs are direct and indirect, to determine the management costs such as administrative, marketing, this includes all the expenses that must be faced from when the product is in storage and originates from market research and studies, sales promotion, advertising, among others. Likewise, financial costs determine the profit margin of the exporting company; This will depend on the commercial objectives that have been proposed, it is essential to specify that this

margin must be related to the prices of the destination market, [11] several researchers agree that the export price can be the easiest and fastest way to increase the competitiveness of companies [12,13]. .Likewise, [14] indicates that export prices face environmental factors that negatively influence when export is on the way.

2.5 Volume of production

According to [15], The production volume is the productive capacity obtained from a raw material, it quantifies the amount of goods and services that a certain productive unit has, this quantity has units of measurement according to the products, expressed in kilograms, liters, tons, through the which we can determine and count the exact quantities, as well as measure and determine the total production capacity, it is also one of the significant indicators in imports and exports, since to determine the price and export quantity, it is necessary to know the volume of this, finally you can also define the maximum and minimum quantity to be exported according to demand. The production volume reflects how profitable a particular product is. On the other hand, the volume of production is a determining factor in exports, because thanks to the volume it is known how much can be exported from time to time and based on this, we can make international quotes and negotiations. Likewise, ignorance or poor application of technology and innovation in production processes causes low performance [16].

2.6 Investment in technology and innovation in commerce

According to [17], investment in technology and innovation is defined, as the remodeling and expansion of the quality of products and services, whether it is an investment in new software or specialized systems. Also, innovation in infrastructure is that tools and machinery that favor and streamline some processes that are developed within the trade to achieve greater competitiveness at the national level and at the international level. Likewise, when talking about investment in technology and innovation, it refers to the technological modification of a product or service and the manufacturing and production processes. Nowadays, technological development has advanced considerably, and it is one of the main most essential factors for the market since not only a country considers technology and innovation, but also in companies and commercialization since this is a tool that facilitates and it simplifies processes, and on many occasions, it is the key factor in closing negotiations. Likewise, if a country has advanced in its technological development, it also means that companies, processes, and exchanges have developed positively and have been updated over time, therefore, the results are satisfactory in terms of competitiveness, demand, and profitability [18].

2.7 Ginger export

According to [19], exports are defined as the commercialization of products produced in a country destined for different markets (countries), also called merchandise exchange, an increase in commercial activity has been achieved at an international level, exports have not they only benefit one country economically, but it positions a country to compete with others, positions companies, products and generates international relations, since through exports it can interact with more than two countries, exports mainly drive the agricultural sector, since artisan producers.

On the other hand, there are many benefits that exports bring, contributing not only to the economy of a country, but also allowing to execute economies of scale that optimize the resources of companies, reducing costs, diversifying and covering foreign markets, generating improvements in the quality standards of the products and broadens the possibilities of generating solid relationships with international partners.

3 Methodology

3.1 Population and sample

An investigation was carried out that has a quantitative approach because it is based on numerical measurement, and it is of the applied type because it was developed based on the existing theory. The level of investigation is correctional in order to determine the relationship between the success of Peruvian exports to the United States for the period 2006 - 2020.

The population was made up of the annual exports of ginger produced in the Peruvian territory for the period 2006-2020. A sample of the total population was estimated, since, when analyzing annual time series, the sample becomes more precise and significant.

3.2 Data collection instrument

Data were obtained from Trademap on the annual exports of Peruvian ginger destined for the United States, from the United Nations Organization for Food and Agriculture, we obtained data on the annual production of ginger from the Ministry of Economy and Finance data was obtained from the amount of annual investment in technology and innovation and Fresh Fruit (commercial intelligence and data from the agro-export sector) obtained the export prices of Peruvian ginger.

Based on the initial information, an analysis was carried out on the internal factors that are determinant in Peruvian ginger exports, six were chosen, whose information was considered reliable for the years 2006 - 2020. The control variable investment in technology and innovation was used to adjust the results.

3.2.1 Study variables

The use of internal factors and the definition of the variables were based on the Trademap (2020).

Table 1 Study variables

Independent Variable (internal factors)	Dependent variable
Export Price	Ginger Export
Volume of production	Exported quantity
Investment in technology and innovation in commerce	
Control variable	Exported value

3.2.2 Econometric model

The Multiple Linear Regression Model that incorporates the dependent variable and the explanatory variables is expressed as follows (1).

$$Y = \beta 0 + \beta 1\,(EP) + \beta 2\,(PV) + \beta 3\,(TI) + \beta 4\,(EV) + u \quad (1)$$

QE = Peruvian ginger export (tons).
EP = Export price
PV = Production volume.
TI = Technology investment and innovation in commerce.
EV = Exported value (control variable)
β0, β1, β2, β3, β4, β5 = Coefficient of the linear regression model.
u = Term that represents the error.

Seasonality test (Dickey Fuller), normality test (Shapiro-Wilk), self-correlation test or error independence (Durbin Watson), linearity test (Variance Inflation Factor), heteroscedasticity test (Breusch-Pagan and Koenker), ANOVA test and goodness of fit tests (R squared).

3.2.3 Hypothesis

H1: There is a direct relationship between the export price and Peruvian ginger exports.

H2: There is a direct relationship between the volume of production and exports of Peruvian ginger.

H3: There is a direct relationship between investment in technology and innovation in Peruvian ginger trade and exports.

H4: There is a direct relationship between the exported value and Peruvian ginger exports.

4 Results

4.1 Descriptive results

In table 2, it is shown that the standard deviation of the exported quantity presents the value of 13953 compared to the export price variable, which presents a standard deviation of 0.8485, showing that the exported quantity variable has greater relevance as opposed to the price of export, this is because the export price varies according to the quantity that is exported. Likewise, Peru is one of the first 3 countries that export large quantities of ginger to the United States, since the export price that Peru manages is flexible compared to other countries, competition is another factor that influences the price from exportation. [20] noted in their study that the price of ginger in Nigeria decreased by 24%, was because the unit price of ginger in Nigeria was higher. higher than the world price, countries like India, Ethiopia, and Peru are some of the countries that won the market in terms of quantity; however, they all lost in terms of price. The average of the volume of production presents the value of 9900 compared to the variable technology and innovation in commerce that presents an average of 1609, showing that the variable volume of production has greater relevance in contrast to the variable technology and innovation in commerce This is because Peru can be able to produce ginger all year round supplying the foreign market, although Peru invests very little in technology and innovation in trade, this does not impede for the production volume to be high. greater each year. The median of the exported value presents the value of 5707 compared to the variable quantity exported, which has a median of 3431, with the exported value being more relevant compared to the quantity exported, this is since the greater the quantity of export, the greater the exported value. Therefore, the variables exported quantity, production volume, and exported value, present data with greater relevance for an optimal export of ginger to the United States, the variables such as export price, technology, and innovation in trade, present low data, which for future studies it is recommended to further evaluate these three variables and reinforce them.

Table 2 Descriptive statistics summary

Variable	Half	Median	Standard Desviation	Min.	Max.
QE	11212	3431	13953	6.000	49657
EP	1.711	2.060	0.8485	0.2600	3.240
PV	9900	3800	10187	165.0	27170
TI	1609	600.0	2286	80.00	7936
EV	10295	5707	11398	3.000	41904

4.2 Correlation coefficient

Table 3 shows the correlation between the variables to measure the strength of the association. In the following results, it is obtained that there is a positive correlation of the exported quantity concerning the export price (0.6376), taking into account that the closer the value is to 1, the higher its association, also in terms of volume of production (0.8653), investment of technology and

innovation (0.9454), and exported value (0.9927). This indicates that the export price is a function of the exported quantity, the more quantity, or the higher the demand for ginger, the lower the price, while there is greater production of ginger in the Peruvian territory, the quantity available to be exported will be, On the other hand, if new investment projects in technology and innovation are managed in the commercial area, it will facilitate the development of production processes, logistics and export processes, therefore it will be possible to export in greater quantities with ease. Being the exported value as a control variable, and the investment variable in technology and innovation those that have the highest positive correlation [21].

Table 3. Correlation coefficient (at a significance level of 5%)

Variable	QE	EP	PV	TI	EV
QE	1				
EP	0.6376	1			
PV	0.8653	0.7810	1		
TI	0.9454	0.6516	0.7975	1	
EV	0.9927	0.6669	0.8495	0.9373	1

Table 4 Result of the ordinary least squares model with heteroscedasticity correction

	Coefficient	Desviation typical	Statistical t	Value p	
Constant	300.225	307.074	0.9777	0.3513	
QE	-1320.20	298.040	-4.430	0.0013	***
PV	0.119796	0.0480607	2.493	0.0318	**
TI	1.40909	0.187814	7.503	0,0000206	***
EV	0.916619	0.0365905	25.05	0,000000000235	***
R-cuadrado	0.998813				
Durbin- Watson	2.309209				

Note: (*) (**) and (***) represent statistical significance at the 10%, 5% and 1% levels, respectively.

4.3 Relationship between the export price and the export quantity of ginger

The results of the ordinary least squares model indicate that if there is a significant direct relationship at a level of 1% to determine the relationship between the export price and the exported quantity of ginger ($p < 0.05$); The coefficient for the export price variable has a value of -1320.20, which indicates that there is a negative inverse correlation, this is because the higher the quantity of ginger exported, the lower the export price. [20] they obtained as a result in their study that the world ginger market grew at a rate of 10% per year in the period 2008 - 2012 that was in In terms of quantity, the price of ginger also grew by 12% annually, but in the period 2011 - 2012 the world price of ginger fell by 29%, which caused the price of ginger in that period to decrease worldwide, countries such as Lithuania, India, Nigeria, Ethiopia, and Peru are some of the countries in which their results were favorable, in the market terms of quantity. Likewise, this variation is due to the different socio-economic, political, and cultural factors used by each country.

4.4 Relationship between the production volume and the exported quantity of ginger

There is a significant direct relationship at a 5% level between the volume of production and the quantity exported ($p < 0.05$). This result indicates that the higher the production volume, the greater the quantity of ginger exported to the destination country. This is because Peru can produce ginger throughout the year, in any season of the year, which benefits the export of ginger, since, with the existing demand, it can supply the foreign market without any problem. Likewise, the optimal production of ginger in Peru is due to the geographical location in which it is produced since Peru has fertile soils and good water resources to keep up with the high demand for ginger, as [22] in their study, emphasizes the importance of these geographical factors, water resources for excellent production, and to become an agricultural power and productive.

4.5 Relationship between investment in technology and innovation in trade and the quantity of ginger exported

Based on the results obtained from the econometric model, it was determined that there is a significant direct relationship at a level of 1% between investment in technology and innovation in commerce and the quantity of ginger exported ($p < 0.05$); The coefficient for the variable investment in technology and innovation in commerce presents a result of 1.40909, this result indicates that the greater investment in technology and innovation in commerce, the greater the quantity exported, since by investing more in technologies, machinery, and

technological equipment within the logistics processes, facilitates the export of Peruvian ginger to the foreign market [23], obtained as a result in their study, that the evolution of technology has provided further expansion of production networks, generating new opportunities for access to new markets. Likewise, it has generated new attractive commercial strategies, a clear example is; how nowadays the production and manufacturing processes in large companies have been simplified thanks to technology because with the necessary machinery and tools this has become possible; However, although the study of international trade has advanced optimally, there are still certain limitations regarding trade and its effects on income for the technological cycle of products and the technical capabilities of the producer. The [24] in his study "Prospecting the information technology (IT) market" in Peru, pointed out that Peru is one of the countries in South America with the highest investment in technology since it allocates 2.57% of GDP, This means that due to the considerable percentage it allocates to investment in technology, it facilitates business, logistical, and systematic processes, among others, which favors and simplifies results.

5 Conclusion

According to the econometric model that was carried out, the relationship between internal factors and the export of ginger to the United States was evidenced. All the internal factors presented in this study are positively related to the exported amount of ginger, according to what is obtained in the model, an optimal and significant relationship is maintained in this study. Therefore, and based on the aforementioned, it is determined that in order to be successful in Peruvian ginger exports to the United States, it is important to consider internal factors such as; ginger export, export price, production volume, Investment in technology and innovation in commercial and exported value, since each of them has a direct and significant relationship with the exported quantity; For example, the determination of the export price is calculated based on the quantity or demand for ginger, since the higher the quantity, the lower the export price; It is also considered that the volume of production depends on geographical, territorial and climatic factors, since the greater the production of ginger there is in the year, the quantities to be exported will be greater, likewise and being one of the most attractive variables in this study, investment in technology and innovation in trade, facilitates production processes, negotiations with other countries, also simplifies and saves time, therefore the relationship with the exported quantity is positive, as well as favorably influencing the increase in exports of Peruvian ginger, although in this study there is a direct relationship between internal factors and the export of ginger, it is recommended that for future studies other additional attractive factors that are significant and relevant be considered, and thus be able to reinforce new studies. On the other hand, it is recommended that this study be considered for agro-export companies that wish to export this type of product to international markets since in this study the main variables were mentioned to be able to carry out an export with optimal results.

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STREAMLINING PACKAGING AS PART OF SUSTAINABLE REVERSE LOGISTICS PROCESSES
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STREAMLINING PACKAGING AS PART OF SUSTAINABLE REVERSE LOGISTICS PROCESSES

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Keywords: packaging, reverse logistics, workflow, standard operating procedure, waste
Abstract: The aim of the article is to present streamlining reverse logistics challenging the trends of increased amount costs of packaging and a need to meet sustainable development goals. Analysis of the packaging process has identified increased costs for the purchase of packaging, increased volume of imported and produced packaging material, increased volume of packaging waste and thus high recycling fees (related to producer responsibility). A proposed solution for streamlining reverse logistics processes have been introduced, including workflow of the packaging process, a new packaging registration system and measures for standardisation of the packaging process. The solution's main benefits are economical and ecological: first, cost reduction for purchasing new packaging materials and cost reduction for recycling fees, the second elimination of negative influence on the environment by respecting the waste management hierarchy and principles of the circular economy. Other benefits expected for the company are shorter, more informative, and practical training of new employees, reduced time for packaging process through its standardisation and visualisation, and more efficient separation of reusable packaging.

1 Introduction

The growing interest in sustainable development and the pressure to reduce costs in logistics processes, including the area of packaging, has intensified in recent years. The objective of the paper is to propose specific measures to streamline packaging processes in the company, considering the analysis of the current state of packaging processes, respecting the goals of sustainable development, reducing costs for procurement of packaging materials and packaging technology, reducing the volume of packaging materials placed on the market in Slovakia, and eliminate negative impacts on the environment.

Understanding and defining reverse logistics, the processes, functions, entities are specific in literature and practice. Hedgepeth (2020) considers reverse and forward logistics as parts of the supply chains within products flow and are transported from one place to another [1]. Gnap and Rovňaník (2012) describe a reverse logistics system based on the four basic processes: 1. Gatekeeping represents the entry control and inspection, through which decisions are made on the entry of material and product, representing a passive logistics element into the reverse logistics system. 2. Collection is a process representing the collection and gathering of products and materials for further processing. 3. Sortation and Separation divides materials according to how they will be further processed. 4. Disposition / Re-processing - products are processed according to their nature and why they entered the return flow, they can be repaired, their functional parts can be dismantled, recycled, incinerated or landfilled [2].

Reverse logistics functions (Bigoš et al. 2008) are collection, sorting, storage and packaging, transport, inspection, disassembly, processing, sale/reuse. The logistics chain of the reverse flow system consists of several entities that perform various functions within the process of recovery of products flowing into this chain. These subjects include final consumer, collector/collection company, equipment for material recovery or sorting, processor, manufacturer [3]. Starostka-Patyk (2017) [4] focuses on the groups of entities involved in reverse flow management.

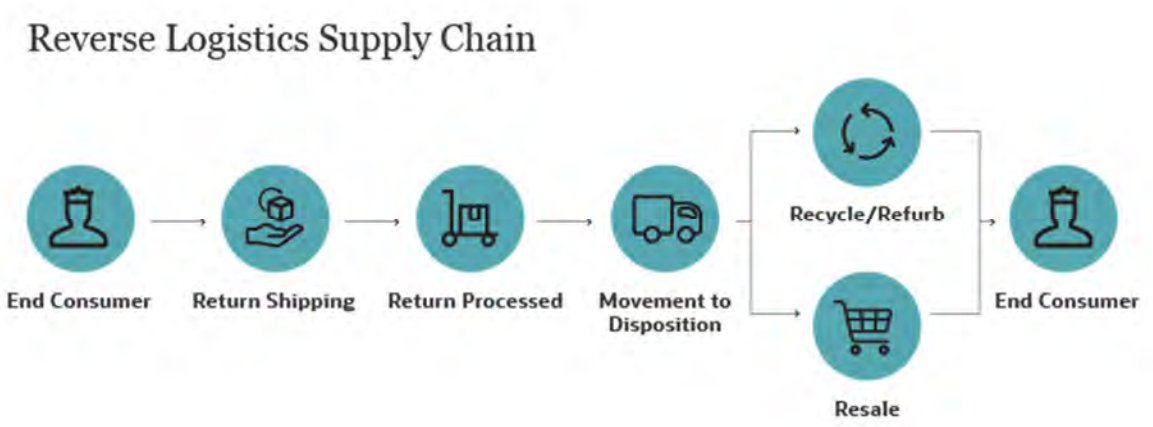

Figure 1 Structure of Reverse Logistics Supply Chain [5]

The reverse logistics supply chain is influenced by the end consumer (customer), then return shipping and return processed follows disposition movement and then either recycling or resale option and again closed by the customer (Figure 1). According to InfinityResearch web portal (2019), adoption of new repair and return policies, improved cooperation between the company and the supplier, reassessment of transport and logistics, optimisation of the reverse logistics process using recent trends, and third parties are four key strategies to improve reverse logistics management, especially in smaller companies: [6]. Mangla et al. (2016) emphasised this as a critical success factor for supply chain management, concluding that global competitiveness is the main factor contributing to the successful implementation of reverse logistics. Regulatory factors, human resources, organisational, economic and strategic factors were also among the essential factors influencing the successful performance of reverse logistics [7]. Reverse logistics is addressed as crucial in achieving sustainable competitive advantage [8-10].

However, the fundamental factors that influence reverse logistics are sustainability, the environment, actual legislation, the stakeholder's pressure on the manufacturer (environmental awareness of employees and customers). Sustainability focuses on reducing the negative impact of the human factor (production) on the environment by efficient use of available resources, increasing the reliability of these resources, and extending the life of input materials and products. Sustainability issues in logistics and ICT issues are discussed by many authors [11-14] and in human resource management [15].

Environmental, economic and technical aspects influence reverse logistics and waste management processes; it is essential to prioritise the reuse of materials, or their recycling, over the energy recovery of waste. The authors consider waste disposal to be the last available option in waste management [16].

Packaging and waste management are closely linked to sustainability issues in enterprise and include the purchase of packaging, the sorting of packaging, the use of environmentally friendly packaging, the storage of packaging, distribution and take-back, disposal and registration as required by higher authorities.

Several factors influence the choice of packaging through one of the critical decisions if the disposable or returnable packaging might be used. Companies consider returnable packaging to be more economical and environmentally acceptable [17].

Authors indicate a comprehensively positive shift in innovation in packaging, evaluation of smart packaging [18]. However, in the context of sustainable reverse logistics, the function of packaging in business-to-business deliveries doesn't end with the product's safe delivery to the customer anymore. An essential fact in a holistic approach to reverse logistics is that each manufactured product (and its packaging) ends its life cycle, and at that point, the product recovery paradigm should determine the type of recovery and reverse logistics activities.

The context of reverse logistics is defined by reasons for the return and driving forces (Why?), processes (How?), product types (What?), locations (Where?) and stakeholders (Who?) are interconnected with the responsibility of the company as a producer. We distinguish between economic, physical and information producer responsibility. The economic responsibility of producers should include the costs associated with the reduction or by eliminating the negative environmental impacts caused by the product. The manufacturer's physical responsibility is the system of accountability where the manufacturer is responsible for the material handling of the product during its life cycle. The information responsibility of the manufacturer is to provide information about the product (whether the product is from recyclable materials). The connection between these three forms of responsibility is ownership of the product throughout the life cycle, even when the product becomes waste [19].

Producers are responsible for disposing of the product and its packaging even after it has become waste, which is

defined as an extended producer responsibility by the Organization for Economic Co-operation and Development (OECD). Traders use product packaging as an autonomous tool in providing customer care. OECD defines extended producer responsibility as a means of environmental policy that extends producer responsibility for products throughout their whole life cycle, from development to the end of their life cycle [20]. The function of packaging to reduce the impact on the environment and facilitate recycling is becoming increasingly important than, for example, the protective, promotional or storage function of packaging.

In logistics, we distinguish three main stages or levels of packaging as follows: primary, secondary and tertiary packaging. Ekobal (2020) defines the primary level of packaging as consumer packaging. The packaging is in direct contact with the product. The packaging forms the first layer of the packaged product, and the purpose of this packaging is primarily to protect the product. The secondary level of packaging often referred to as group packaging, is mainly used for storage and logistics purposes. Secondary packaging protects and accumulates the primary packaging products, for example, in larger boxes, and expediently facilitates handling the goods and their transport. The tertiary level of packaging is referred to as bulk packaging, and its purpose is to group larger quantities of storage units in secondary packaging during their transport from one point to another. For example, cardboard boxes are placed on a pallet wrapped in foil [21].

The requirements for the packaging process and packaging material depend on the specific features of the products. The choice of suitable packaging ensures that harmful environmental influences on the transported material's quality and properties are eliminated. The choice of the appropriate type of packaging material ought to be made based on product properties, environmental impact, method of transport and handling, method of storage and, of course, business conditions and legislation must be taken into account (Zhu, Guillemat, Vitrac 2019) [22].

Legislation on packaging and packaging waste is addressed by Directive 94/62 / EC of the European Parliament and the Council of 20 December 1994 on packaging and packaging waste, which aims to "harmonise national measures on the management of packaging and packaging waste" [23,24]. To prevent or eliminate the impact on the environment of all Member States as well as other countries, on the one hand, by a high level of environmental protection and, on the other hand, to ensure a functioning internal market to avoid barriers to trade and distortions and the restriction of competition in the' Community'. Packaging waste is also regulated on the national level in the Slovak Republic by Act no. 79/2015 Coll., of 17 March 2015 on waste [25]. This legislative defines waste management as follows: Waste management in general is: collection, transport, recovery and disposal of waste, including supervision of these activities and subsequent care of disposal sites, and includes the actions of a trader or broker. The hierarchy of waste management is represented by Act no. 79/2015 Coll. such as a binding order of the following priorities: a) waste prevention, b) preparation for reuse, c) recycling, d) another recovery, such as energy recovery, e) disposal.

Reverse logistics and its management have four possible benefits for businesses and consumers (Hedgepeth 2020): secondary return on investment, increased public and consumer perception of the company, support for production competition, and increased consumer data protection [1]. However, the disadvantage is the risk that businesses and customers may not be satisfied with the company's partners in the field of reverse logistics and recycling [1].

Managers might get an insight into risks in reverse logistics and understand their relative importance [26] and opportunities such as combining the recycling operations with reusing or remanufacturing operations means for companies to stay profitable Klausner and Henrikson [27]. Crucial identification of critical success factors linked to the implementation of reverse logistics /waste management in manufacturing. Straka et al. point out the relevance of analysis and classification types of waste using descriptive statistics data [28].

Six critical success factors for the implementation of reverse logistics in the context of sustainability (SDGs): reasonable income control, standardised and mapped processes, reduced time cycle, information systems, planned logistic grid and collaborative relations between customers and suppliers. Well-structured and implemented reverse logistics process brings benefits and advantages to companies beyond environmental ones [29].

2 Problem definition and methods

The introduced model of the packaging process is based on analysis of existing literature, presented case study and previous industry practices. It utilises data about packaging amount and trends, average costs of packaging, data about return flows. The proposed solution of optimisation of packaging process has the following steps: Objective definition; Data collection for identification of trends; Defining the optimisation constraints and parameters; Analysis of data about return flows in packaging process (average costs for packaging, volume and amount of packaging); Application of principles of industrial engineering/logistics, sustainable development goals and waste hierarchy; Model of packaging process applying visualisation using workflow management and standardisation.

For visualisation of packaging process and proposed solution are used process flowcharts, diagrams that depict a process, system or computer algorithm. Flow charts can range from simple, hand-drawn charts to comprehensive computer-drawn diagrams illustrating multiple steps and routes. Flow charts represent in graphical form logistics or manufacturing process from beginning to end., help find inefficiencies in a manufacturing or procurement process.

Flowchart consists of rectangles, ovals, diamonds, and potentially numerous other shapes to define the step type and connect arrows to describe flow and sequence. Each diagram must have a starting point. It can have multiple ending points and some loops as well.

Visualisation of the packaging process using workflow is presented in a case study in simplified form with a fixed set of structures. Inputs and outputs are marked with an oval grey colour, while their relationship with processes, i.e. input and output, are marked with a red dashed arrow. Inputs and outputs are marked with two colours, grey represents the document, and brown represents the material. The individual activities are drawn as a sequence of rectangles, and the diamonds in the flow diagram represent the decision-making process.

3 Streamlining the packaging in logistics company

This part of the article introduces a case study concerning streamlining of the packaging process in the logistics company dealing with distribution activities of fasteners meeting the requirements of standards STN, DIN, ISO, UNI, or PLN and GOST on the domestic and foreign markets (screws with metric thread, or UNC and UNF, nuts, washers, cotter pins, rivets, tight springs, pins and pins, blind rivets and rivet nuts, dowels, and fasteners).

3.1 Packaging process in the logistics company

First, the responsibility for the packaging processes is covered by the company's storekeepers, and the warehouse department handles the process of packaging and return of packaging. The company's packaging process begins by identifying the products to be sent to the warehouse. According to the documentation from the economic department, the goods are collected by the warehouseman for dispatch. When searching for and preparing goods for shipment, the warehouseman checks the status of each item. According to the types and quantities of ordered goods, the warehouseman chooses the appropriate variety of packaging material. In the case of weighed types of goods, the storekeeper selects the proper size of the package, usually a cardboard box or, in the case of smaller ordered quantities, a plastic closable bag. If the customer requests a number of goods corresponding to the contents of the package in the warehouse, the warehouse keeper will use this package but will first check its contents, find out whether the number of pieces fits and whether the goods are undamaged. After content control, it is necessary to affix a label to the box, which describes the contents of the package and the name of the company. The inspected, flawless goods are then secured in the selected packaging by closing the box. The company used adhesive tapes to close boxes or prevent the box from opening during transport and handling. After completing the box, an envelope with an invoice or a delivery note is glued to the box using adhesive tape. For some types of goods, especially for more oversized products, warehouse keepers use binding tapes to ensure the strength and stability of the products. Using binding tapes prevents an unnecessarily large packing box, i.e. an excessive amount of packaging waste. Orders are picked up on pallets, on which all goods are placed according to the order.

The role of storekeepers is also to adequately place goods on pallets, either based on the size or weight of the package. After putting all the order items on the pallet, the warehouseman must also ensure the stability of the complexly picked goods for shipment. It will do so most often with the help of stretch film, which will ensure that during the handling and transport of goods to prevent unwanted movement of goods on the pallet or possible damage to boxes and another packaging. The packaged goods are first transferred to a platform scale through a pallet truck, where their weight is measured and recorded on a picking sheet, which the warehouseman then returns to the economic department to issue an invoice. The goods are moved on a pallet from the platform scale for further loading directly into the car intended for transport. Warehouses can use two options when sorting goods on a pallet, they can transport a pallet around the warehouse using a pallet truck in search of a specific product and store it directly on it, or they can use a transport platform truck on which they keep the goods and then unload them on a pallet, which is prepared at the scale. After weighing, the pallet is moved to where the goods are loaded directly into the transport truck. The logistics company sends packaged goods ready for dispatch to the customer through two transport companies in multi-layer cardboard boxes in larger quantities on pallets. The workflow of the packaging process is in figure 2.

Second, we analysed the trend in packaging quantity in tonnes placed on the Slovak Republic's market and calculated the company's packaging costs. The amount of packaging (paper and cardboard, plastics, and wood) has increased from 2017-2019, the only year 2020 due to the covid crises and less demand of customers (Figure 3).

The logistics company marketed over the last three years through imports, on average around 28.77 tonnes of packaging per year and through production on average around 4.05 tonnes of packaging materials per year with a trend of increased costs excluding the specific year 2020 (Table1).

Following the hierarchy of waste management and the goals of sustainable development, the solutions for streamlining, the packaging is introduced to reduce the amount of packaging that the company markets and thus reduce the financial costs associated with this issue.

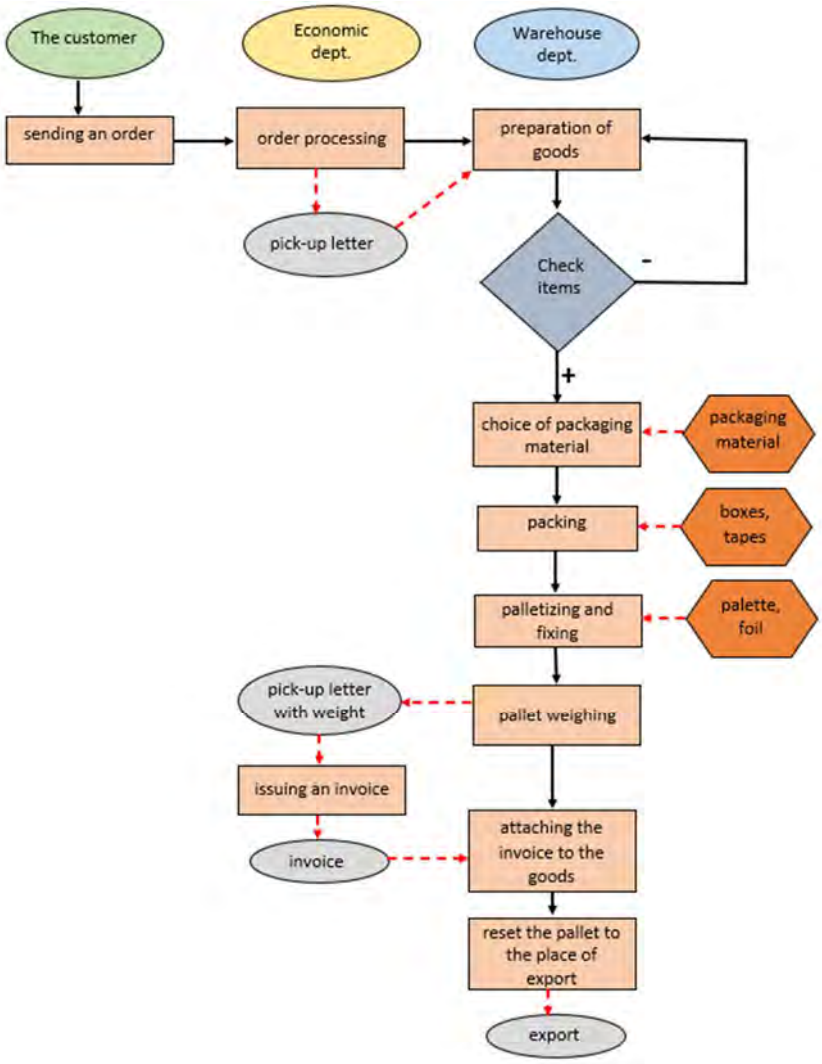

Figure 2 Workflow for the packaging process

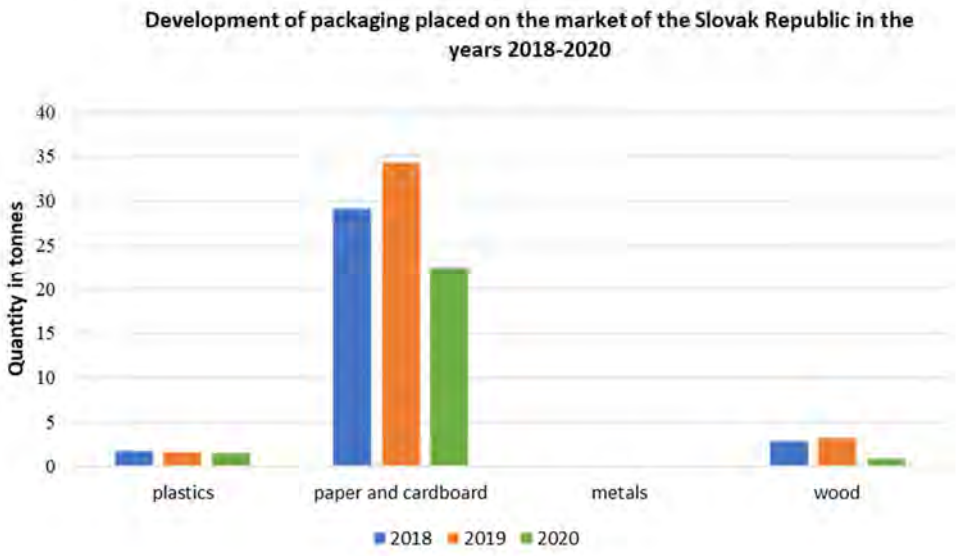

Figure 3 Trend in packaging quantity placed on the market by company in the years 2018-2020

Table 1 Increase in the costs for the packaging waste in logistics company

YEAR	TYPE OF PACKAGING	QUALITY PURCHASED (pcs)	PRICE (€)
2018	Pressed Palette INKA - small	200	664.45
	Stretch foil	270	1166.40
	Tape	1152	857.09
	EUR Pressed Palette - dark	50	330.00
Total price			**3017.94**
2019	Pressed Palette INKA - small	601	1999.93
	Presses Palette INKA - big	1	7.2
	EUR Pressed Palette - dark	50	330.00
	Stretch foil	404	1391.59
	Box 192/128/111	10000	1524.00
	Box 130/100/80	10000	1128.00
	Tape	470	355.32
	Closable pockets	54000	405.60
Total price			**7141.64**
2020	Pressed Palette INKA - small	640	2470.47
	Stretch foil	460	1606.32
	Tape	660	498.98
	Box 192/128/111	3800	656.64
	Box 130/100/80	3000	370.80
	EUR Pressed Palette - dark	3	25.20
Total price			**5628.39**

The increase in the amount of packaging placed on the market through production could be caused by several factors such as the purchase of packaging material from Slovak suppliers for stock or poor management of warehouse workers with packaging material. After using empirical analysis methods, by analogy, observation, interviews and study of documentation, the conclusion is that the main identified problem is an increase in the volume of packaging marketed through production, which is caused mainly by insufficient training of warehouse workers. However, the training of newly hired warehouse employees consists primarily of getting acquainted with the registration system in the warehouse and short demonstration of their work activities, which is considered insufficient and after a more extended period, this is reflected in the costs.

The competence of employees and the selection of packaging material by warehouse workers seem to be very uneconomical; thus, according to information from the economic department, warehouse workers choose unsuitable types of packaging material or use too many packaging materials, which will be reflected in the economic as well as the environmental sphere. Another cause for an increased amount of packaging waste is the import of material from the company's suppliers. However, this problem can be eliminated, for example, by the proposed solution of reusing undamaged packaging materials from suppliers and the registration system.

3.2 Packaging registration system

As mentioned, one issue is introducing a new system of registration for the packaging material, specifically packaging material made of paper and cardboard, which represents the largest share of packaging. The comprehensive approach of records consists of the following parts: Records of all cardboard and cardboard packaging from suppliers of goods; Inspection of registered packages and their manual sorting into two groups; Evidence of usable packaging and their sorting in Microsoft Excel; Records of the balance of available boxes in stock; Insertion of a collection/storage container for usable packaging; Training of warehouse workers for a given type of work. A sample of records used to register packaging materials from suppliers of goods according to the group of usability is presented in Table 2.

Before registration, manual sorting and visual control by warehouse workers are required. After control, the box is assigned to the usability group (Table 3), specific quantities of usable packaging are recorded in the record sheet, and the stock balance /quantities of boxes according to the waste category are calculated using a function in Microsoft Excel.

Table 2 Records of the paper and cardboard packaging from suppliers of goods

Date	Amount of packaging (pcs)	Usable (pcs)	Waste (pcs)
19.3.	25	15	10
19.3.	27	10	17
22.3.	41	27	14
22.3.	29	16	13
22.3.	41	27	14
25.3.	35	21	14
26.3	40	21	19

Table 3 Records about sorting of usable packaging

Registered				
Date	small < 150mm	medium < 250 mm	large > 250 mm	Total pieces
19.3.	5	7	3	15
19.3.	3	1	6	10
22.3.	7	12	8	27
22.3.	9	4	3	16
22.3.	12	9	6	27
25.3.	6	12	3	21
26.3.	10	5	6	21
SUM	52	50	35	137

The cardboard boxes are in groups according to their sizes and dimensions into the following groups (table5): The next step is the registration of the balance of usable packaging (boxes) in the warehouse, which, together with the previous actions, will create a comprehensive system of registration.

Table 4 Records the balance of used boxes in stock

Used			
Date	small < 150mm	medium < 250 mm	large > 250 mm
22.3.	3	1	9
22.3.	2	15	3
23.3.	1	2	1
26.3	5		

The quantities of boxes consumed are recorded in the columns of the table according to size. The interval for recording box consumption data is individual, and it is recommended to register for the day/change worked. Based on the formula formatted in the stock balance table, the quantities of boxes entered in the consumed table are automatically recalculated in the stock balance table, thus subtracting the used amounts from the total stock quantity and evaluating the balance.

Table 5 Stock balance of packaging according to the size

Stock balance			
small < 150mm	medium < 250 mm	large > 250 mm	Total stock
41	32	22	95

The next step in this proposal is to purchase and place containers for the separation and disposal of packaging entering the company. As part of this step, two alternative solutions are as follows: The first alternative is the purchase the three types of boxes/containers for storage of usable boxes: Plastic box perforated 700 litres; (Intended for box packaging size larger than 250 mm); Plastic container 520 litres (designed for boxes size smaller than 250 mm); and in the smallest package with a volume of 300 litres. The second more environmentally friendly and economical alternative is using large boxes from the suppliers of goods, but have no other use and become waste for the company. This solution would be more efficient for the company from the economic point of view, as the company has long-term suppliers of goods, from which it has a constant purchase of goods. The company might cyclically change these boxes to newer ones if they were worn out over time.

The proposed change in packaging processes represents a streamlining of the whole process through the following changes: records enter the process of choosing the type of packaging material, a new decision-making process is also emerging, the priority of which is the choice of reusable packaging. The original packaging process in the company (Figure 1) and the new packaging process in the context of waste hierarchy with new evidence/ records of packaging entering the company from suppliers of goods are introduced applying the flow chart (Figure 4).

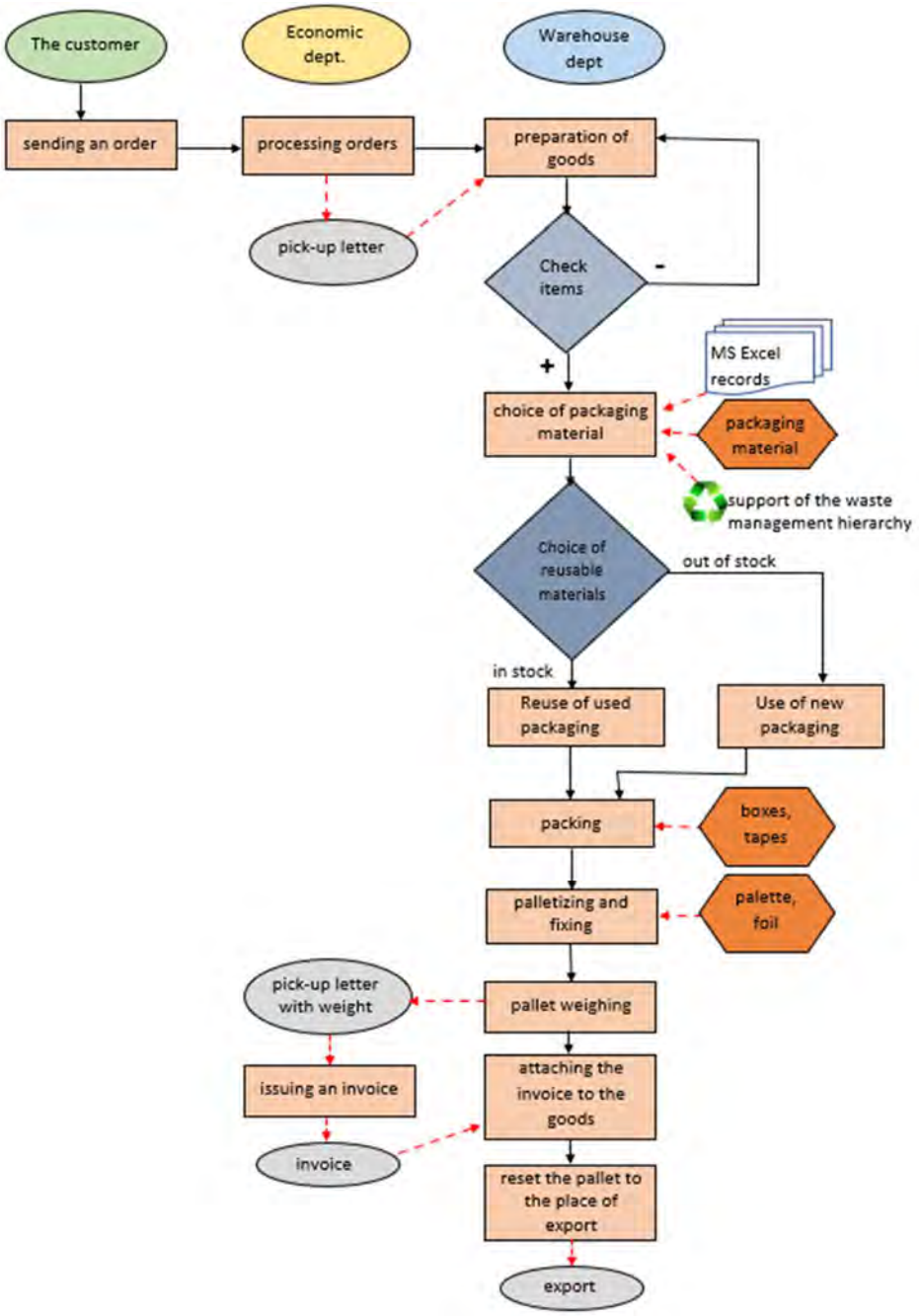

Figure 4 Workflow for streamlining the packaging process

The creation of a standardised workflow supports the visualisation of the proposed solution as a support for change. This procedure can serve as a system available at sites designated for sorting and registering reusable packaging material (Figure 4).

The proposal to introduce a standardised workflow as part of the visualisation of portions is intended to help guide the workers assigned to in their work, with the comprehensive registration system introduced in the first proposal. Visualisation helps to understand the meaning and interconnection of requirements by presenting them in a simple and easy-to-understand format [30, 31].

A more important benefit of the presented proposal is the prevention of time wastage in terms of lean management. The standardised workflow consists of simple, concise and clear instructions, which is suitable for any reader. The introduction of a standardised workflow will reduce time loss due to demands in the implementation of records, more accessible training in hiring a new employee, prevention of inappropriate separation of reusable packaging, and ensuring systematisation and order in the warehouse department.

4 Conclusions

Sustainable reverse logistics is closely connected with waste management in companies and helps meet objectives of sustainable development and the requirements of the law at the same time [32]. Efficiently carried logistic processes condition the quality of the product at every stage of the flow, starting with obtaining the raw material, ending with creating inventories and delivering the finished product to the customer [33]. Studying the issues of reverse logistics even in the developed logistics systems is still considered an area that has to be continuously researched with the aim of optimising the entire supply chain [34].

The quality and competitiveness are crucial specific implications for implementing sustainability in reverse logistics for companies with the guidance to apply sustainability in reverse logistics [35,36]. Incorporating the three pillars of sustainable development (environmental, social and economic) in packaging supports the innovative solution [37]. The proposed solution in sustainable logistics is to reduce the volume of paper and cardboard packaging placed on the market through production and import, which represents a significant part of the total packaging. The aim is to reduce the cost of recycling fees to organisations responsible for the production and eliminate the negative impact on the environment in line with implementation objectives and sustainable development. Introducing a system for registering packaging from suppliers will provide knowledge about the amount of packaging that flows into the company from suppliers. An essential part of records are records of the amount of reusable packaging. Following the introduction of a registration system, the company can determine the exact quantities of reusable packaging, indicating stakeholders' preferences in packaging. Subsequently, after the proposed registration system's data collection and analysis period, it is possible to predict the amount of packaging received from suppliers and quantify the usability percentage. Information about usable packaging in stock and the amount of new packaging material needed will make it easier and more accessible for logistical management.

We also see a positive aspect of the environment; the proposal respects the waste management hierarchy in the Slovak Republic in two areas. The first area of the waste hierarchy supports waste prevention by establishing records to map the quantity and control of all packaging from suppliers, thus reducing the risk of evaluating packaging that can be used for waste. The second area respecting the waste hierarchy is preparation for reuse through inspection, registration and separation of packaging from suppliers. A summary of the expected benefits of the solution for the introduction of a system of registration of packaging from suppliers is as follows: reduction of costs for the purchase of new packaging materials - cardboard boxes, costs reduction for fees to producer responsibility organisations for placing packaging on the market of the Slovak Republic, information about the quantities of reusable cardboard boxes in stock and promoting the national and European waste hierarchy, support for the company's circular economy and sustainable development goals (Sustainable industry). The costs associated with this proposal are minimal.

In mapping packaging processes and introducing a registration system for reusable packaging, the main requirement was a waste management hierarchy in terms of sustainability. By implementing a new decision-making process whose priority is reusable packaging, colour visualisation of elements supports a simplified view and clarity of processes and their owners, simplifying the management and implementation of possible changes and innovation. A simplified view of the packaging process in the context of sustainable development goals helps to understand its essence. It is a tool for warehouse workers - it contains the composition, availability on the test site and evidence of usable packaging. The result is streamlining and unifying new or recurring training, prevention of conflicts in the workplace, and preventing inappropriate sorting of packages evaluated as reusable and a prerequisite for better warehouse organisation.

Future research in sustainable packaging will introduce more innovative solutions for industry using smart packaging and more complex solutions to enhance sustainable development goals. One of the critical scopes identifying and analysing the contributors to circular economy/sustainability and its evolution from three broader perspectives: sustainable development, environment, and economic growth [38]. In a more complex view, the sustainable reverse logistics network needs to enhance considering circular economy [39] and the framework Triple Bottom Line which considers three strategies: economic, environmental, and social [40].

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IMPACT OF DIFFERENT PRICE MOVEMENTS ON THE ACCURACY OF NUMERICAL PRICE FORECASTING

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Keywords: price forecasting, numerical modelling, exponential approximation, commodity exchange
Abstract: The focus of this paper aims at comparison of two prognostic numerical models with different strategies for accuracy improvement. To verify prediction performance of proposed models, the forecasts of aluminium stock exchanges on the London Metal Exchange were carried out as numerical solution of the Cauchy initial problem for the first-order ordinary differential equation. Two techniques for accuracy improvement were utilized, replacing the initial condition value by the nearest known stock exchange and a modification of the differential equation in solved Cauchy initial problem by means of two known initial values. We dealt with an idea of how different price development affected the accuracy of proposed strategies. With regard to obtained results, it was found that the prognoses obtained by using two known initial values were more increasing or decreasing than prognoses calculated by utilizing the initial condition drift. The strategy of a changing form of the differential equation in the Cauchy initial problem can be considered slightly more accurate. Faster increased prognoses were more advantageous especially at a steep price increase and within a price increase following the price decline. A moderate increase of the prognoses determined by the initial condition drift fit reasonably well a price fluctuation and a price decline following the price increase.

1 Introduction

Non-ferrous metals are widely used in many different industries. The predictions of metal prices can provide references of future investments and make the right decisions in the industry. Therefore, commodity price forecasting is very important and active area of research in recent times, although forecasting metal prices with reasonable accuracy is complicated by their cosiderable variability and uncertainty. It made forecasting extremely difficult. In view of this difficulties in accurately forecasting, different types of predictive mathematical models are utilized. The prediction of the future is often done by means of statistical models based widely on time series [1-4]. Recently statistical models with multi-objective programming for non-linear time series [5], different strategies for automatic lag selection in time series analysis [6] and functional time series analysis [7,8] are mostly proposed. There are a lot of novel hybrid methods to forecast commodity prices consisting of the classical GARCH model and neural network model to boost the prediction performance [9,10]. The methods for time series analysis are also combined by adding stochastic term to the first-order differential equation. Solution of this equation represents the time response function which is capable of creating evolving path of the commodity price [11]. New tools from machine learning, artificial intelligence based on neural network and adaptive neuro-fuzzy systems complement traditional methods [12-17].

Our research has been focused on development of alternative approaches to metal price forecasting. The forecasting process was decribed by the Cauchy initial problem for the first-order ordinary differential equation [18-21]. The numerical solution of corresponding Cauchy initial problem provided metal price forecasts.

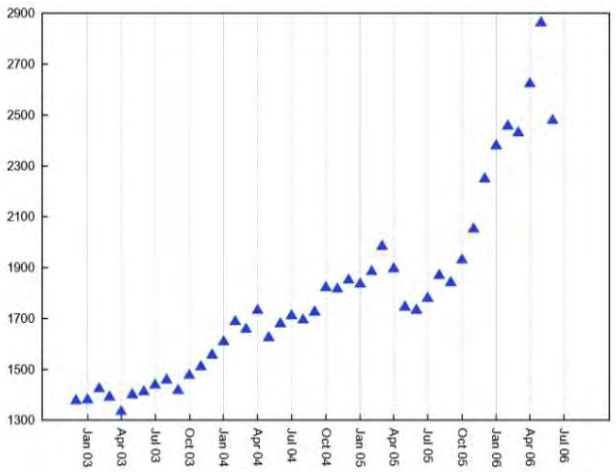

Figure 1 Aluminium price development on LME in the years 2003 – 2006 [18-21]

The forecasting problem in data set of the monthly averages of the daily closing aluminium prices "Cash Seller&Settlement price" (in US dollars per tonne) were examined. The data of our theoretical interest included publicly available aluminium prices on the London Metal Exchange (LME) collected from December 2002 to June 2006 [22]. As can be seen in Figure 1 the course of aluminium prices within considered period changes dramatically. Therefore, observed data period was advantageous for assessing the accuracy of alternative price forecasting within different price movements.

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Non-ferrous industrial metal aluminium was determine as the objective of our research. It has a high strength-to-weight ratio combined with excellent thermal conductivity and good corrosion resistance. It is also recyclable metal. Therefore, aluminium is an attractive material for many applications, including transportation, electrical and packaging industries. It is considered a symbol of modernity. Present applications of aluminium include 3D printing, composite materials, nano-roads, biomedicine devices and aerospace uses [23].

2 Mathematical models

In our previous research [18-21] we proposed several prognostic numerical models and verified their forecast performance. Based on obtained results, the most accurate prognostic approaches were selected. Considered successful forecasting strategies were presented in two models, the model using initial condition drift [19-21] and the model using two known initial values [18,21]. All our studied numerical models were based on solving the Cauchy initial problem in the form

$$y' = a_1 y, \;\; y(x_0) = y_0 . \tag{1}$$

The particular solution of the problem (1) had the exponential form $y = k\, e^{a_1 x}$, where $k = y_0\, e^{-a_1 x_0}$.

In the model using initial condition drift the coefficient a_1 was gained by approximating the aluminium stock exchanges of the approximation term by the least squares method. Let us consider two different ways of the approximation terms' creation, variant B and variant E [19-21]. In variant B the first approximation term was period January 2003 – June 2003. The next approximation terms were created by sequential extension of this period by three months, see Figure 2. As can be seen in Figure 3, the length of approximation terms was constant. Each approximation term of length of twelve months was shifted by one month.

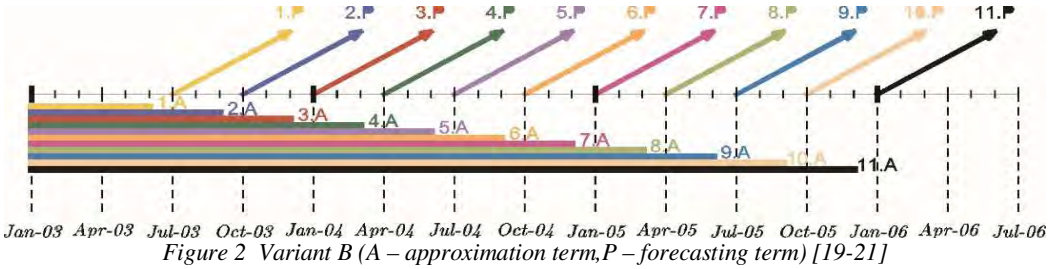

Figure 2 Variant B (A – approximation term,P – forecasting term) [19-21]

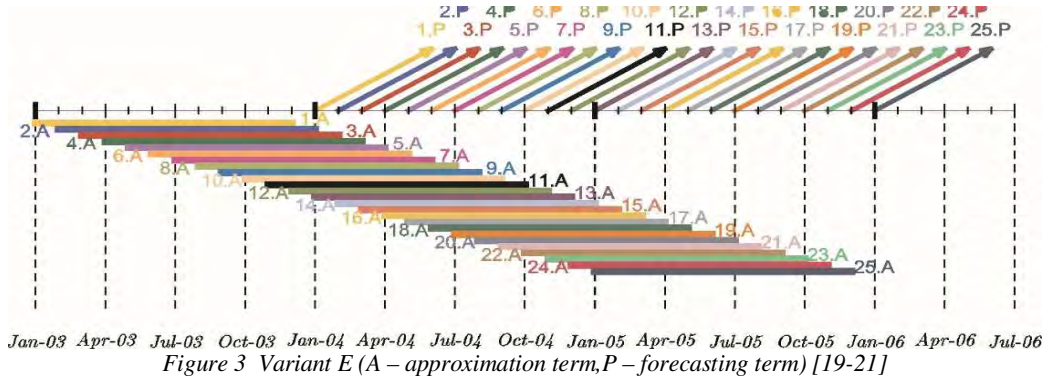

Figure 3 Variant E (A – approximation term,P – forecasting term) [19-21]

According to the acquired exponential approximation function $\tilde{y} = a_0 e^{a_1 x}$, the Cauchy initial problem (1) was written in the form

$$y' = a_1 y, \;\; y(x_i) = Y_i, \tag{2}$$

where $x_i = i$ was the last month of the approximation term, Y_i was the stock exchange in the month x_i.

In the model using two known initial values, two known points $[x_{i-1}, Y_{i-1}]$ and $[x_i, Y_i]$ were considered, where x_{i-1}, x_i were the orders of the month and Y_{i-1}, Y_i were stock exchanges in the months x_{i-1}, x_i. Substituing points $[x_{i-1}, Y_{i-1}]$, $[x_i, Y_i]$ to the general solution of the problem (2) we gained

$$Y_i = Y_{i-1} e^{a_1 (x_i - x_{i-1})}.$$

After some manipulation the formula of unknown coefficient a_1 was determined

$$a_1 = \frac{1}{x_i - x_{i-1}} ln\left(\frac{Y_i}{Y_{i-1}}\right).$$

Substituting a_1 to the Cauchy initial problem (2) we obtained (3)

$$y' = \frac{1}{x_i - x_{i-1}} ln\left(\frac{Y_i}{Y_{i-1}}\right) y, \;\; y(x_i) = Y_i. \tag{3}$$

for $i = 1, 2, 3, \ldots$

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The unknown values of aluminium prices' prognoses were computed by means of the numerical method, which used the following numerical formulae [24]

$$x_{i+1} = x_i + h,$$
$$y_{i+1} = y_i + bh + Qe^{vx_i}\left(e^{vh} - 1\right),$$

for $i = 1, 2, 3, \ldots$, where $h = x_{i+1} - x_i$ was the constant size step. The unknown coefficients were calculated by means of these formulae $v = \frac{f''(x_i, y_i)}{f'(x_i, y_i)}$, $Q = \frac{f'(x_i, y_i) - f''(x_i, y_i)}{(1-v)\, v^2 e^{vx_i}}$, $b = f(x_i, y_i) - \frac{f'(x_i, y_i)}{v}$.

In both determined models daily forecasting was used [18-21]. We form a monthly prognosis in the month x_{i+1} by calculating the arithmetic mean of obtained daily prognoses. Thus, $y_{i+1} = \frac{\sum_{j=1}^{n} y_{ij}}{n}$. In the model using initial condition drift the monthly prognoses within six months following the end of the approximation term were determined. In the model using two known initial values by means of two known points $[x_{i-1}, Y_{i-1}]$ and $[x_i, Y_i]$ just one the prognosis y_{i+1} in the month x_{i+1}, for $i = 1, 2, 3, \ldots$, was calculated.

To compare the real data Y_S with calculated prognosis y_s, the absolute percentage error $|p_s| = \frac{|y_s - Y_s|}{Y_s}.100\,\%$ was computed. The price prognosis y_s is acceptable in practice, if $|p_s| < 10\,\%$. Otherwise, it is called critical value [18-21]. In the following figures (Figure 4, 5, 6, 7, 8, 9 and 10), critical values are red. If the prognosis was not critical value, but its absolute percentage error was greater than 7%, then that is blue. The prognoses with the absolute percentage error less than 7% are green. To evaluate effectiveness of forecasting in different forecasting terms of the length of six months, traditional statistical metrics, the mean absolute percentage error (MAPE), $\bar{p} = \frac{\sum_{s=1}^{t} |p_s|}{t}$, was utilized [19-21].

3 Results and discussion

3.1 *Results of proposed numerical commodity price forecasting*

Among all our proposed approaches consisted in formation of the numerical price forecasts two the most acceptable numerical prognostic models were found. The objective of this study is to compare the performance of two suggested accuracy improvements within numerical forecast. The first way of improvement, used in the model using initial condition drift, was focused on changing the value of the initial condition in solved Cauchy initial problem within forecasting process. Based on previous research [19], it has found that replacing the initial condition value y_{i+s}, for $s = 1, 2, \ldots, 5$ by the stock exchange Y_{i+s-1}, in case that the absolute percentage prognosis error in the month x_{i+s} exceeded chosen value 7%, was the most accurate. Otherwise, the initial condition value in the month x_{i+s} was changed by evaluated monthly prognosis y_{i+s}. This initial condition drift allowed to fit reasonably well the real stock exchanges and significantly improved the accuracy of predictions.

Another improvement of the forecasting process, used in the model using two known initial values, was relying on the creation of the new differential equation in the form $y' = a_1 y$ for each calculated prognosis. The coefficient a_1 in the Cauchy intial problem was determined by utilizing two known points $[x_{i-1}, Y_{i-1}]$ and $[x_i, Y_i]$, where Y_{i-1} and Y_i were known stock exchanges in previous months x_{i-1} and x_i. It allowed to calculate just one prognosis in the month x_{i+1}. To determine next prognosis y_{i+2}, a new form of the differential equation was acquired by calculating a new value of the coefficient a_1 [18].

Within considered group of 36 forecasting terms of variants B and E, see Figure 2 and Figure 3, the forecasting performance of two studied numerical models was investigated. To confirm the effecienty of proposed models the most accurate numerical model was defined for each forecasting term [21]. The forecasting success of chosen numerical forecasting strategies is shown in Table 1. The analysis reported in previous research [21] show that prediction performance of the model using two known initial values was higher, especially in variant B. This strategy acquired the lowest MAPE in 21 forecasting terms. In one forecasting term the same results in both determined models were obtained. On the other hand, the model using initial condition drift was the most successful in 14 forecasting terms.

Comparing the values of calculated prognoses and stock exchanges within observed forecasting terms in two chosen numerical models we have found that the prognoses determined by the model using two known initial values were more increasing or decreasing than prognoses calculated by the model using initial condition drift [21]. They were able to immediately change their course. The computed prognosis followed the trend of two previous initial stock exchanges in the months x_{i-1} and x_i, $Y_{i-1} < Y_i < y_{i+1}$, $Y_{i-1} > Y_i > y_{i+1}$, respectively. The forecasting performance depended on the intensity of either an increase or a decrease of the stock exchanges within three observed months x_{i-1}, x_i and x_{i+1}. The steeper the increase or decrease in the price development was, that means the difference $|Y_{i+1} - Y_i| - |Y_i - Y_{i-1}|$ was larger, the more effective was forecasting by the model using two known initial value [18].

Table 1 The success rate of determined mathematical models

	The model using initial condition drift	The model using two known initial values
Variant B	2	9
Variant E	13	13
Total	15	22

As can be seen in Figure 2, in variant B longer approximation terms than in variant E were used. Obtained exponential approximation functions $\tilde{y} = a_0 e^{a_1 x}$ which determined differential equations in the form $y' = a_1 y$ affected the rate of an increase or a decrease of calculated prognoses in the model using initial condition drift. Using longer approximation terms of variant B a prognoses increase was more moderate. It was often more disadvantageous than steeper increasing prognoses calculated by the model using two known initial values. On the contrary, there were shorter approximation terms in variant E, see Figure 3. Thus, calculated prognoses in the model using initial condition drift increased or decreased steeper. It was the reason why differences in the forecasting success of chosen numerical models became smaller.

Let analyze the forecasting effectiveness of two determined numerical models within different price evolution. We were interested wheather the price movements affected accuracy of two chosen forecasting strategies. The forecasting terms of variants B and E were divided into groups with the same type of the price movement. Within these groups, for each forecasting term the model with lower MAPE value was found. The forecasting effectiveness of proposed mathematical models is illustrated in Table 2 and Table 3.

Table 2 Distribution of the number of forecasting terms in groups of price movement - variant B

	The model using initial condition drift	The model using two known initial values
Stable price increase	0	3
Significant fluctuation	1	3
Price decline following the price increase	1	1
Price increase following the price decline	0	2

Table 3 Distribution of the number of forecasting terms in groups of price movement - variant E

	The model using initial condition drift	The model using two known initial values
Stable price increase	1	2
Significant fluctuation	6	3
Price decline following the price increase	5	1
Price increase following the price decline	1	7

The results confirm higher forecasting effectiveness of the model using two known initial values in both variants B and E within a stable price increase, and when the change in the price development lasted longer, as could be seen in a price increase following the price decline. Within these price movements, the model using two known initial values was more accurate 13 times in both variants. There was only one forecasting term when the model using initial condition drift was more suitable. The same results by both numerical models were obtained in one forecasting term. When the change in the price development was short, more advantageous was the model using initial condition drift. That can be seen within a price decline following the price increase, when better results were obtained by the model using initial condition drift six times. Otherwise, forecasting by the model using two known initial values was more accurate in two forecasting terms. Also significant fluctuation in variant E, using shorter approximation terms, was not always suitable for the forecasting strategy used in the model using two known initial values. In 2/3 of the forecasting terms with significant fluctuation in variant E the model using initial condition drift was more appropriate. In variant B, where longer approximation terms were used, forecasting by the model using two known initial values became more accurate. This strategy

was more successful in 3/4 of the forecasting terms with significant fluctuation in variant B.

3.2 *Discussion about the forecasting success of the model using two known initial values*

Let analyze the forecasting success of a more successful numerical model, that is the model using two known initial values. The significant property of this forecasting was steeply changing calculated prognoses. It was more advantageous in the following price movements

- **a stable price increase**

If a price increase was steep, the absolute percentage prognoses errors increased with time. If they exceeded 7%, the initial condition drifts occurred. That was necessary for an approach to the real steeply increasing stock exchanges and remarkably improved forecasting by the model using initial condition drift. But approaching to real stock exchanges was gradual and slower in comparison to forecasting by the model using two known initial value. The advantage of using two known values was based on steeper increasing prognosis following the increasing trend of two previous initial stock exchanges. The steeper an increase in the price development was, the higher was an increase of the prognosis. Therefore, forecasting was able to faster accommodate to a steep increase of the stock exchanges in the forecasting terms.

Within the period *October 2003 – March 2004* (see Figure 4), due to a steep increase, forecasting by the model using initial condition drift failed in two months of the period (December 2003, February 2004). Using the initial condition drifts, MAPE declined from 9.44% to 4.98%. MAPE of this forecasting term by utilizing the model using two known initial values was 2.74%. As shown in Figure 4, a prognoses increase in the model using two known initial values was higher in comparison to the model using initial condition drift. That made forecasting more successful.

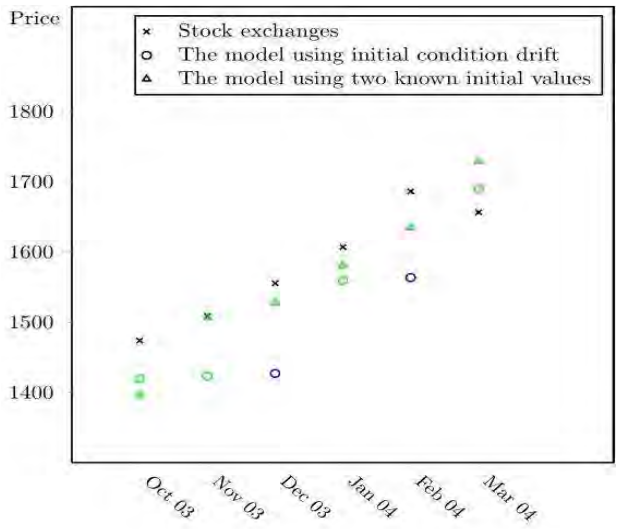

Figure 4 Forecasting by the numerical models within October 2003 – March 2004 (variant B)

If an increase of stock exchanges was moderate, forecasting by the model using two known initial values was also more advantageous. Moderate increasing prognoses calculated by the model using initial condition drift obtained the absolute percentage prognoses errors less than 7%, so the initial condition value was not replaced by the stock exchange. That made the absolute percentage prognoses errors increased with time. On the other hand, steeper increasing prognoses in the model using two known initial values showed better forecasting results. A moderate increase was presented in the forecasting term *July 2003 – December 2003* (see Figure 5). The initial condition drift did not occur, thus MAPE of this forecasting term was higher, 4.17%. More convenient forecasting by the model using two known initial values provided MAPE 2.14%.

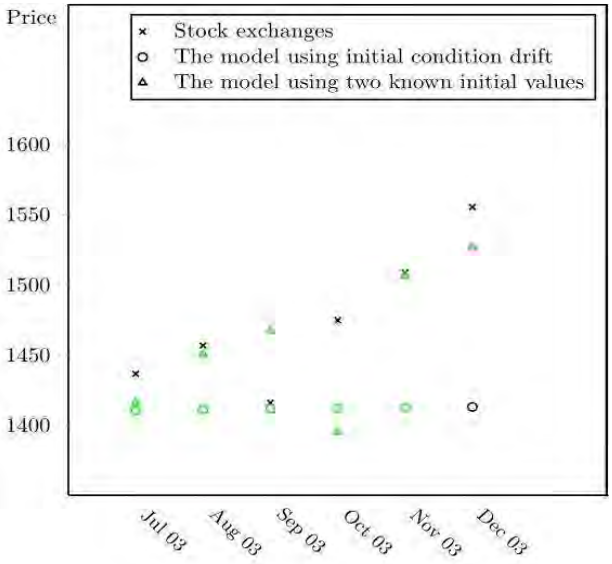

Figure 5 Forecasting by the numerical models within July 2003 – December 2003 (variant B)

- **longer lasting changes in the price development, in our case a price increase following the price decline**

The significant and longer lasting changes in the price development made forecasting more problematic. In case of a price increase following the price decline, decreasing stock exchanges in the corresponding approximation terms caused either slowly increasing or even decreasing course of the approximation functions. Thus, calculated prognoses in the model using initial condition drift were highly inaccurate at a steep increase. Repeated initial condition drift was necessary for putting the prognoses nearer to a steep price increase.

Within the period *August 2005 – January 2006* (see Figure 6) the initial condition drift occurred twice in the months with a steeper increase of the stock exchange (October 2005, December 2005). By replacing the initial condition value by the nearest stock exchange, forecasting was able to fit well a steep price increase. MAPE of

investigated forecasting term considerably declined from 12.13% to 6.71%. Due to higher and continuous increase of prognoses, better forecasting results were obtained by the model using two known initial values, MAPE 3.85%.

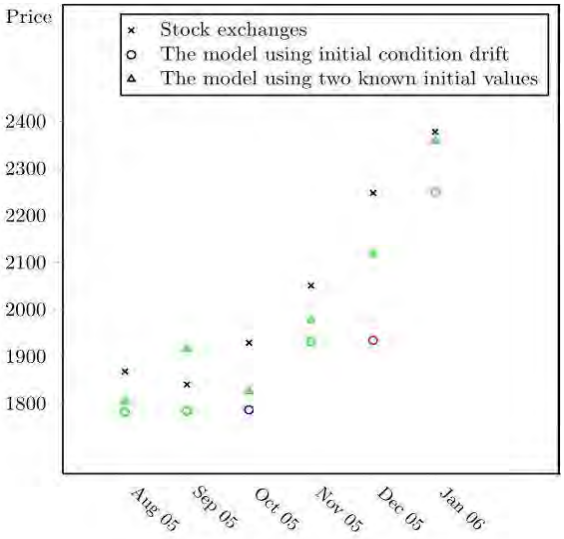

Figure 6 Forecasting by the numerical models within August 2005 – January 2006 (variant E)

3.3 Discussion about the forecasting success of the model using initial condition drift

Although forecasting by the model using two known initial values was generally more suitable, a moderate increase of prognoses supported by occasional initial condition drift in the model using initial condition drift was more advantegeous especially in either a moderate fluctuation or in a significant decline following the price increase.

- **shorter lasting changes in the price development, in our case a price decline following the price increase**

In case of a price decline following the price increase, the prognoses calculated by the model using initial condition drift were increasing as well. Forecasting was able to fit considerably well a steep decline of the stock exchanges due to replacing the value of the initial condition by the stock exchange from decreasing price development. In variant E, the model using initial condition drift was more appropriate. Shorter approximation terms made steeper increasing prognoses, so the absolute percentage prognoses errors were higher and caused the initial condition drift sooner than in variant B with a moderate increase of the forecast prognoses.

The disadvantage of forecasting by the model using two known initial values was steep change of calculated prognoses. Within a steep decrease of the stock exchanges, a decline of calculated prognoses was usually higher than a decrease of the stock exchanges. Then shorter lasting significant decline was changed to a moderate increase. But an increase of calculated prognoses in the model using two known initial values were higher, too. That made this forecasting stategy less accurate.

Within the period *February 2005 – July 2005* (see Figure 7) forecasting using the initial condition drift was more suitable. The absolute percentage prognosis error in month with the highest decline (May 2005) exceeded 7%, thus the initial condition drift occurred. Using the drift a decline of the stock exchanges was captured and remarkably reduced forecasting errors. MAPE of the forecasting term obtained by the model using initial condition drift declined from 5.48% to 3.30%. MAPE for the model using two known initial values was 4.48% due to higher decreased or increased prognoses.

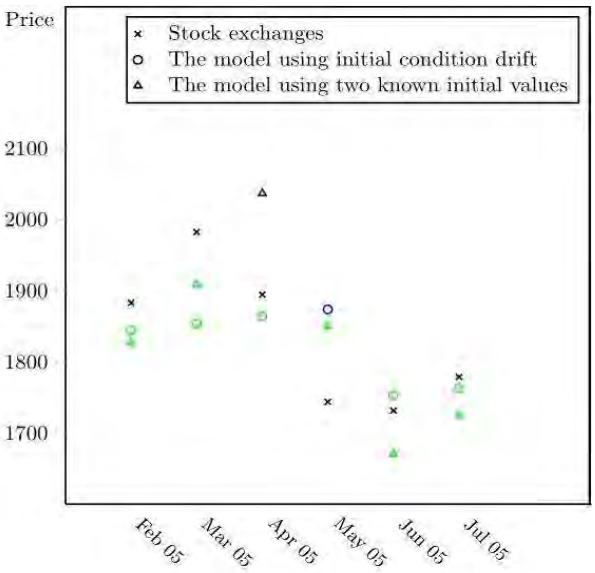

Figure 7 Forecasting by the numerical models within February 2005 – July 2005 (variant E)

- **significant fluctuation**

Also a significant fluctuation was usually innapropriate for forecasting by the model using two known initial values. Often changing values of the stock exchanges caused higher increased or decreased prognoses. But a moderate increase of the stock exchanges made this forecasting less inaccurate. More suitable was a moderate increase of the prognoses acquired by the model using initial condition drift. If stock exchanges in the forecasting term tended to moderately fluctuation, usually the initial condition value was not occured. This situation can be seen in the period *November 2004 – April 2005* (see Figure 8), when due to a moderate increase of the prognoses calculated by the model using initial condition drift MAPE of the forecasting term was 1.47%. By the model using two known initial values MAPE was higher, 3.56%.

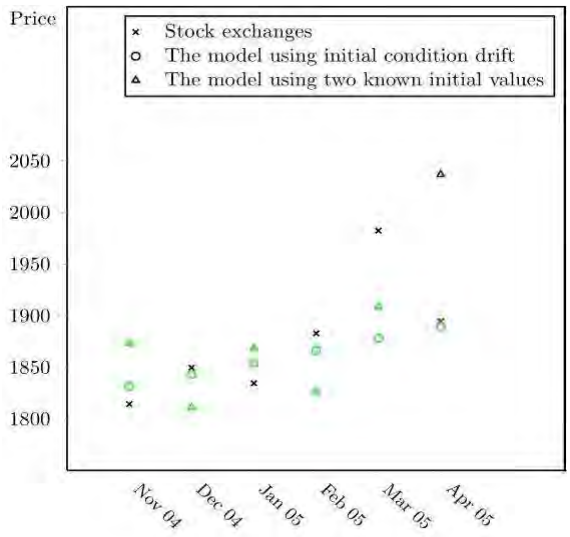

Figure 8 Forecasting by the numerical models within November 2004 – April 2005 (variant E)

If a fluctuation of the stock exchanges became steeper, some of the absolute percentage prognosis error became greater than 7%, therefore the initial condition drift occurred in the model using initial condition drift. That put calculated prognoses closer to steeper fluctuated stock exchanges and forecasting became more accurate. Considering the forecasting term *May 2004 – October 2004* (see Figure 9), the absolute percentage prognosis error in the first month of the forecasting term was so high that it caused the initial condition drift. The next prognoses better forecast the stock exchanges without new initial condition drift. Thus, MAPE of the forecasting term in the model using initial condition drift decreased from 5.14% to 3.64%. The prognoses obtained by the model using two known initial values changed faster, so for this model greater MAPE, 4.04%, was gained.

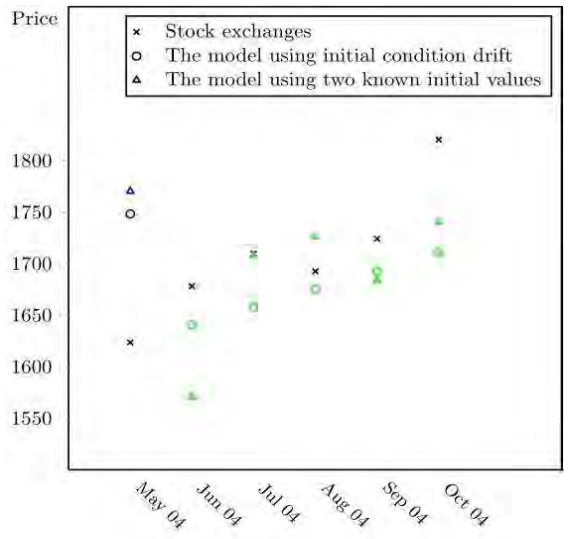

Figure 9 Forecasting by the numerical models within May 2004 – October 2004 (variant E)

Within a steep fluctuation of the stock exchanges bigger changes of the prognoses obtained by forecasting in the model using two known initial values were more accurate. Even reapeated initial drifts in the model using initial condition drift were not able to catch steeply changing price development. Thus, MAPE of the forecasting term *January 2006 – June 2006* in the model using initial condition drift improved from 9.43% to 8% (variant B) or 8.06% (variant E). Due to steeper fluctuating stock exchanges the initial condition drift occurred twice, see Figure 10. Forecasting by the model using two known initial values was more suitable for these steep movements of the stock exchanges, MAPE of observed forecasting term was 6.21%.

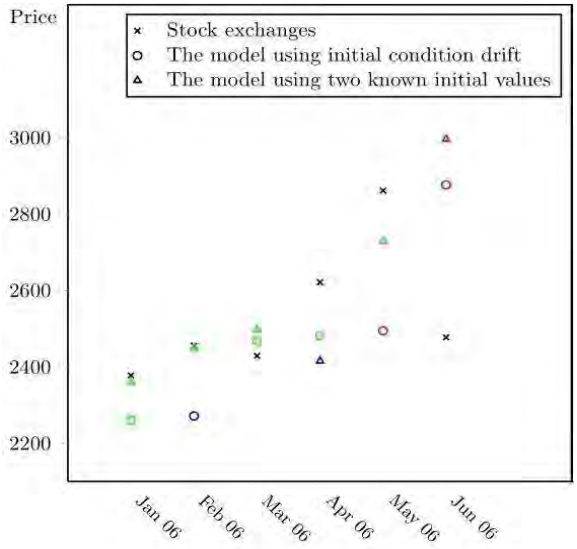

Figure 10 Forecasting by the numerical models within January 2006 – June 2006 (variant E)

4 Conclusions

The improvement of metal prices prediction accuracy is still a highly challinging task. For this purpose two successful strategies of numerical price forecasting were created in our previous research work. In this paper the effectiveness of their forecasts within different movements of the price development was assessed. The exploratory results confirmed that proposed models achieved significant increments in the accuracy of the commodity price forecasts by reduction of the mean absolute percentage error in investigated forecasting terms.

By comparing the obtained forecasts with investigated aluminium stock exchanges, we have found that forecasting by the model using two known initial value was usually more accurate. The success of forecasting by this model depended on the intensity of either an increase or a decrease of the stock exchanges. The steeper the increase or decrease in the price development was, the more advantageous was forecasting by the model using two known initial value. For each calculated prognosis a

new form of the differential equation in the Cauchy initial problem was determined using two nearest known stock exchanges. It made prognoses steeper increasing or decreasing than prognoses gained by the model using initial condition drif. Therefore, we recommend to utilize the stategy of using two known initial values within steeper price movements. The forecasting was more successful especially at a stable price increase and within an increase of the stock exchanges following the price decrease. On the other hand, moderate and gradually changing prognoses calculated by the model using initial condition drift were more suitable especially at a moderate fluctuation and within a price decline following the price increase. If the absolute percentage prognosis error became higher, replacing the value of the initial condition by the nearest known stock exchange made forecasting more accurate. The movements of the price development influenced the forecasting accuracy. Therefore, the use of appropriate forecasting strategies could significantly improved the final results.

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THE INFLUENCE OF RESOURCES DIMENSIONS AND INNOVATION SOLUTION ON VALUE CREATION: A CASE STUDY OF HALAL LOGISTICS SERVICE IN THAILAND

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Keywords: resources dimensions, innovation solution, value creation, halal logistics, mediation
Abstract: This study examines the influence of the relationship between resources dimensions and the value creation of logistics service providers (LSPs), in the economic crisis caused by the coronavirus disease 2019 (COVID-19). It also explores the mediating role of innovation solutions in halal logistics in the relationship between resources dimensions and value creation. Halal logistics play an important role in Muslim countries, and there has been a growing demand for halal products from non-Muslims. Despite its importance, there is limited knowledge of halal logistics problems in Thailand among the LSPs. To understand these issues, the study uses a questionnaire to collect data from 200 Thai LSPs selected through purposive sampling based on their logistics experience in halal, agricultural, or food products. We test the hypotheses using structural equation modeling. The results show a direct relationship between resources dimensions and the value creation of LSPs. The resource dimension is indirectly related to value creation through innovation solutions that mean it acts as a partial mediator in the relationship between resources dimensions and value creation. This study has important implications for LSPs in Thailand in that it demonstrates that they can promote innovation through resources utilization and thereby enhance financial and business performance.

1 Introduction

Since its onset, the coronavirus disease 2019 (COVID-19) has been adversely impacting the economy of several countries. This can be attributed to the impact of the virus control measures on production operations, service sector businesses, and people's livelihoods. This impact has been most prominent on agricultural consumption, which is key to the survival of the population and an important economic driver of every country. In the given context, this study considers Thailand's upstream food chain. Thailand's economy heavily depends on its export volume, including agricultural and processed agricultural products. Thailand's export products are recognized for their quality in Asia, North America, and Europe [1]. However, these exports and their volumes have been impacted owing to the current economic slowdown. On comparing the overall situation of agricultural products exported from Thailand between 2019 and 2020, the volume of Thai agricultural exports decreased by 3.2 percent [1]. The Ministry of Agriculture and Cooperatives in Thailand encourages entrepreneurs to control the quality of agricultural products throughout the supply chain without viral contamination, which is safe for the consumer. In addition, they are considering the opportunities market to the replacement value.

Based on the impact of this crisis, agricultural and food entrepreneurs should seek business opportunities and undertake process development aimed at inhibiting spoilage and maintaining the shelf-life of their products. Although this crisis has affected agricultural consumption, the demand for certain food products, such as halal products, has remained positive. A survey conducted by the Export-Import Bank of Thailand [2] during the pandemic showed steady growth in the global food demand for halal products. Especially, this demand has been rising in the member countries of the Gulf Cooperation Council (GCC), which include the United Arab Emirates, Qatar, Saudi Arabia, Oman, Kuwait, Bahrain, and Brunei. In these countries, the steady demand can be attributed to the high income and purchasing power of the people and the strict compliance of the imported halal products to the same halal standards [3]. The food safety and hygiene standards of halal products have further increased their demand among non-Muslim consumers. Thus, in this pandemic scenario, the demand for halal products has increased across countries [2].

Concerning demand, it must be noted that its change impacts businesses adapting their strategies to survive; these businesses include logistics service providers (LSPs) required to cope with supply chain fluctuations who must focus on the effective allocation and utilization of tangible and intangible resources. This approach helps businesses to create competitive advantages and transfer the value of products and services from upstream to downstream users and match the rapid demand and supply fluctuations [4].

Concurrent to resource utilization, service innovation improves service quality by changing the operating process; this leads to the creative differentiation of products and services [5]. In this regard, notably creative products and services can reduce the competitiveness of (LSPs) in Thailand. Most of the products and services focus on the mass market; a basic service assesses service efficiency with speed and reduced operating costs rather than a constructive change [6].

The literature review found that the effective utilization of organizational resources can lead to the development of value-added goods and services. In particular, inventive resources allocation to innovations can create utility by responding to customers' needs [7]. This literature review lends an in-depth character to this study. First, this study provides a case study of the resource dimension and innovation solutions that can create value through a supply chain, which draws on the resource-based theory and the literature on value creation with resources dimensions and innovation solutions. Second, the findings of this study emphasize the indirect role of innovation solutions in mediating the relationship between resource dimension and value creation. The final contribution of this study pertains to the development of a LSP in Thailand**.**

2 Literature review

2.1 Resource-based theory (RBT)

The resource-based theory provides valuable insight into a firm's competitive and sustained advantages. Sharma and Vredenburg [8] and Barney [4] discussed the resource-based theory that competitive advantage reflects on the firm performance based on the utilization of resources and capabilities. The first category of resources includes tangible resources. They refer to substantial resources in organizational control such as human resources, factories, warehouses, tools, and equipment. Talib, Rahim, Chin, and Hamid [9] explain the importance of tangible resources in logistics activity and supply chain management. They show that tangible resources comprise basic resources supporting basic services and advanced technology resources connecting upstream to downstream logistics activities. The second category of intangible resources refers to information and management that bring substantial value to an organization and are difficult to replicate. The benefits of intangible resources are manifested through effective communication and avoiding the impact of supply chain management [10-11]. The third category of capabilities includes firm expertise, which uses resources about objectives and achieves organizational goals [12] such as knowledge, establishing, and maintaining relationships in the supply chain network.

2.2 Value Creation

Porter [13] discusses the difference between supply chain and value chain. The supply chain refers to the integration of all activities involved in sourcing, purchasing, transforming, and logistics from upstream to downstream. However, the concept of the value chain focuses on finding activity links to transform inputs into products or services, which benefit goods and services proposed by the firm to enhance customer value. This value is evaluated based on customer satisfaction level and the willingness to pay for goods and services. The value added to products and services is a result of several factors. The first factor is effective resource utilization. Second, the relevant intangible resources are used to manage supply chain relationships influencing the value creation at a service level; specifically, these resources are used to respond to customers' needs and gain their trust, thereby cultivating positive customer perception [14]. Finally, tangible resources are allocated in blockchain information technology to facilitate data sharing between business partners, which moderate unexpected situations from market changes and improve operational flexibility [15]. In this COVID-19 context, it is necessary to implement organizational innovation to solve problems emerging from rapid changes in supply and demand. A service business addresses these problems and responds to customers' needs in changing situations through service innovation. This approach helps organizations to reduce the financial impact of crises [16].

On the resource-based theory and value creation, organizations integrate tangible and intangible resources and capabilities to provide a competitive advantage through unique patterns. In this regard, Phillips, Thai, and Halim [17] prove that the value chain impacts organizational performance in terms of financial and non-financial measures, and the intangible resources in the value chain eventually affect sustainable organizational performance. Through the resource-based theory and value creation concepts, LSPs can gain insights into effective resource utilization. This approach can enable them to combine resources and supply chain resources to create value in response to customer needs, thereby gaining a competitive advantage.

Hence, we hypothesize as follows:

Hypothesis 1 (H1): Resources dimensions have a positive relationship with value creation

2.3 Innovation Solution

According to the Organization for Economic Co-operation and Development [18], innovation is results from activities that improve and develop the basics in the creative process; these basics are different from basic resources and advanced resource utilization. Data transformation, tools, equipment, and human resource management are necessary to conduct the research and development for products and services having competitive advantage and different types of economic utility—form, time, place, and possession. Given this, the role of organizational innovation is to apply knowledge, capabilities, creativity, skills, experience, technology, or organizational management principles to strategic service

enhancement and to apply restructured processes to new services [19-20].

Concerning halal logistics, it is a service innovation, different from basic service. It is based on compliance with the beliefs and religious practices of Islam throughout the process—from the source to the end-user. It requires an inspection of all activities per the indicators of halal certification; for example, it uses separate equipment for halal and non-halal products [21-22]. The halal logistics providers focus on the segregation and contamination issues between halal and non-halal products to achieve the halal integrity supply chain. Concerning supply chain failure, the literature demonstrates that its failure is caused by a lack of collaboration between stakeholders, such as suppliers, manufacturers, warehouses, retailers, and distributors. A non-compliance to halal standards will negatively impact the halal integrity of the halal products. The poor performance of the halal supply chain, both qualitatively and quantitatively, may disrupt the halal integrity; the chances of contamination increase when the halal products are delivered to end customers. This problem can be addressed by integrating halal supply chain operations of organizations with improved innovations and better traceability systems. Further, Talib and Wahab [23] explained that the exponential growth rate in the halal industry encourages LSPs to offer halal logistics services. It motivates service differentiation by implementing halal logistics and prominence from the saturated logistics industry. Thus, services innovation influences the market value.

Almost all organizations compete in an innovation view that organizational innovation should be the challenging capabilities of their company, observed as a solution to dynamic capabilities in rapidly changing environments for organizational success.

Therefore, we hypothesize as follows:

Hypothesis 2 (H2): Resources dimensions have a positive relationship with innovation solutions for halal logistics.

Hypothesis 3 (H3): Innovation solutions for halal logistics have a positive relationship with value creation.

A literature review of the relationship between innovation, resources dimensions, and value creation in the service sector showed that the use of resources dimensions (e.g., technology development, information technology, knowledge, infrastructure, organizational strategy) to create innovation has a positive influence on the performance of organizations that are growing exponentially and possess the ability to survive in a fiercely competitive environment. Utilization of resources in innovation creation can also create better service levels and unique qualities. Based on a previous study result, innovation is a mediator of the relationship between resources and organizational performance. Safari and Saleh [24] considered determinants of RBV and found that marketing data is an essential source to forecast and respond to customers' needs. These are impacts on the performance of the small and medium-sized export businesses of Vietnam. Innovation is an important factor that defines export strategy achievement. Thus, competition, environmental changes, and strategic planning enable organizations to develop business models to achieve competitive advantage and seize opportunities in emerging markets [25-26]. Latifah et al. [7] examined variables that innovation is directly related to the competitive advantage that succeeds in narrowing the gap between supply and demand with differentiated products and services to create value-addition for customers. Although, innovation can create unique qualities, the organization must simultaneously adjust its operation strategy with the development, which leads to the hypothesis test that found that organizational strategy has a positive influence on organizational performance when it focuses on innovation. Moreover, Guerreiro and Pacheco [27] and Phillips, Thai, and Halim [17] studied the mediation between business capabilities and firm performance in response to changes in the business environment. Several studies have shown that innovative processes and products define a firm's performance when facing fierce competition. Hence, it can be stated that innovation solutions mediate the influence between resources dimensions and value creation. Innovation solutions encompass the development processes in organization management, production, and services to target a specific market and enter a new market.

Given this, we hypothesize as follows:

Hypothesis 4 (H4): Innovation solution for halal logistics mediates the relationship between resources dimensions and value creation.

Based on a literature review, we found the following elements of the resources dimensions' variable: basic resources, advances resources, information, relationship management, and knowledge. The organization, environment, assurance, and technology factors are elements of the innovation solution variable. Differentiation, reputation, flexible processes, and cost leadership are the elements of value creation.

Resources dimensions' utility is related to value creation and innovative creation through halal logistics services. Halal logistics generates value through firm performance from financial and marketing perspectives. This study tests the mediating relationship between resources dimensions and value creation through innovation solutions for halal logistics that are more than basic services based on price competition. There are reasons for the change in the relationships between the resource dimension and the value creation of LSPs in Thailand. Based on the relationship between variables, we formulate a hypothesis and concept model, as shown in figure 1.

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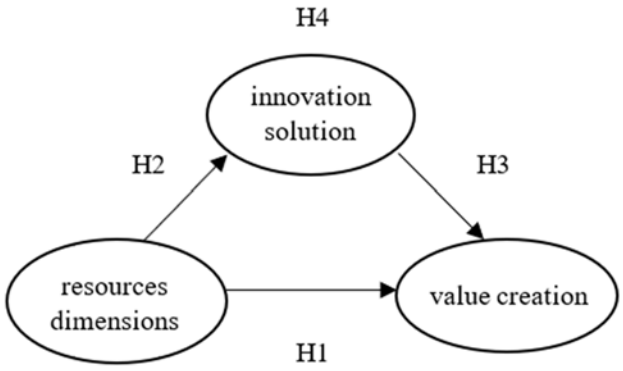

Figure 1 Conceptual model

3 Data collection and methodology

3.1 Data collection

We collected quantitative data using a questionnaire designed and based on the conceptual framework and distributed it to 200 LSPs. We chose the purposive sampling approach, selecting an executive director (e.g., the CEO, director, freight manager) from the LSPs registered as juristic persons in the service sector in transportation and storage facilities from the Department of Business Development Ministry of Commerce. Our sample comprised LSPs with experience in halal products, agricultural products, or food products; this was one of the selection criteria consistent with the aims of the study. While collecting data, the researcher inquired about the preliminary information of the logistics provider experience. When the qualification of a logistics provider is met through the specific objectives of the research, it leads to the appointment process: collecting data from the executive director with the face-to-face method, and checking the questionnaire completed after the survey. Given a limited number of samples, N = 200 also fulfilled the criteria for conducting the structural equation model [28].

3.2 Methodology

Content validity

Questionnaires had a validity between 0.67 and 1.00, which is greater than the criteria 0.50 [29], and reliability with Cronbach's alpha coefficient between 0.76 and 0.9, which is greater than the threshold of 0.70 [30]. Thus, it can be concluded that the questionnaire was an accurate and reliable tool.

Construct validity

Table 1 summarizes the latent variables, including resources dimensions, innovation solutions, and value creation. A structural equation model was employed to examine convergent validity and discriminant validity before its hypotheses testing and testing the mediating variable. Convergent validity shows that the values of composite reliability (CR) are greater than the criteria 0.7 [31]. For discriminant validity, the square roots of average variance extracted (AVE) should be higher than the correlation coefficient of constructs given under the diagonal. The results showed that all of the AVE exceeds the criteria 0.5 [32]. Thus, the questionnaire and methodologies were qualified for use in the study according to the theory.

Table 1 Matrix of length

	Resources Dimension	Innovation Solution	Value Creation
Correlation matrix			
Resources Dimension	1	-	-
Innovation Solution	0.581**	1	-
Value Creation	0.487**	0.514**	1
Mean	4.23	4.05	4.22
S.D.	0.395	0.490	0.425
Average variance extracted (AVE)	0.86	0.87	0.90
Composite Reliability (CR)	0.992	0.992	0.995

*p < 0.05; **p < 0.01; ***p < 0.001

4 Result

4.1 Company information

This section presents the results of the demographic characteristics of the 200 LSPs. The number of firms that had a juristic person status, limited partnership/juristic partnership, and public limited status accounted for 172 firms (86%), 19 firms (9.5%), and 9 firms (4.5%), respectively. Based on firm location, most of the firms were located in the central region. The number of firms exceeding 16 years of operations accounted for 110 firms (55%). Respondents had various characteristics. Table 2 shows the descriptive statistics of the company information.

4.2 Assumption Tests

Based on data in Table 3, this section presents the hypotheses testing below:

We used structural equation modeling to examine the hypotheses and showed the construct variable relationships. The results show the direct positive relationship between resources dimension and value creation in halal logistics; this finding is based on the coefficient (β) of 0.308 and the 0.05 significance level, which supports H1. The resources dimensions share a positive relationship with innovation solutions; this finding is based on the coefficient (β) of 0.707 and a significance level of 0.001 level, which supports H2. The result further reveals a positive and significant direct effect of innovation

solutions and value creation on halal logistics, given its coefficient (β) of 0.355 and significance level of 0.001 level, which supports H3.

The indirect influence of innovation solutions as the mediating variable.

First, we found a mediating effect of innovation solutions on the relationship between resources dimensions and value creation in halal logistics; this is based on the coefficient (β) of 0.255. Second, concerning the mediating role of innovation solutions, we compared the difference between the direct and indirect influences of resources dimension and value creation to halal logistics. The results showed that innovation solutions reduce the direct influence coefficient significantly between the resources dimension and value creation. Thus, the innovation solution is a partial mediator, which supports H4.

Based on the results, we adopt a model fit to investigate the mediating role of innovation solutions in the relationship between the resources dimension and value creation. In line with Hair, Black, Babin, and Anderson [31] and Hu and Bentler [33], we used the chi-square criteria, chi-square to degrees of freedom, standard root mean square residual (SRMR), root mean square error of approximation (RMSEA), goodness of fit (GFI), and adjusted goodness of fit index (AGFI) to evaluate the overall goodness of fit ($\chi^2 = 133.057$, df = 62, $\chi^2/df = 2.146$, SRMR = 0.076, GFI = 0.905 and AGFI = 0.860). Consequently, the results show that the hypothesized model fits the empirical data well.

Table 2 Company information

Company Group		Frequently (LSP)	Percent (%)
Companies Registration			
	Public Limited Company	9	4.5
	Limited company	172	86
	Limited Partnership/ Ordinary Partnership	19	9.5
Total		200	100
Location			
	North	15	7.5
	Central	71	35.5
	South	26	13
	Eastern	39	19.5
	Western	21	10.5
	Northeast	28	14
Total		200	100
Age of the establishment and operation			
	less than 5 years	15	7.5
	5–10 years	30	15
	11–15 years	45	22.5
	more than 16 years	110	55
Total		200	100

Table 3 Hypothesis testing results

Hypothesis	Path	Direct effect	indirect effect	Note
Direct hypothesis				
H1	resources → value	0.308*	-	Support
H2	resources → innovation	0.707***	-	Support
H3	innovation → value	0.355***	-	Support
Mediation hypothesis				
H4	resource → innovation → value	-	0.255	Support

Note: Chi-Square = 133.057; df = 62; SRMR = 0.016; RMSEA = 0.076; GFI = 0.905; AGFI = 0.860
significance level: *p < 0.05; **p < 0.01; ***p < 0.001

5 Discussion

5.1 The influence of resources dimension on value creation

There is a significant relationship between the resources dimension and value creation. This is consistent with the resource-based theory, in which a firm's performance reflects a competitive advantage based on the

organization's resource utilization and capabilities [1,8]. Furthermore, the effective utilization of supply chain resources, through which the tangible and intangible resources add value, include the following three areas: 1) value added from a common goal of supply chain management, 2) value added from joint development, and 3) value added from solving supply chain problems [34]. The result of the effective utilization of supply chain resources, as mentioned above, the performance evaluation outcomes (e.g., corporate growth, survival in the market) can include customer satisfaction and financial performance. While examining the relationship between resource dimensions and value creation in the role of the halal industry, Othman et al. [35] confirmed that knowledge in halal practice is a significant resource. These ensure that operators comply with halal standards to obtain halal products and quality services. In a similar approach, Tarmizi et al. [36] provided the supporting information that halal customer's confidence includes supply chain integrated systems and separation of facilities, equipment, and infrastructure for Halal products and services.

5.2 The influence of resources dimension on innovation solutions

Based on the hypothesis test, there is a positive influence of resources dimensions on innovation solutions. This means the ongoing global pandemic affects consumer behavior. Consumers have become increasingly hygiene conscious, which determines their decision to buy hygiene products; they have also become aware of the security measures to manage product and process quality. Thus, LSPs must manage the changing consumer behavior by employing effective strategic management measures [21,20]. For example, information sharing among supply chain partners to reduce the risks associated with internal and external factors [37,38] and creative inputs for new products, services, and process development can attract diverse customers [39]. Further, the role of the halal LSPs involves operational supervision and control following halal standards while transferring the control of products and services to other activities in the supply chain. Technology can provide more efficient monitoring of the halal supply chain that has supported services innovation to halal logistics [40].

5.3 The influence of innovation solutions on value creation

The results of the data analysis show a positive influence of innovation solutions on value creation in halal logistics. The findings agree with the research conducted by Mikl, Herold, Cwiklicki, and Kummer [41]. Their study compared the value added from different service types between basic logistics services and innovative logistics services. They found that basic logistics services emphasize mass markets with specific expertise to create value from the ability to manage redundant logistics activities. However, innovative logistics services are focused on process development and technological factors creating value beyond that emerging from a chain of linked activities and the ability to fulfill customer needs in the industry.

The innovation solution for halal logistics is related to value creation in terms of the quality of halal products and services compliant across the upstream and downstream supply chains. The level of services provided to customers reflects the LSPs' expertise, which could show a positive increase in customer satisfaction levels, customer trust, and confidence [42-43].

5.4 The influence of resources dimensions on value creation through innovation solutions

The results show a positive and significant relationship between resources dimensions and value creation through innovation solutions. Hence, it can be concluded that the innovation solutions have been successful in partial mediation of the influence of the resources dimensions on value creation. We also conclude that effective utilization of resources in various dimensions will improve the value of the halal logistics service levels if supported by innovative solutions. These findings can be explained by the fact that halal logistics service utilizes resources from five dimensions—basic resources, advanced technology, information sharing, relationship management, and knowledge management [14,15,43]. Resource utilization can facilitate service innovation by halal logistics services providers in the areas of compliance. For example, halal products must be kept separate from non-halal products, cleaning activities for the dirt and stains removal should ensure non-contamination, and attention should be paid to halal documentation. These measures can enhance the innovation impact, a mechanism to increase service choice that LSPs can add value to the firm and integrity in the halal food chain.

6 Conclusion

6.1 Theoretical contributions

This study applied resource-based theory to examine the value added by LSPs. However, there are limitations as an empirical study on the value-added factors of halal LSPs in Thailand. The resource-based theory is also related to resource utilization adopted to create value through products and services in social context differences and crises [11,37,44]. Through this lens, it has been proven that resource utilization can be used to facilitate service innovation [21]. This study extends the definition of innovation in previous studies. Innovation can enhance competitive advantage by facilitating the development of better products and services at a faster and worth. This study contributes to the development of service levels through innovation in halal logistics and thereby responds to customer needs in changing situations [21,45,46]. Thus, the findings increase the knowledge of value creation in

logistics services by connecting three concepts: resources dimensions, innovation solutions, and value creation.

6.2 Practical implications

This study has important implications for LSPs in Thailand. First, resources utilization from five dimensions can create value in terms of financial and market for LSPs. Resources utilization can be described as follows: Basic resources, LSPs should consider flexible choices about using limited resources to obtain the maximum benefit (e.g., basic service coupled with other services). Advanced resources, the advanced technology may bring benefits that make it worth the difference in services. Halal logistics services is a service innovation of LSPs in Thailand that differs from basic services. They can set their prices in a fair market value transaction without price competition. Therefore, there is an opportunity for LSPs' faster payback period to influence technology investment. Information, a key of business opportunities, involves information from customers and stakeholders. Customer information sharing help in understanding customer needs with a lack of responses and creating products and services of great value. Moreover, information sharing between stakeholders in the supply chain enhances the quality control of halal logistics services. In terms of relationship management, LSPs need to build trust in a relationship with partners making provisions to deliver value in halal logistics services throughout the supply chain and reduce contamination errors between halal and non-halal products during operation. Additionally, knowledge is the significant limitation of halal logistics services in Thailand; Buddhism being the most common practice of Thai people is a reason for operators lacking knowledge and understanding of Islamic practices. Thus, the organization has a role in providing knowledge and understanding to operators to increase the operation efficiency following the halal standard. Second, resources play a critical role in facilitating service innovation, enabling LSPs to adapt their knowledge base to gain a competitive advantage. As a service innovation for LSPs in Thailand, halal logistics can facilitate the development of value-added services. Specifically, it can build customer trust during the ongoing COVID – 19 crisis by offering products and services that meet food quality, hygiene, and halal standards. Although LSPs are interested in halal logistics service innovation, there is no concrete government support and promotion to enter the potential halal market. The government should begin to promote halal logistics with clear standardization and rule of halal. There is no difference between the standards of Muslim countries and halal logistics provides extensive supports to businesses, both domestic and international. Finally, this study suggests that LSPs focus on promoting innovation in their organizations through resources utilization for improving their business performance, particularly in terms of creation of value-addition from finite resources in a crisis.

6.3 Limitations and future research

This study collected data during the pandemic. Therefore, the information was collected from logistics providers in non-normal operating circumstances. Because this scenario was influenced by rapid changes in demand and supply factors, the logistics providers may have paid less attention to innovation and focused on risk management. Moreover, innovation solutions partially mediate the relationship between the resources dimension and value creation; given this, there may be more than one mediator in this relationship. The future study can be replicated with additional mediators of more than one of these conditions (e.g., consumer demand and thriving halal industries) to describe the relationship between resources dimensions and value creation of LSPs in changing situations.

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THE DECADES OF RESEARCH ON SCM AND ITS ADVANCEMENTS: COMPREHENSIVE FRAMEWORK
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THE DECADES OF RESEARCH ON SCM AND ITS ADVANCEMENTS: COMPREHENSIVE FRAMEWORK

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Keywords: Global Supply Chain Management, Green Supply Chain Management, SCM 4.0, Supply Chain Management, VOSviewer
Abstract: Supply Chain Management (SCM), a corporate strategy approach to materials and distribution management, has been evolving over the last decades from traditional marketing and production functions. The purpose of the study is to explore the bibliometric data of Supply Chain Management and its advancements. Besides, it describes from the origins of traditional SCM to the progress of modern SCM 4.0, with reference to the benefits, function, importance and limitations of all five branches of SCM. The methodology includes a detailed and systematic review of scientific articles published in Scopus indexed journals. The data were obtained from the Scopus database between 1990 and 2021 in order to achieve the study's desired outcome. Boolean operators and filtering were applied to obtain relevant data. In addition, VOSviewer software is used to visually classify and analyse bibliometric data distribution and network using cluster maps. The study's findings were divided into three main categories: publication period, coauthorship and citations, with the results demonstrating the diverse needs of SCM in the globalised digital era. Further, the results emphasise that SCM and its advancements have unique merits around the world, but Sustainable SCM and SCM 4.0 remain the most popular as they play a vital role in changing environmental concerns. In addition, the findings reveal that the visualization networks of each category exhibit the strengths and connections of publications. These visualization networks, followed by their analysis, explain the new insight to the present research. This research also paves the way for future research into the evolving trends of SCM in today's technologically advanced world.

1 Introduction

In the global competitive market environment, creating a customer circle and adhering to their needs are the most critical tasks for the majority of the market owners. Customers ventured in search of goods and products in ancient times, but in modern times, market producers make it easier for customers to have the products of their choice delivered to their doorstep and at their available time. These days, marketing companies look for raw materials, basic components, and parts for their manufacturing processes beyond their city, state, and country's borders. The finished goods are then distributed through a network of channels to various parts of the world, depending on where the final customer is located. To put it in simpler terms, Supply Chain Management (SCM) is the synchronization of all of the above activities, which in turn manages demand and supply on a global scale. To begin with the advent of SCM, in the year 1958, Forrester predicted that "there will come general recognition of the advantage enjoyed by the pioneering management who have been the first to improve their understanding of the interrelationships between separate company functions and between the company and its markets, its industry, and the national economy" [1]. Though Forrester mentioned this several decades ago, Mentzer et al. (2001) claim that Forrester identified effective management issues and illustrated the dynamics of determinants with the concept now known as Supply Chain Management (SCM) in modern business literature [2]. Further, Oliver and Webber mentioned Supply Chain (SC) in 1982, who described it as a network of organizations [3].

The concept of SCM initially emerged and flourished in the manufacturing industry in the 1990s [4,5]. The widespread use of SCM can be understood through the words of Ross where he states, SCM has become such an important topic that it is impossible to open up a periodical on marketing or customer management without seeing an article about SCM and its related topics [6]. According to the analysis of Lalonde in 1997, the words "supply chain" appeared in 13.5% of recurrent titles at the Council of Logistics Management's Annual Conference

in 1995. Only two years later, at the 1997 conference, the term was mentioned in 22.4% of the sessions [7]. The prominence of SCM plays a vital role in marketing as it manages the entire supply chain process as a single entity, reduces total supply chain costs and time process in product development, profitability, increases customers satisfaction towards the product, loyalty and overall corporate growth [8]. Over the past decades, the term SCM has gained popularity worldwide. Accordingly, the definition of SCM has been described by many researchers at different times. SCM is the coordination of activities within and between upright connected businesses in order to profitably serve end customers [9]. After successfully implementing SCM, it has been upgrading and advancing rapidly based on the business needs, sustainable environment, and technology developments.

SCM further widens its scope globally, which paves the way for the emergence of Global Supply Chain Management (Global SCM). The immense benefit of Global SCM in the marketing environment is that it makes the product available to customers across the world. Its practical application can result in more efficient risk management and enterprise utilisation, producing lower costs and higher revenues, as Global SCM necessitates both operational and financial decisions [10,11].

Environmental Management has been pursuing the idea of environmental protection by managing human interactions and their impacts through pollution control and prevention, as well as managing ecological systems since the late 1960s [12]. Accordingly, it paves the way to Green Supply Chain Management, which is a sub-area of Sustainable SCM that combines Supply Chain Management and Environmental Management [13,14]. Green SCM measures provide cost and risk benefits to businesses, such as higher efficiency, greater property value and enhanced environmental conditions. As a result, raw material and energy costs can be reduced, low-emission manufacturing can be structured, and the company's image can be strengthened, all of which can lead to increased product sales and societal acceptance[15-18].

On the other hand, Sustainable Supply Chain Management (Sustainable SCM) has become a growing concern for businesses of all sizes and in various industries [19,20]. The significance of sustainability in a supply chain goes beyond going green because environmental responsibility is a critical focal point in today's industry. A supply chain built on a sustainable platform creates more partnership opportunities [21,22].

The recent trend in SCM is Supply Chain 4.0 (SCM 4.0), which offers significant opportunities for firms to improve productivity, profitability, quality of products and efficiency in global trade [23]. According to the World Trade Organization (2019), "Supply Chain 4.0" is the re-organization of supply chains – design and planning, production, distribution, consumption, and reverse logistics – using technologies that are known as "Industry 4.0" [20]. Supply Chain 4.0 is already having a significant impact on human well-being as it influences the size distribution of firms within industries as well as income distribution across countries. Above all, e-commerce, enabled by Supply Chain 4.0, involves a significant substitution of market labour for household shopping time [24-27].

Though there are numerous studies in SCM and its advanced areas, bibliographic studies are still scarce. In addition to that, even if the preference for bibliometric researches is increasing, the SCM and its advanced areas provide a plethora of chances for the methodology to identify future recommendations and trends. There are a few studies, which have been attempted to explore the key indicators of SCM, but according to the understanding of authors and based on the reviewed literature[28-50], there is no overall approach for SCM and its advancements, such as Global SCM, Green SCM, Sustainable SCM and SCM 4.0. Considering this, the present study will extend a full understanding of the proposed issues. Consequently, this study seeks to offer a bibliometric approach to SCM, Global SCM, Green SCM, Sustainable SCM and SCM 4.0. More precisely, explaining and identifying trends and other key issues by surveying and reviewing the published articles. The data for published articles related to proposed areas are obtained from the Scopus database, which links with millions of publications. Further, this study uses VOSviewer software for analysis. Besides explaining the trends of SCM, Global SCM, Green SCM, Sustainable SCM and SCM 4.0, the authors also identify gaps and opportunities of SCM and its advancements.

2 Detail understanding of SCM and its advancements

2.1 Supply Chain Management (SCM)

SCM is an interconnected and complex network concept that refers to the sum of all processes that begin with the acquisition of raw materials from the manufacturer/producer and end with the delivery of the finished product to the customer [51,52]. For decades, the ability to reduce costs was regarded as the pinnacle of supply chain management. Currently, this goal is linked to customer satisfaction, industrial productivity, environmental sustainability, and technological advancements. In the digital age, modern supply chains must create specific, technological, procedural, and managerial capabilities and capacities to achieve four new demands: customer focus, technology adoption, relationship management, and leadership styles [53].On the other hand, supply chain management activities are responsible for over 90% of the environmental impact on resources such as air, soil, and land, as well as over 80% of greenhouse-gas emissions for consumer goods[54].

Supply chain dynamics influence not only employment practices and working conditions but also business practices and functionality that structure decent work opportunities [55]. The significance of SCM on business needs is vital as SCM helps in supporting and improving supply chain efficiency while also creating business optimization. According to the scope of SCM, businesses should emphasise greater organisational support for SCM implementation and a greater degree of attention for manufacturing integration and information flow integration in the manufacturing process to maximise benefit and reduce expenses [56].

SCM further advances its effects on the sustainable environment. A fair trade environment should be fostered to promote and enhance seller-buyer collaboration, and supply chain collaborative effort had a positive impact on long-term supply chain performance [57]. Further, it is analyzed that successful safety management necessitates long-term SCM activities that positively impact workplace safety and environmental performance [58].

Consequently, SCM has gained popularity to assist businesses in better utilising the resources of their suppliers to gain a competitive advantage [59,60]. As a result, SCM extends its roots into various branches, which are discussed briefly in the following section.

2.2 Global Supply Chain Management (Global SCM)

Globalization has reconfigured the business world and proposed the concept of a global supply chain. It is defined as a global network of companies that network and outsource services [61,62]. Globalization also underscores the need to rethink the criteria used in selecting supply chain managers [63]. Advances in industrial technology increased globalisation of demand and supply sources, phenomenal advances in information and communication availability, abundant investment funds and creative business design drive fierce competition in today's markets. As a result of the global market's emergence, SCM must be reoriented in a global network context. Global supply chains involve cross-border, inter-organizational relationships between suppliers, governments, intermediaries, local traders, and customers. Firms compete in a global economy, so the world, rather than a country or region, serves as the unit of business analysis [64,65]. Global supply chains are becoming increasingly important in determining a company's and a country's competitiveness. Modern global supply networks span continents, host a diverse range of economic operators, and deliver goods and services in ever-increasing volumes to the global community [66]. Global collaboration frameworks that enable supply chain teams to solve intricate supply and logistics problems open up new opportunities and improve decision-making for businesses [67]. Global supply chains provide the most benefit when the right supply chain partner applies knowledge at the right time [68]. Knowledge of GSCM allows supply chains (SCs) to be distributed as a unified entity of fragmented parts that perform within their respective functions [69]. GSCM is crucial to the success of all growing enterprises wanting to enhance competitive advantage in the global market [70].

2.3 Green Supply Chain Management (Green SCM)

In recent years, environmental concerns have become a global issue. Green SCM has been identified as an important topic that has an impact on the environmental concerns for any business that engages in supply chain activities and, as a result, leads to improved environmental performance [71,72]. For manufacturers who want to maintain a competitive edge while also becoming more environmentally sustainable, integrating environmental concerns into supply chain management has become increasingly important [73]. As a result, combining a "green" component into SCM, also known as Green SCM, entails considering the impact and interrelations between SCM and the natural environment [74]. For many businesses in the twenty-first century, the green supply chain is becoming a growing concern and challenge. Green SCM covers the entire customer order cycle, including design, procurement, production, assembly, packaging, logistics, and distribution [75]. The words of Rauter et al. best illustrate the concept of Green SCM as follows: A green or sustainable business, in general, can be defined as any organization that takes environmentally sustainable initiatives to improve that each process, marketing strategy, and economic growth adequately addresses existing environmental issues while still making a profit [76]. According to the traditional supply chain viewpoint, the "quality revolution" of the 1980s and the supply chain revolution of the 1990s were the catalysts for Green SCM. Its primary goal is environmental efficiency, which seeks to limit harm to the environment while also enhancing the productivity of production and remanufacturing, which have become the essential sources for achieving industry standards [54-56,77,78]. New government policies have made it illegal to sell products that contain environmentally harmful materials or are made through polluting processes. Companies that use environmentally damaging and/or contaminating processes are prohibited from selling their products and may face financial penalties as well as prosecution [79]. As a result of these new legal regulations, the significance of Green SCM has recently increased. To conclude, many global enterprises have already implemented, and others are considering Green SCM for a variety of reasons, including compliance with various environmental laws and regulations, brand enhancement, career advancement, and cost reduction [80].

2.4 Sustainable Supply Chain Management (Sustainable SCM)

Sustainable development, it can be said, has evolved into a term that encompasses more than just economic concerns, as it also considers the environmental impact and resource use, as well as social consequences [81]. According to Metta and Badurdeen, managing Sustainable Supply Chains (SSCs) necessitates greater cooperation and integration between product and process designers and their SC counterparts [82]. Sustainable SCM is exemplified by environmental or green SCM, which aims to reduce negative environmental impacts in supply chains [83-84]. It also includes social issues in the supply chain, such as ensuring that manufacturers work in safe conditions or that goods are sourced ethically and fairly throughout the supply chain. Sustainable SCM differs from traditional SCM in that it explicitly incorporates environmental or social objectives that extend the economic dimension to the triple bottom line [85]. The primary goal of supply chain sustainability management is to create designs for supply chains that are less hazardous or even contribute to sustainable development [86]. Sustainable SCM practises are becoming a common business trend in the industry for long-term development [87-88]. The need for organisations to achieve sustainability and strengthen supply chain performance has prompted the transition to a Sustainable Supply Chain (SSC), which encompasses operations from a three-dimensional perspective, such as economic, social and environmental [62,89-91]. Purchasing from local suppliers as part of the economic aspect of sustainable SCM can help to support local economic regeneration. The focus of sustainable supply chain activities varies by organisation, emphasising environmental issues and others focusing on social issues [92,93]. The words of Zeplin et al. best describe the future trends and significance of Sustainable Supply Chain Management as follows: “If manufacturing companies are to survive and compete in the global economy, they must implement Sustainable SCM practices” [62].

2.5 Supply Chain Management 4.0 (SCM 4.0)

Digital technologies have changed the way societies exchange information and interact [63]. Technological advancements have altered how people communicate and share information, and every industry is undergoing a rapid transformation as a result of the fourth industrial revolution (Industry 4.0), which paves the way for SCM 4.0 [67,68]. Industry 4.0, which combines a variety of technologies, concepts, and methods to enable production systems’ autonomy, versatility, dynamism, and precision, has been incorporated into the Supply Chain Management 4.0 development process [74,75]. SCM 4.0 model integrates IT and future technologies, aided by IoT, AI and big data, in a holistic, cross-functional framework under the strategic leadership of the SCM [76-79]. SCM 4.0 is an advanced and powerful framework with interlinked procedures that evolve from isolated applications to a large, synchronised, and effective correlation between SC phases [71]. The new supply chain is characterised by the following characteristics: progressive digitalization, agility, net value regulation, real-time track-and-traceability, installation of control tower programme, receptive to changes in the environment, sensitivity to demand uncertainty and customer behaviour, implementation of intelligent processing through big data, and finally, connectivity not only with customers but also to their social networks and potential customers’ Internet communities [81,82]. Apart from its significance, Supply chains are threatened by the fourth industrial revolution’s digital transformation, which creates a level of complexity and uncertainty. As a result of the adoption and acceptance of multiple technologies in the SC, new risks, such as confidentiality, privacy, integrity, hacking, malware, cyber-attacks, spyware and data loss, have an impact on businesses, which can have a significant impact on various production procedures [83-85]. However, as SCM 4.0 is currently underway, with the most important benefits being increased flexibility, quality standards, efficiency and productivity, which each company must reconsider how to enforce and implement as new technology for instrumentation, interconnection, and intelligence can create the robust, secure, and sustainable SCs required by businesses [77,78].

3 Methodology

The methodology of the study is based on a bibliometric review of SCM, Global SCM, Green SCM, Sustainable SCM and SCM 4.0. The methodology based on bibliometric review is crucial as it gives a detailed examination of the studies published in each research field, and it helps to classify and analyze the objective criteria. In addition to that, the adoption of VOSviewer software shows the bibliometric data distribution and its network in a graphical way via cluster maps.

The data relating to the present study were collected in June 2021 from the Scopus database, which is the most used and reliable database. The data were collected from 1990 to 2021 because this duration is considered a crucial period for SCM and its advancements, and most of the studies were conducted during this period. The obtained dataset includes the bibliometric data related to SCM, Global SCM, Green SCM, Sustainable SCM and SCM 4.0 published in Scopus indexed journals. The collected datasets attempt to give and capture insight into a larger world around a piece of research.

The query for the terms Supply Chain Management, Global Supply Chain Management, Green Supply Chain Management, Sustainable Supply Chain Management and Supply Chain Management 4.0 received large results. Boolean operators and filtering were used to obtain the relevant results. Subsequent to the application of Boolean operators, the filtered bibliometric data were acquired.

The overall collected datasets and filtered datasets were presented in the following sections. Further, the filtered data were analyzed in the present research. Bibliometric analysis was conducted by the authors using bibliometric indicators. This analysis is considered as the mechanism employed to interpret and analyze the collected data. The datasets were then processed using VOSviewer to graphically show some of the potential findings. The synchronized occurrences of publications by year, coauthor analysis among countries and author citation network were employed in the present study. The findings of the processed dataset displayed key trends state of development SCM, Global SCM, Green SCM, Sustainable SCM and SCM 4.0 in the scientific research. Graphic representation and analysis of aforesaid occurrences are significant, as they can assist researchers to better understand what has been studied in the field of SCM and its advancements, and they map the important trends in the areas.

Figure 1 shows the complete research framework of the present research. Besides, it elaborates on the detailed methodological workflow of the study.

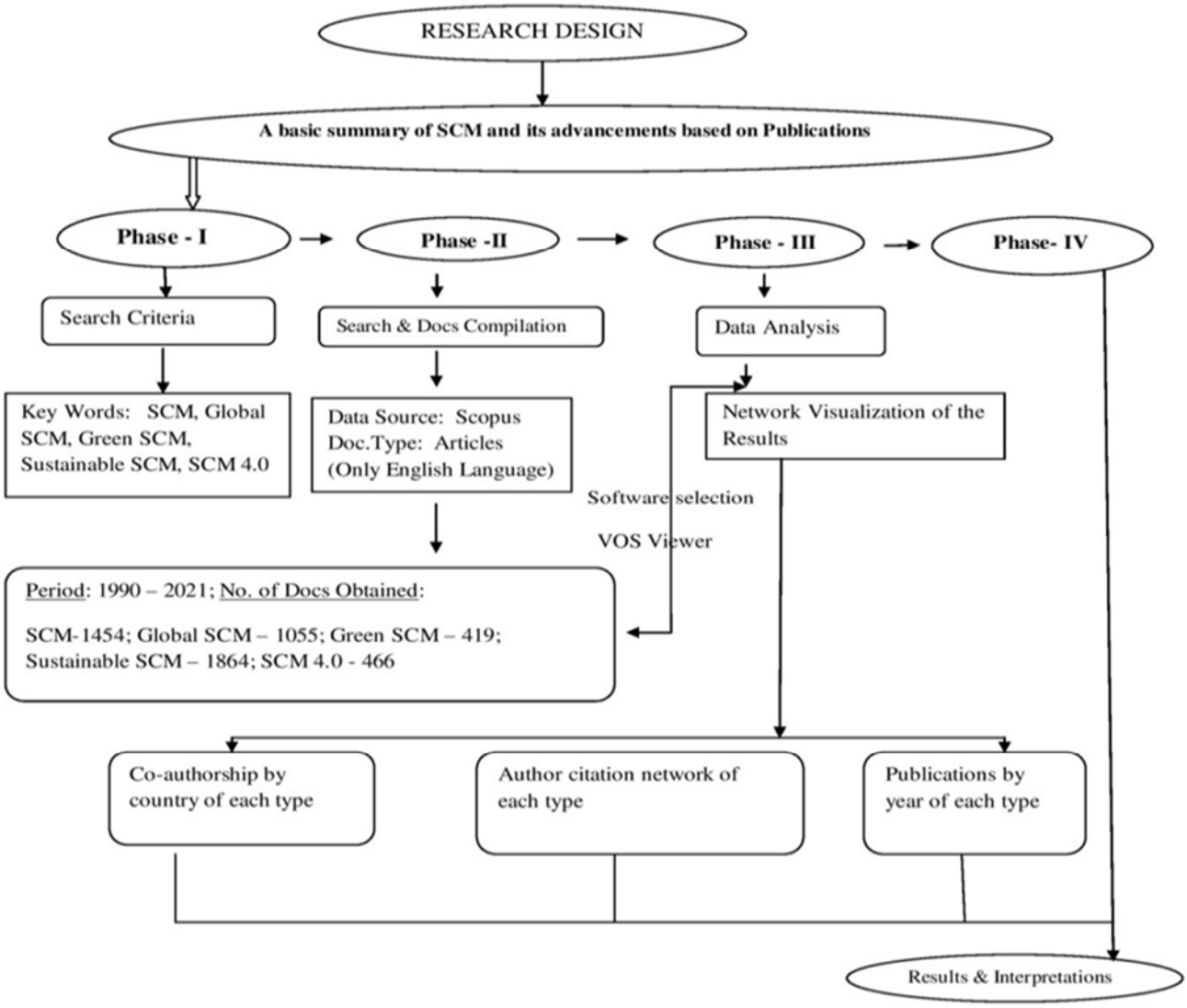

Figure 1 Research Design of the Study

3.1 Supply Chain Management

3.1.1 Publications by year

Using keyword search in Scopus data search, it comes to know that the first article related to SCM was published in 1969. It is associated to provide all necessary sterile supplies and portable equipment for patient care [79]. Though it was not completely satisfied SCM requirements, the initiatives were started this year. However, the momentum was started to SCM in the year 1993. The publications of research articles gradually increased from this period. The number of publications has grown significantly ever since (as portrayed in Figure 2). While seeing the annual productivity, the article publications were continuously in uptrend still now. A

total of 62547 research articles were published between 1990 and 2021. After using filters and Boolean operators, 1454 articles were obtained for analysis related to SCM. The annual trends of publications of articles related to this topic are shown in Figure 2, which is illustrated from the sample of 1454 articles. A total of 127 articles were published in the year 2010 that is considered as a peak in publication. Here, it is important to mention that there was a gradual decline in the publications related to SCM because there might be the reason that there were numerous advancements in the field of SCM so that the past researchers would concentrate on those specific fields. The authors of the present study have also focused on those specialized fields of SCM too. After analyzing the growth in the number of articles on SCM published over the years, the analysis will be refined to disclose information allowing for a better understanding of the relevance of past research.

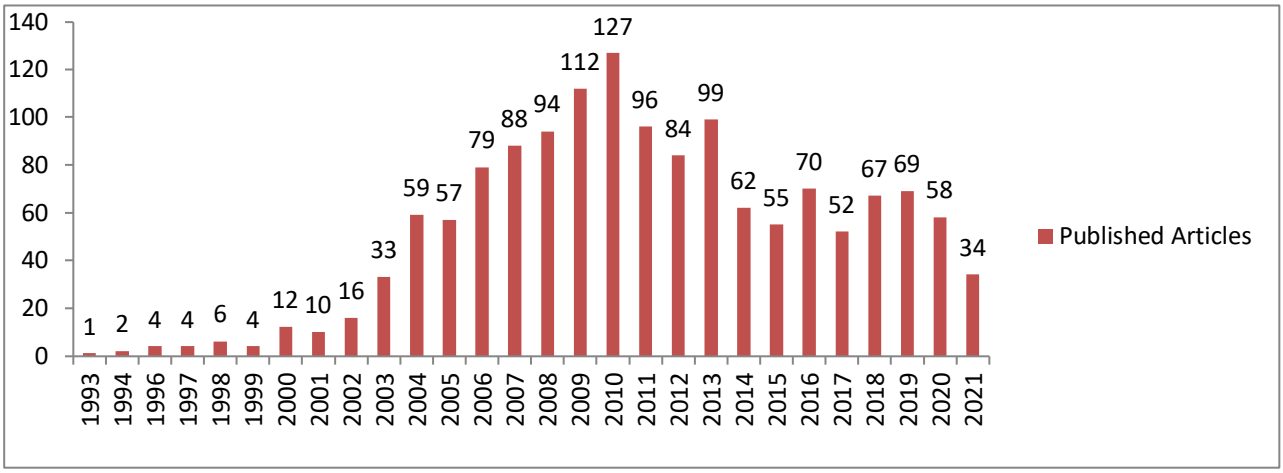

Figure 2 SCM Publications by Year

3.1.2 Geographical analysis of SCM publications

It is excited to mention here that while analyzing the authors' country of affiliation, the articles related to SCM received global attention because the published articles (1454) were distributed among 78 countries. Table 1 shows the top 10 countries where most of the academic papers were published related to SCM. In addition to that, these countries account for 82.80% of all published articles. According to the data, United States of America (USA) holds the highest number of publications, totalling 378 articles, followed by United Kingdom (UK) with 237 articles, and India with 187 articles. Sweden is in 10th place as it holds 47 publications.

Table 1 Top 10 number of SCM publications in coauthorship by country

S. No	Coauthorship By Countries	Number of Publications	Percentage Calculated from Total Number of Publications (% of 1454)
1	United States	378	26%
2	United Kingdom	237	16%
3	India	187	13%
4	Australia	74	5%
5	China	61	4%
6	Finland	59	4%
7	Germany	56	4%
8	Italy	55	4%
9	Canada	50	3%
10	Sweden	47	3%

Figure 3 is obtained from VOSviewer. It shows the country coauthorship map that was generated from the considered articles of 1454. It is clear to see that the clusters of countries USA, UK and India are in evidence. This occurs as these three countries together account for 54% of the publications. The lines connecting the points shown on the map indicate the coauthorship between countries, and the distance between the clusters indicates the strength between them and how much these countries publish in coauthorship.

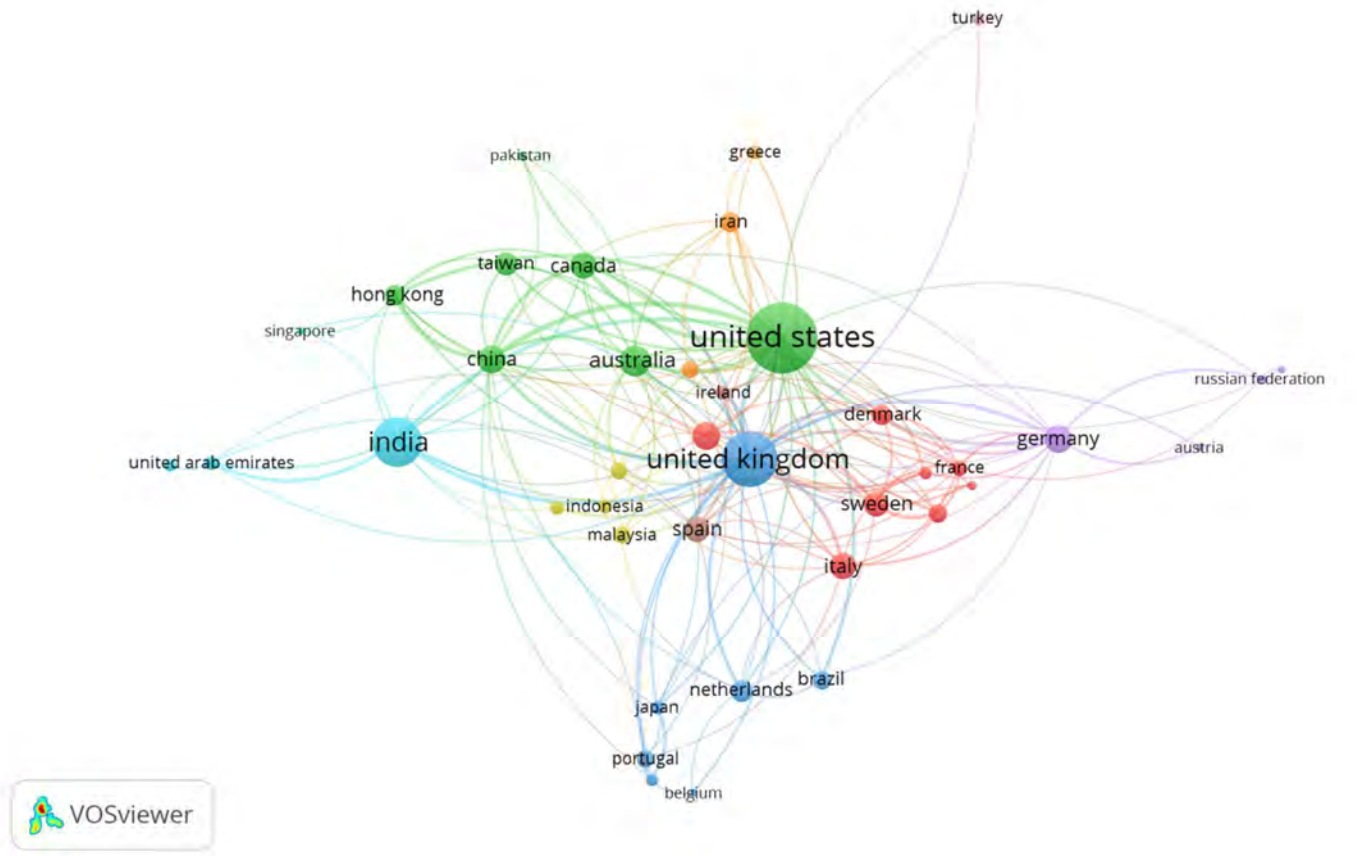

Figure 3 Coauthorship by country for SCM publications

3.1.3 Analysis of citations of SCM

Citations analysis is considered the most broadly used method of assessing the impact of the authors and articles since it discovers the key papers in the research field. Identifying the most cited articles can help researchers understand the seminal material that can be used as a reference to support their studies in terms of both historical average and annual average so that there is, in advance, a clear starting point [80].

In the present study, the author citation network is presented in Figure 4 (obtained from VOSviewer). The citation of the article can be generated when two articles refer to the same document. This method is implemented for documents, journals and authors and reveals the relevance of a document for a thematic field. The American author Gunasekaran shows in the yellow cluster as one of the authors mentioned most often with the total strength link of 5082 and citations of 103.

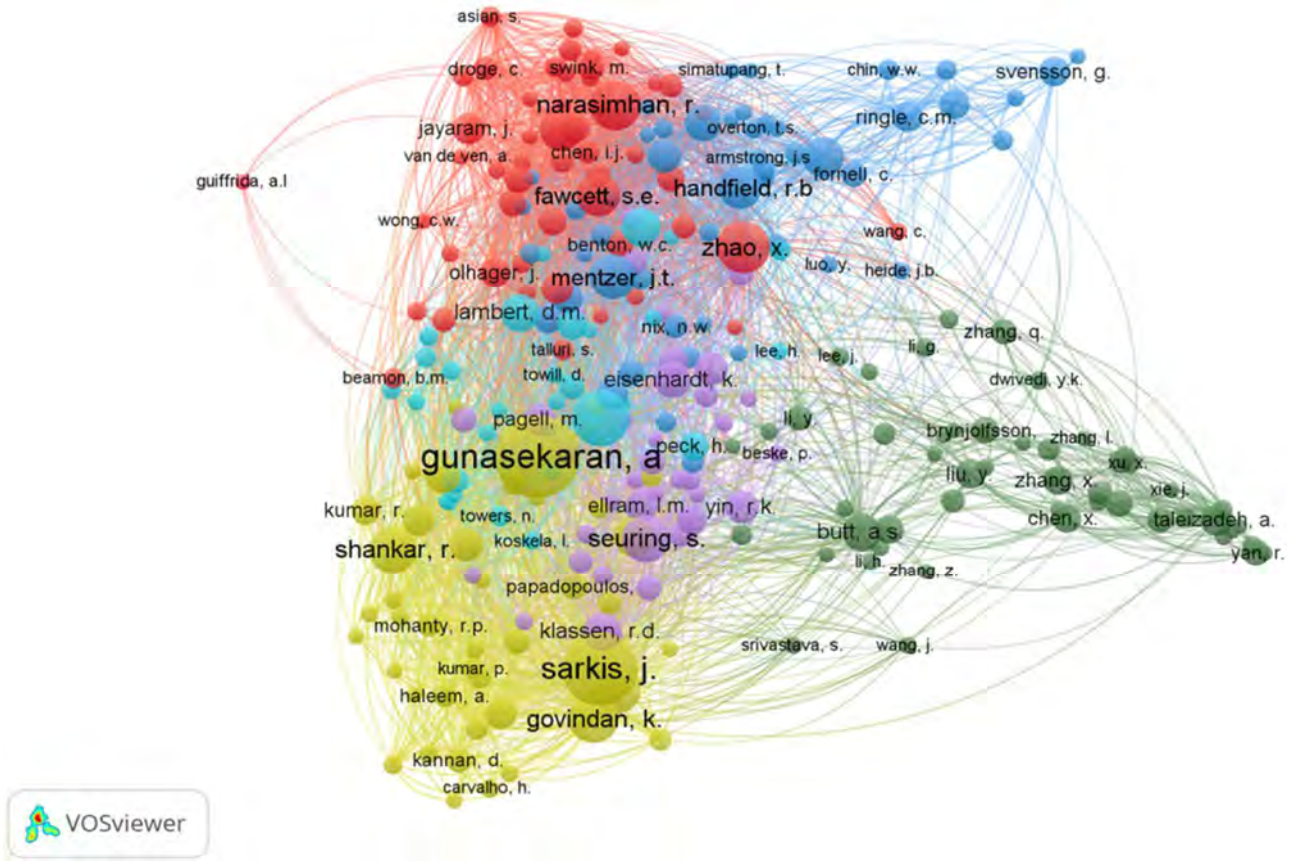

Figure 4 Author citation network of SCM

3.2 Global Supply Chain Management

3.2.1 Global SCM publications by year

The first publication related to Global SCM was published in the year 1990. It is considered the beginning of Global SCM because the term globalization received global attention during this period, and the companies around the world are interconnected using a global supply chain. There were 7891 research articles published between 1990 and 2021. Following the application of filters and Boolean operators, 1055 articles for Global SCM analysis were found. According to bibliometric analysis, it is exciting that the year 1990 is significant as the studies related to Global SCM were started this year. Consequently, there is a constant increase of studies concerning Global SCM through slight ups and downs. It can be seen from Figure 5. Though there is a high impact due to Covid 19 in business around the world, there are considerable studies related to Global SCM in 2020. It is observed that there were 115 articles published related to Global SCM this year. Further, it keeps on increasing; the researchers around the world may conduct more studies concerning Global SCM in the upcoming years also by considering positive and negative outcomes of Global SCM.

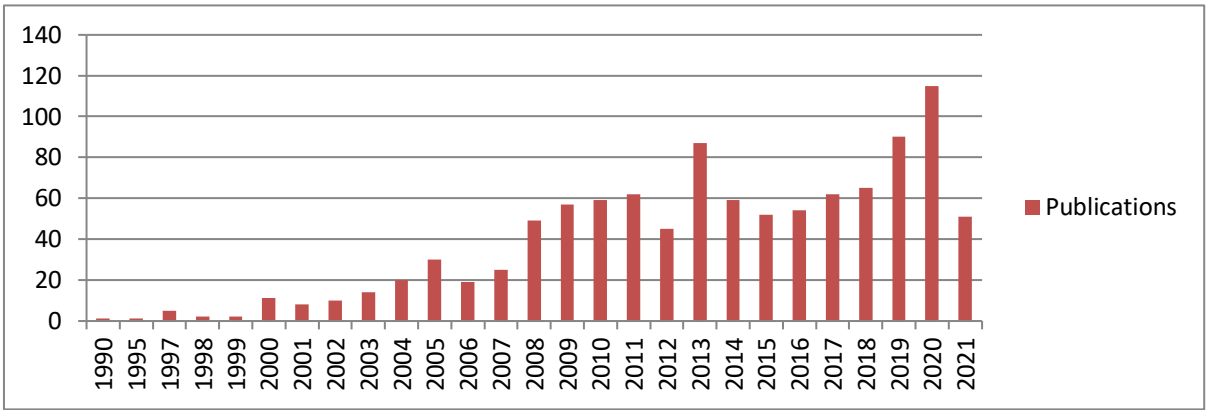

Figure 5 Global SCM Publications by Year

3.2.2 Geographical analysis of Global SCM publications

While analyzing the bibliometric data of Global SCM, it is interesting to discover that Global SCM is considered the desired subject for global researchers who conduct research on the supply chain. Though the studies are lesser than SCM, the studies conducted for Global SCM receive worldwide attraction. The authors' country of affiliation is significantly attractive because 1055 published articles were distributed among 80 countries. Table 2 shows the top 10 countries where most of the academic papers were published related to Global SCM. In addition to that, these countries account for 83.79% of all published articles. According to the data, United States of America (USA) holds the highest number of publications, totalling 333 articles, followed by United Kingdom (UK) with 121 articles, and India with 120 articles. France is in 10th place as it holds 34 publications.

Table 2 Top 10 number of Global SCM publications in coauthorship by country

S. No	Coauthorship By Countries	Number of Publications	Percentage Calculated from Total Number of Publications (% of 1055)
1	United States	333	32%
2	United Kingdom	121	11%
3	India	120	11%
4	Australia	52	5%
5	Germany	50	5%
6	Italy	50	5%
7	China	48	5%
8	Canada	40	4%
9	Taiwan	36	3%
10	France	34	3%

Figure 6 shows the map of coauthors' country of affiliation generated by VOSviewer. The network visualization cluster of Global SCM publications related to coauthorship countries reveals that the clusters of countries USA, UK and India are in evidence and link with many nations. It indicates that these three countries together account for 54% of the publications as same as SCM publications. Coauthorship between countries is represented by the lines connecting the points on the map. The distance between the clusters represents the strength of the coauthorship and how much each country publishes in coauthorship.

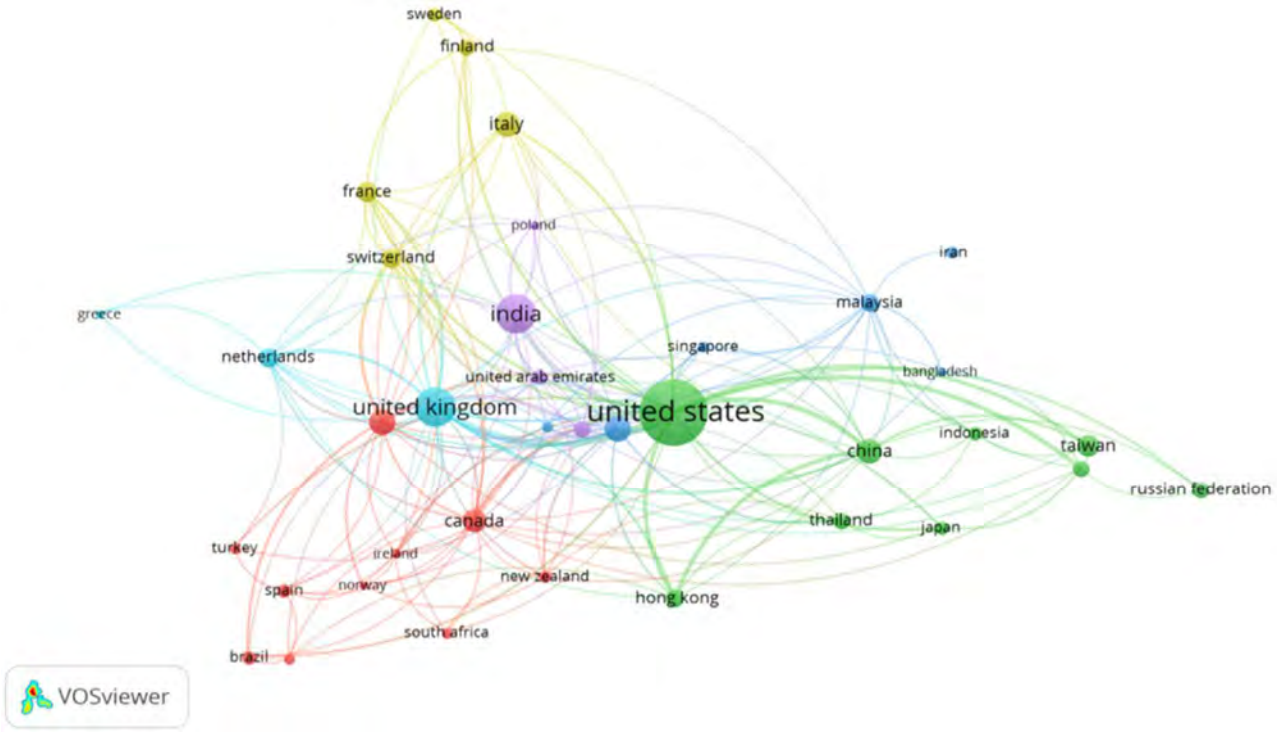

Figure 6 Coauthorship by country for Global SCM publications

3.2.3 Analysis of citations of Global SCM

The present study obtained the author citation network of Global SCM using the network visualization of VOSviewer, and pictures in Figure 7. An article citation is created when two articles refer to the same document. This method is used to evaluate the thematic relevance of documents, journals and authors. The American author Gunasekaran shows in the blue cluster as one of the authors mentioned most often with the total link strength of 2518 and citations of 100.

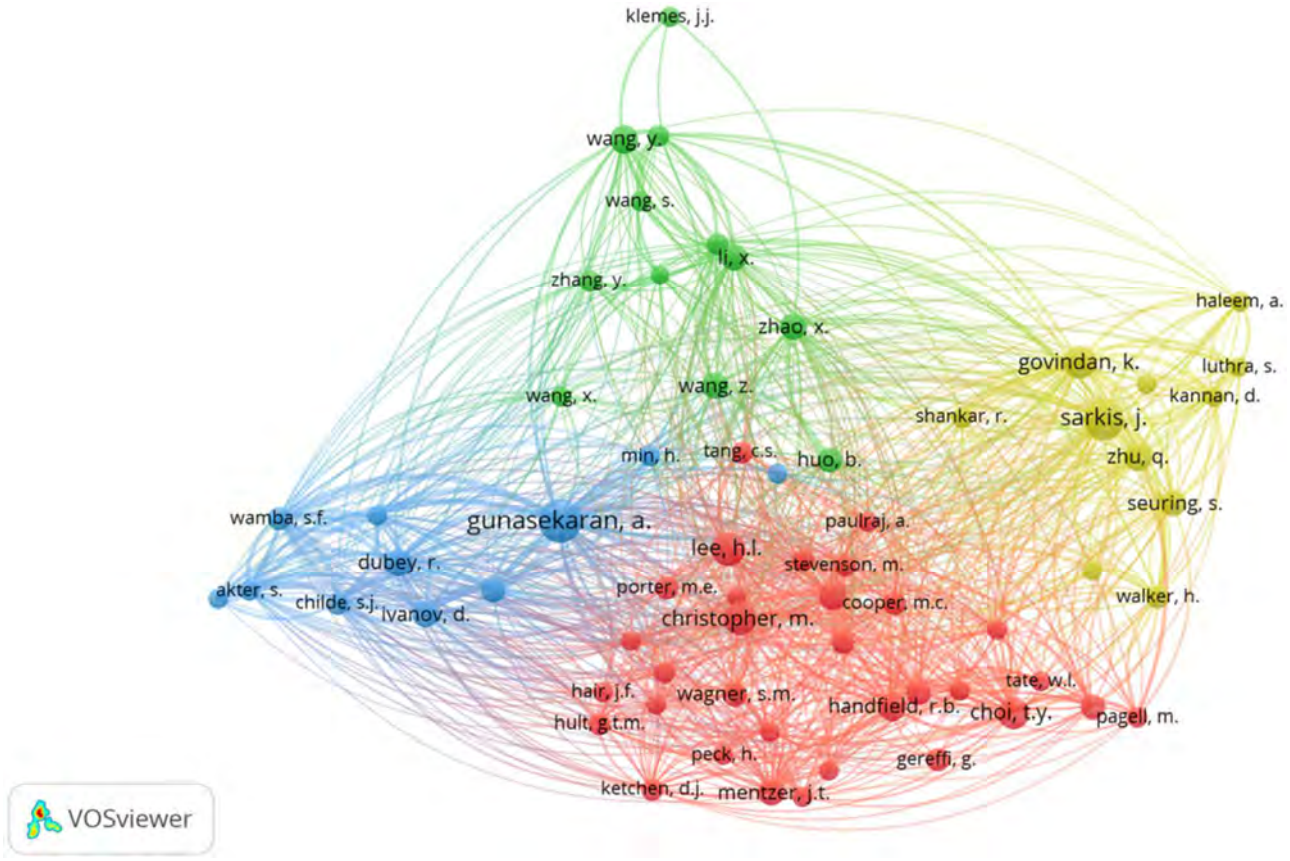

Figure 7 Author citation network of Global SCM

3.3 Green Supply Chain Management

3.3.1 Green SCM publications by year

It is observed from the bibliometric data that between 1990 and 2021, there were a total of 3767 research articles published. Using filters and Boolean operators, 419 articles for Green SCM analysis were discovered. Though the studies related to SCM emerged/published in the early 1990s, the researchers were interested in conducting research on Green SCM only after 2004; it is evidenced from the first research article related to Green SCM, which was published in the year 2004. It can be identified from Figure 8 that shows the steady increase of publications concerning Green SCM year on year. Nowadays, the industries worldwide concentrate on more environmentally-friendly surroundings for their businesses; it might be the reason for the past researchers to conduct and explore the impact of Green SCM. It is also clearly visible in the reviewed literature. In 2020, there are many studies conducted in relation to Green SCM, which marks 63 published research articles, and this count is considered high.

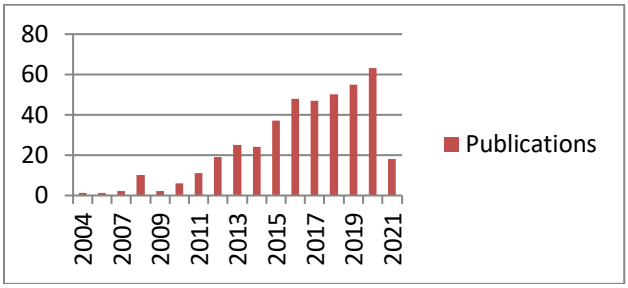

Figure 8 Green SCM Publications by Year

3.3.2 Geographical analysis of Green SCM publications

The attention on environmentally-friendly surroundings for the supply chain, especially Green SCM, receives much importance. Considering that, the researchers of different countries contribute a lot in terms of their research articles publication. After applying required filters and Boolean operators, there were 419 articles considered for geographical analysis of Green

SCM. The country-wise affiliation of authors is spread across 61 countries. This connection is more significant in recent years. It shows that most of the nations and their researchers are interested in conducting research on Green SCM. Table 3 shows the top ten number of Green SCM publications in coauthorship by country. The listed top ten countries occupy 94% of all published articles concerning Green SCM. From Table 3, it can be identified that India has the highest number of publications, totaling 86 articles, followed by China with 76 articles, and USA with 64 articles. Australia and Indonesia deserve 10th position by having 16 articles.

Table 3 Top 10 number of Green SCM publications in coauthorship by country

S. No	Coauthorship By Countries	Number of Publications	Percentage Calculated from Total Number of Publications (% of 419)
1	India	86	21%
2	China	76	18%
3	United States	64	15%
4	United Kingdom	46	11%
5	Iran	27	6%
6	Brazil	23	5%
7	Malaysia	22	5%
8	Taiwan	20	5%
9	South Korea	17	4%
10	Australia/Indonesia	16	4%

The software tool, VOSviewer, is used to map the coauthors' country of affiliation. The network visualization clusters of Green SCM publications concerning coauthorship countries are displayed in Figure 9. The clusters of India, China and USA are emphasized, and they link with many nations. From Table 3 and Figure 9, it can be determined that the top three countries, in terms of Green SCM publications, account for 54% of publications. The lines connecting the points shown on the map indicate the coauthorship between countries, and the distance between the clusters indicates the strength between them and how much these countries publish in coauthorship.

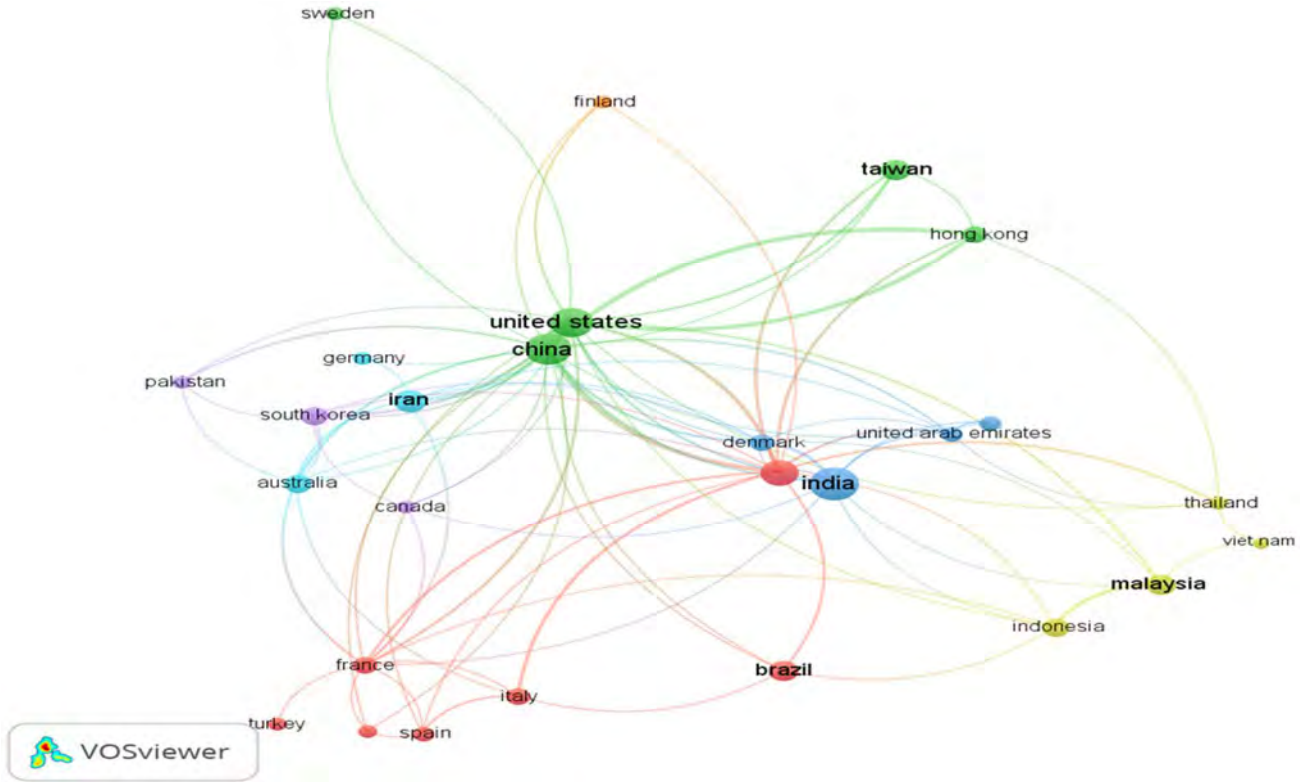

Figure 9 Coauthorship by country for Green SCM publications

3.3.3 Analysis of citations of Green SCM

The bibliometric data of Green SCM using the network visualization of VOSviewer reveals the author citation network, which is shown in Figure 10. When two articles refer to the same document, the citation of the article can be generated. This method is used for documents, journals, and authors to determine the relevance of a document to a specific thematic field. The American author Joseph Sarkis shows in the green cluster as one of the authors mentioned most often with the total strength link of 77853 and citations of 1023.

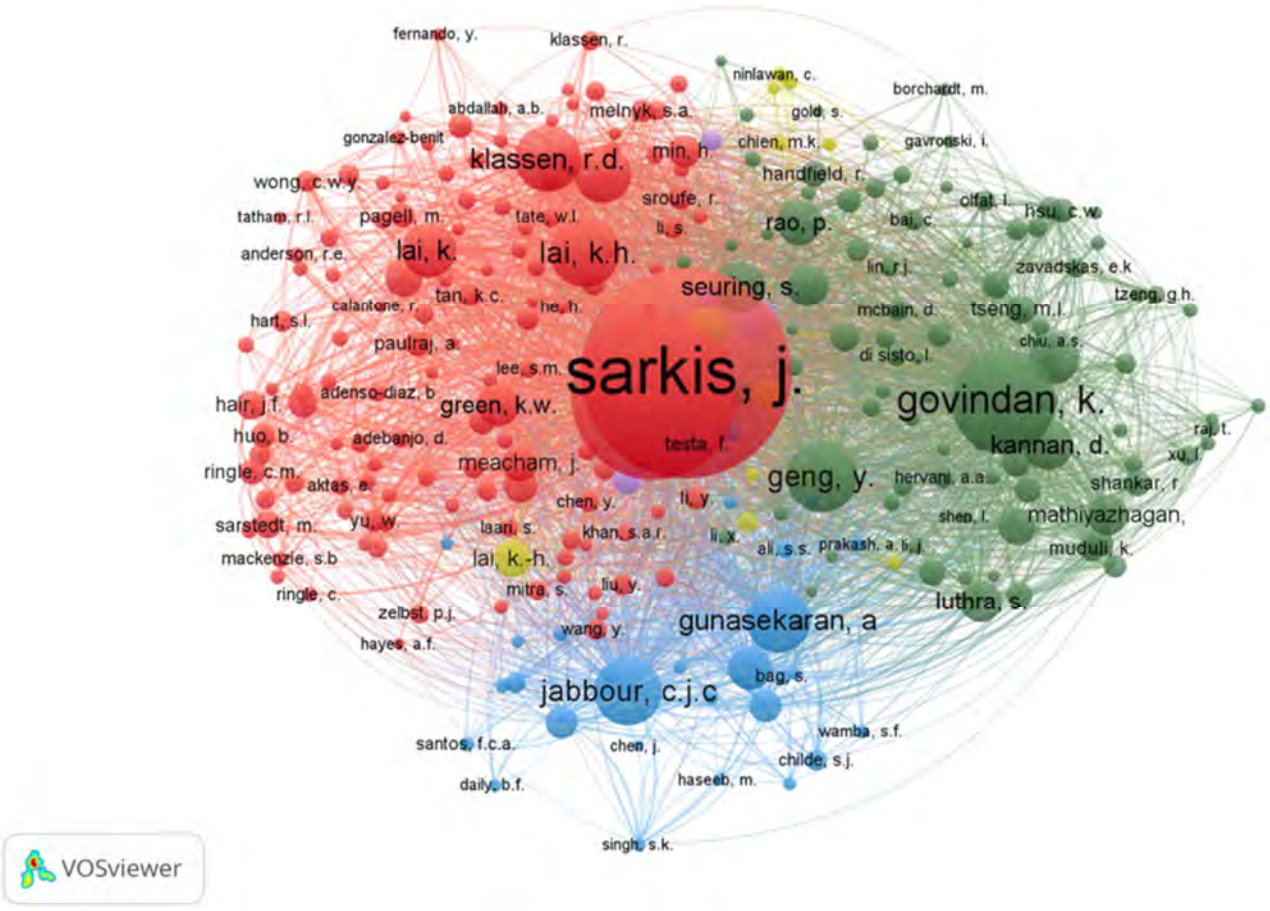

Figure 10 Author citation network of Green SCM

3.4 Sustainable Supply Chain Management

3.4.1 Sustainable SCM publications by year

The integration of environmentally-friendly and financially viable practices into the complete supply chain lifecycle is called sustainable supply chain management [52]. From 7413 published research articles, 1864 articles were considered for the present study after applying filtering and Boolean operators. Further, it is observed that the emergence of publication relation to Sustainable SCM was initially identified in the year 1996. The publications trend of Sustainable SCM is shown in Figure 11. It is easy to understand the trend of publications in Sustainable SCM from Figure 11; there is a constant growth of publications in Sustainable SCM as it shows the increasing interest of the researchers in this field. It is not only for the interest of the researchers on Sustainable SCM, but also the industries and economies have given more importance to Sustainable SCM. There are more articles published in the year 2020; this year has marked the highest count in Sustainable SCM.

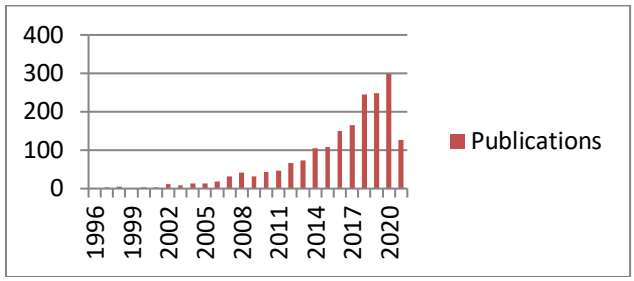

Figure 11 Sustainable SCM Publications by Year

3.4.2 Geographical analysis of sustainable SCM publications

In the current era, making a sustainable environment is an important task for any economy. Considering this concept, researchers and industries and countries have

shown much attention to Sustainable SCM. Thus, many research articles were published in collaboration with diverse nations with the help of researchers around the world. From the obtained bibliometric data, there were 1864 articles were considered for analysis. The country-wise affiliation of authors is spread across 83 countries. Table 4 shows the top ten number of Sustainable SCM publications in coauthorship by country. The listed top ten countries occupy 88% of all published articles concerning Sustainable SCM. From Table 4, it can be seen that USA has the highest number of publications, totaling 351 articles, followed by UK with 315 articles, and India with 189 articles. Iran deserves 10th position by having 81 articles.

Table 4 Top 10 number of Sustainable SCM publications in coauthorship by country

S. No	Coauthorship By Countries	Number of Publications	Percentage Calculated from Total Number of Publications (% of 1864)
1	United States of America	351	18%
2	United Kingdom	315	17%
3	India	189	10%
4	China	183	10%
5	Germany	137	7%
6	Italy	116	6%
7	Canada	101	5%
8	France	94	5%
9	Australia	91	5%
10	Iran	81	4%

The obtained bibliometric data of Sustainable SCM were processed in VOSviewer to identify the coauthors' country of affiliation. The network visualization of coauthorship countries is displayed in Figure 12, which was generated from VOSviewer. The clusters of USA, UK and India are exposed well, which means they link with many nations. From Table 4 and Figure 12, it can be determined that the top three countries of sustainable SCM publications account for 45% of publications. The coauthorship of countries is represented by the lines connecting points on the map, and the distance between clusters indicates the strength of the countries and their coauthorship publications.

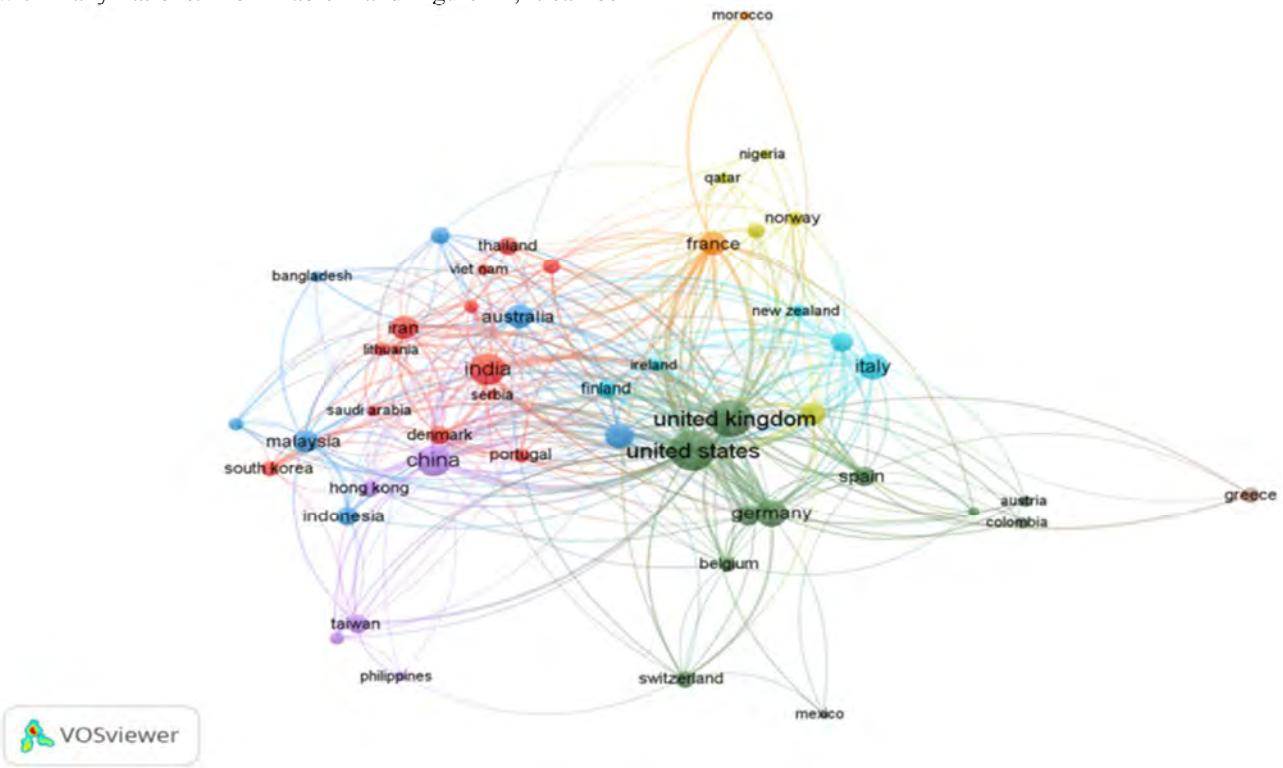

Figure 12 Coauthorship by country for Sustainable SCM publications

3.4.3 Analysis of citations of sustainable SCM

The author citation network is presented in Figure 13, which was generated by citation network visualization of VOSviewer, and the bibliometric metric data of Sustainable SCM obtained from the Scopus database were used for analysis. The citation of the article can be generated when two articles refer to the same document. This method is implemented for documents, journals and authors and reveals the relevance of a document for a thematic field. There are a few authors who are emphasized in Figure 13, which means their citation networks are highly linked with other studies. Among them, the American author, Joseph Sarkis, shows in the blue cluster as one of the authors mentioned most often with the total strength link of 137995 and citations of 1396.

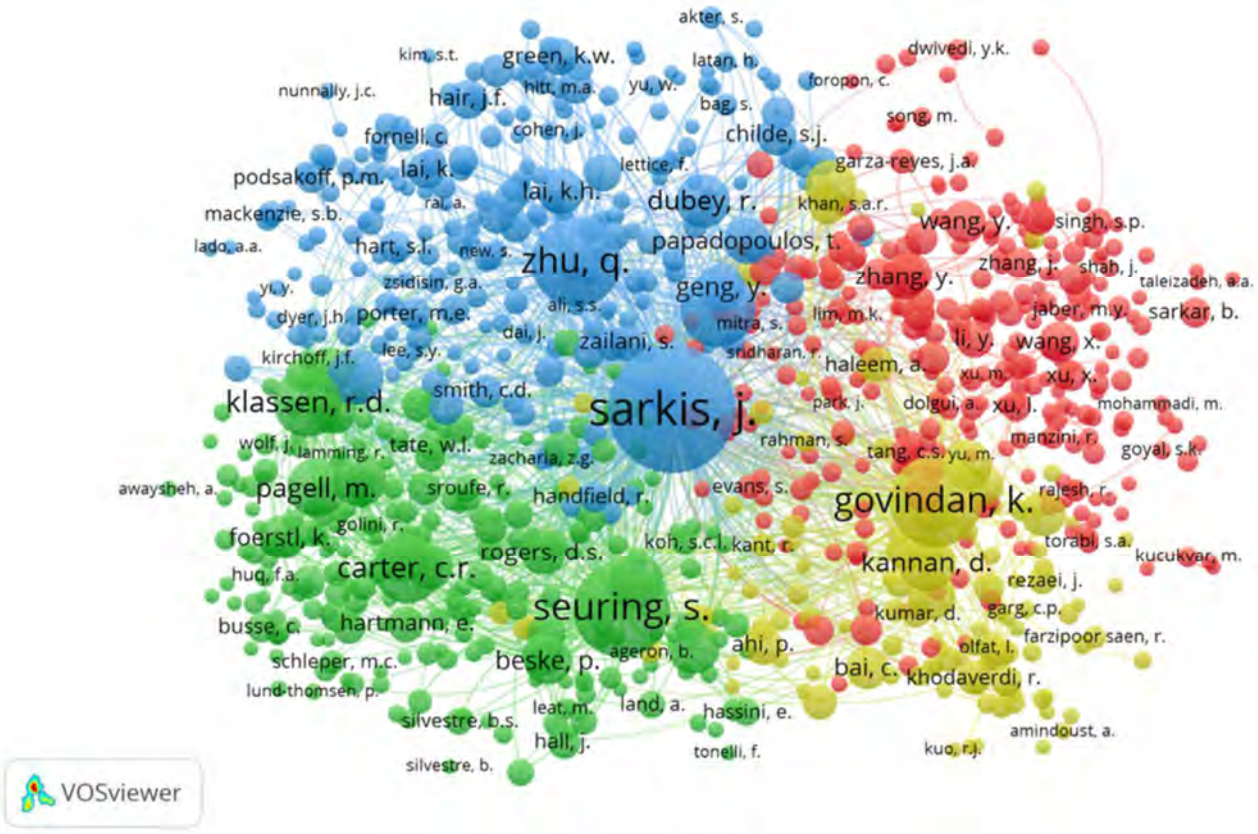

Figure 13 Author citation network of Sustainable SCM

3.5 Supply Chain Management 4.0

3.5.1 SCM 4.0 publications by year

In this digital era, all the fields have been digitalized or automated. The vision of Industry 4.0 engulfs SCM too. Considering that, many industries and countries adopt automation in SCM, which means SCM 4.0. Due to the technology adoption of industries and countries, researchers around the world also conducted research on this field vibrantly nowadays. For SCM 4.0, there were 466 articles considered for analysis after applying filtering and Boolean operators; earlier, there were 1194 articles. Figure 14 shows the trend of publications in SCM 4.0. SCM 4.0 highly emerged after 2010 because most of the industries started adopting automation in the last decade, especially after 2015. The year 2020 marked the highest number of publications, there might be a reason that Covid 19 restricted the human workforce and companies, drastically transferred to automation, and the researchers got interested in exploring the impact of this changeover, SCM 4.0. From the bibliometric analysis, it can be understood that there would be an uptrend in SCM 4.0 publications in the upcoming years as most of the businesses start implementing automation, and researchers also hunt for emerging areas to conduct their research.

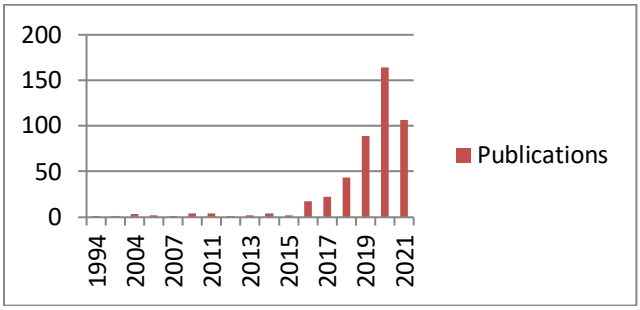

Figure 14 SCM 4.0 Publications by Year

3.5.2 Geographical analysis of SCM4.0 publications

Technology or automation adoption has been increasing all around the world in SCM, which is known as SCM 4.0. The researchers of the world show more importance to this field, and SCM 4.0 becomes a trendy word in recent days. That is the reason the research on SCM 4.0 spread across the world in collaboration with diverse nations. The present study had considered 466 articles for geographical analysis of SCM 4.0. It is exciting to know that the country-wise affiliation of authors is linked across 76 countries. Table 5 shows the top ten number of SCM 4.0 publications in coauthorship by country. The listed top ten countries cover 81% of all published articles related to SCM 4.0. Table 5 shows that India has the highest number of publications, totalling 57 articles, followed by USA with 56 articles and UK with 54 articles. Australia holds 10th position by having 20 articles.

Table 5 Top 10 number of SCM 4.0 publications in coauthorship by country

S. No	Coauthorship By Countries	Number of Publications	Percentage Calculated from Total Number of Publications (% of 466)
1	India	57	12%
2	United States of America	56	12%
3	United Kingdom	54	12%
4	Italy	40	9%
5	Germany	38	8%
6	China	36	8%
7	Brazil	29	6%
8	Spain	26	6%
9	France	24	5%
10	Australia	20	4%

The bibliometric data of SCM 4.0 were processed in VOSviewer to determine the country of affiliation of the coauthors. Figure 15 shows the network visualisation of coauthorship countries, which was generated using VOSviewer. The clusters of India, the USA, and the UK are well-exposed, implying that they are linked to many countries. Table 5 and Figure 15 show that the top three countries in terms of SCM 4.0 publications account for 36% of all publications. While comparing with other SCM advancements, the publications related to SCM 4.0 almost spread across the top 10 countries of SCM 4.0 publication equally that shows the interest of the global researchers. The coauthorship of countries is represented by lines connected to points on the map, and the distance between clusters indicates the strength among the countries and the publication in coauthorship of those countries.

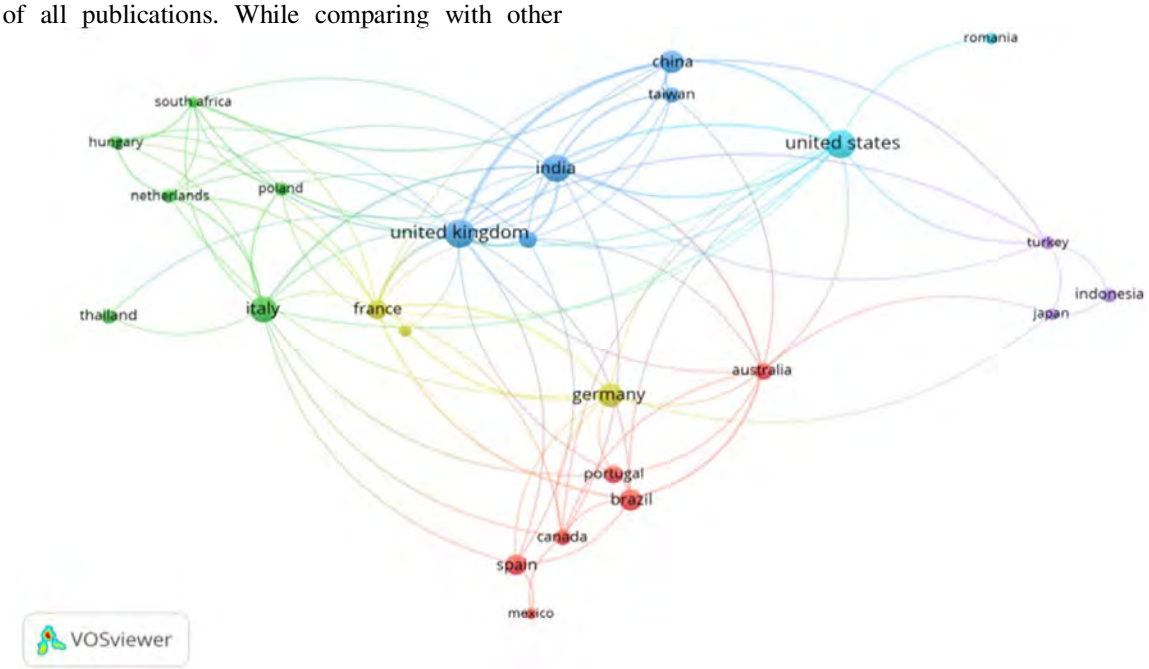

Figure 15 Coauthorship by country for SCM 4.0 publications

3.5.3 Analysis of citations of SCM 4.0

Figure 16 depicts the author's citation network and analyses it using SCM 4.0 bibliometric data obtained from the Scopus database, as generated by VOSviewer's citation network visualisation. The citation of the article can be generated when two articles refer to the same document. This method is used to determine the relevance of a document to a specific thematic field for documents, journals, and authors. Several authors are highlighted in Figure 16, indicating that their citation networks are strongly linked to other studies. The American author, Gunasekaran, appears in the yellow cluster as one of the authors mentioned most frequently, with total link strength of 6891 and 158 citations.

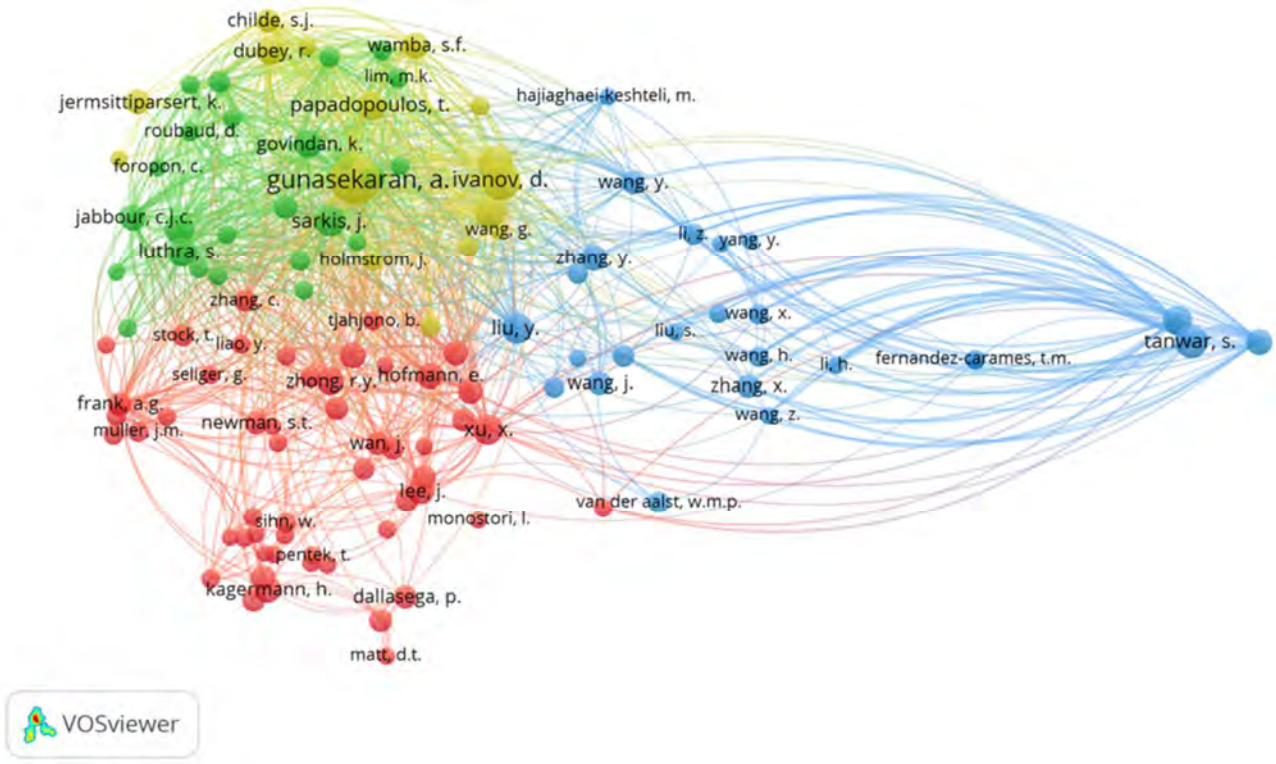

Figure 16 Author citation network of SCM 4.0

4 Results

The overall results of the bibliometric analysis and findings obtained from VOSviewer, publications by year, countries, and citations of studies related to SCM, Global SCM, Green SCM, Sustainable SCM and SCM 4.0 are discussed in this section of the paper.

4.1 Summary of publications by year

According to the results of a keyword search in the Scopus database, the first article about SCM was published in 1969. However, the increase in the number of publications gained popularity in 1993. SCM was found to be mentioned in 1454 articles out of a total of 62547 articles (while using the keyword Supply Chain Management). According to the bibliometric analysis, the advent of Global SCM began in 1990, with a total of 7891 articles found between 1990 and 2021. A total of 1055 articles were found to be more significant to Global SCM. It should be noted that, while Covid 19 has had a significant impact on businesses around the world, in the year 2020, there were 115 significant articles related to Global SCM were published. Concerning the bibliometric analysis of Green SCM, a total of 3767 research articles were published. Using Boolean operators to filter articles, 419 articles for Green SCM analysis were discovered. Since 2004, the publication trend of Green SCM has increased as industries all over the world strive to create more environmentally-friendly environments for their businesses. There is a steady increase in publications in Sustainable SCM, indicating that researchers are becoming more interested in this field as industries and economies place greater emphasis on Sustainable SCM. 1864 articles were found to be relevant for Sustainable SCM out of 7413 published research articles, with the highest publication count in the year 2020. Out of 1194 articles, 466 were considered for analysis in SCM 4.0 after filtering and Boolean operators were applied. The findings of the bibliometric analysis emphasise that there will be an increase in SCM 4.0 publications in the coming years, as most businesses begin to implement automation and researchers seek out new areas in which to conduct research. The net results of the analysis clearly show that the year 2020 has the highest number of publications in all the five branches of SCM.

4.2 Summary of Geographical Analysis of Publications

Based on data obtained from the bibliometric analysis, it is fascinating to learn that SCM and its advancements were regarded as the most desired subject for global supply chain researchers. Studies on SCM were conducted frequently in the United States of America, which has the most publications (378), followed by the United Kingdom and India, with Sweden ranking tenth with 47 publications. In comparison to SCM, Global SCM received worldwide attention, with published articles distributed among 80 countries, with the United States of America holding first place with 333 articles and France holding tenth place with 34 publications. With 86 articles, India leads the list of the gradually emerging Green SCM, followed by Indonesia and Australia in tenth place. Concerning Sustainable SCM, it can be seen that the United States has the most publications, totaling 351 articles, followed by the United Kingdom (315 articles), India (189 articles), and Iran ranking the tenth position with (81 articles). The emerging SCM 4.0 is gaining its popularity, with India ranking first with 57 articles and Australia ranking tenth with a total of 20 articles. The overall network visualization of country-wise publications generated by VOSviewer shows the clusters of India, the United States, and the United Kingdom are well-exposed, implying that they are linked to many countries with the highest number of SCM publications.

4.3 Summary of Analysis of Citations

The author citation network obtained from VOSviewer shows the American author Gunasekaran as one of the authors mentioned most often for SCM, Global SCM and SCM 4.0 concerning studies with the total strength link of 5082 and citations of 103, total link strength of 2518 and citations of 100 and total link strength of 6891 and 158 citations, respectively. Similarly, the American author Joseph Sarkis citations networks are highly linked with other studies regarding Green SCM and Sustainable SCM with the total strength link of 77853 and citations of 1023 and total strength link of 137995 and citations of 1396, respectively. The researchers have shown the overall summary of the results in Table 6.

Table 6 Summary of overall Results

Types of SCM	Total Number of Publications	Top 10 Countries by Publications	Total Number of Clusters of Coauthorship by country	Total Number of Clusters of Citation Network	Renowned Author	Most Cited Article
SCM	1454	USA, UK, India, Australia, China, Finland, Germany, Italy, Canada and Sweden	9	5	Gunasekaran	[47]
Global SCM	1055	USA, UK, India, Australia, Germany, Italy, China, Canada, Taiwan and France	7	4	Gunasekaran	[81]
Green SCM	419	India, China USA, UK, Iran, Brazil, Malaysia, Taiwan, South Korea and Australia/ Indonesia	7	5	Joseph Sarkis	[82]
Sustainable SCM	1864	USA, UK, India, China, Germany, Italy, Canada, France, Australia and Iran	8	4	Joseph Sarkis	[83]
SCM 4.0	466	India, USA, UK, Italy, Germany, China, Brazil, Spain, France and Australia	6	4	Gunasekaran	[84]

5 Discussion

According to the foregoing study of literature, it can be seen that several researchers have undertaken distinct studies related to Supply Chain Management [2-4,6,88-90], Global Supply Chain Management [88-93], Green Supply Chain Management [45,94-101], Sustainable Supply Chain Management [17,23,54,62,86,102-104] and SCM 4.0 [66,105-109].

Though many studies were conducted individually, there is no such study has been carried out to comprehend all five branches. For instance, the study by Croom et al. focuses on only two criteria of SCM: content and methodology-based review papers, whereas the current paper focuses on accurate information about the highest-ranked country, author and articles published related to SCM. Similarly, Closs and Mollenkopf's study on the conceptual framework of Global SCM focuses on the

United States, with data from Australia and New Zealand (ANZ) being compared, whereas the current study focuses on SCM globally. Likewise, Luthra et al., research look into the impact of organisational size on the adoption of Green Supply Chain Management practises in the Indian industry, but the current study looks at the impact of Green SCM globally. On the other hand, Brandenburg et al. study focused on Sustainable SCM and was limited to six journals, whereas the current study has no such constraints. The study by Princes discusses the disruptive challenges that SCM 4.0 presents to the modern manufacturing industry, whereas the current study examines both the strengths of SCM 4.0's artificial intelligence advancements as well as the drawbacks of cybercrime.

The novelty of the present study stands here, as this research analyse main five SCM topics in the literature and quantitative trends of their aperance together with authorship, citations and authors' geographical affiliation as well as authors interrelations, and in this way, it differs from the previous researches. Further, it can be noted that the present findings of the study fulfil the gap in the development of a comprehensive conceptual framework that integrates all of the five SCM branches as a single entity left in previous studies. The current study distinguishes itself by using a VOSviewer that combines graphical analysis of the biblometric network via cluster maps with a detailed study and systematic review of published papers from 1990 to 2021, yielding a new study in the SCM trends.

Furthermore, accurate information on the publication period of SCM, Co-authorship of each country and citations have been obtained using standard research tools from the commencement of SCM to the present day. As a result, the study discovers that countries like India, United States of America and United Kingdom have the most publications relating to SCM and its advancements, thereby promoting and encouraging readers to develop its significance relevant to the modern commercial world. On the other hand, the study raises awareness among countries with lower publication rates by alerting them to gain a better understanding of SCM and its advancements in the globalised era.

6 Conclusion

The current study focuses on a historical overview of the Supply Chain Management concept, from its commencement to the recent development of Supply Chain Management 4.0. The review of literature provides a comprehensive overview of SCM and various dimensions of all five types of SCM derived from papers published in scientific journals indexed in the Scopus database, a highly regarded database for academic and scientific articles.The methodology of this study incorporates VOSviewer software to classify and analyse bibliometric data distribution and network in a graphical way via cluster maps using a detailed examination and systematic review of literature based on bibliometric reviews published in each research field. The findings of the study illustrate that the present study is unique in its construction as it exposes all five branches of SCM using VOSviewer in which no previous research has been conducted to date. Though the study thoroughly explains SCM and its advancements, it does have certain limitations, as it only looks at articles in the Scopus database, excluding journal articles from other databases like Web of Science, Dimensions, PubMed, etc. Furthermore, only English-language literature are taken into account, which gives scope to future researchers to explore and obtain insight on work done in different languages related to SCM.

The study not only ends with comprehending the SCM and its advancements but also it recommends and provides opportunities for future researchers. The detail recommendations and opportunities are as follow; for SCM – Only a few countries have conducted the majority of SCM studies, hence there are many chances for researchers in areas where studies have not been performed, for Global SCM – nowadays, due to the impact of Covid 19 the studies related to Global SCM were declined, researchers all over the world take this opportunity to investigate further into the impact of Covid 19 on Global SCM, for Green SCM – only a few countries, especially the top ten countries listed in Table 3 has 94 percent, conducted most of the studies in relation to Green SCM, so researchers from other countries may concentrate on this field, and it give a lot of opportunities to them, for Sustainable SCM – there are a lot of opportunities to the researchers to conduct the studies in different industries as the past studies focus only the limited industries that concerning the environmentally friendly, and for SCM 4.0 – only very few articles in relation to technology adoption were published in the recent years related to SCM 4.0, so the future researchers have a lot of opportunities to conduct research concerning SCM 4.0 in line with the hosting countries' industries that deal with SCM 4.0.

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