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Actualities of Supply Chain Concept Evolution

Aurelija Burinskienė, Olga Lingaitienė

Business Management Faculty, Vilnius Gediminas Technical University, Sauletekio ave. 11, LT-10223 Vilnius, Lithuania

aurelija.burinskiene@vilniustech.lt

Abstract. In the burgeoning field of supply chain (SC) management at the beginning of the twenty-first century, many predictions have been made to determine the state of the fundamental concepts in the field, as well as stimulate debate, help guide resource allocation and implementation initiatives, and initiate research to improve many of the revolutionary topics in the understanding of SC management. Publications priorities on SC topics have changed considerably since 2000, with the focus more on automatisation and digital technologies. The authors showed the evolution from 1PL to 5PL and technology-related development trends in the supply chain for each decade. Finally, the authors presented the results of bibliometric analysis, during which 12 different clusters on the topic of supply chain were formed. Each cluster presents contemporary criteria announced in the publications during the last two years, particularly in 2022-2023.

Keywords: supply chain, supply chain management, evolution, criteria, third party logistics (3PL).

1. Introduction

In the 21st century, around 422 thousand books on supply chain topics were published. Fifty percent of books were rising production-oriented and costs related questions; 45 percent of them – were on international supply chain and the application of electronic means to SC operations; 40 percent of books (in particular, 172 thousand books) were dedicated to logistics, processes management, and strategic approach; 1/3 of them described sustainability issues (most of them were written from 2010), and the implementation of different technologies; 18 percent of them were associated with consumer needs, and 13 percent of books highlighted warehouse importance, 10 percent – enterprise role and social responsibility, and 5 percent of books were oriented to competition challenges, reverse products flow and third party services. However, some topics that received low attention, like 9210 books, were given to the resilience paradigm importance in supply chain management, or closed loop topics, which got attention in 7210 books where supply chain was mentioned in their titles.

Stevens, G. (1989) defines the SC as an interrelated activity of planning, coordinating, and controlling the flows of materials, parts, and finished products from suppliers to customers, where the flow of materials is considered only at the operational level. To meet the market's needs, SC shall be integrated and operate as a whole, ensuring the appropriate use of tools and techniques and is sufficiently competitive.

According to Stevens, G. (1990), the SC includes the flows of information and materials in a manufacturing firm from the suppliers to the customers. Traditionally, the flows of materials have been considered only at an operational level, but this approach no longer seems adequate. It is now essential for businesses to manage the SC seeking to improve customer service by achieving a balance between cost and service level, thereby increasing the enterprise's competitive advantage. While material flow used to be measured only at the operational level, companies now focus on the importance of SC management and integrated SC processes to improve customer service and balance service and cost. With an integrated supply chain, material flows are managed at three levels: strategic, tactical, and operational, with all processes and resources coordinated and aligned as a whole at each level.

Gundlach G. et al. (2006) identify the supply chain as a network of enterprises or independent business units from suppliers to final consumers. Kovacs, G. (2004) describes a SC as an intertwined set of actors, their functions, and resources. Basu, R. & Wright, N. (2008) classify supply chain improvement as customer service improvement, reducing lead times, delivering everything on time, always making a product that the specification, and reducing costs are also important factors. Cooper et al. (1997) point out that the popularity of the SC as a management model has only emerged in the last ten years and that the conceptual model of supply chain management is now well established, which, according to Christopher, M. & Holweg, M. (2017), has helped to give a number of companies an advantage. According to Habib, M. (2010), supply chain management is a concept whose primary objective is to integrate, source, supply, and control materials by using systems that incorporate various functions and information flow from suppliers.

Supply chain processes for competition and customer demand are complex and quite complicated. Here are ten facts about the complexity of the supply chain:

- mass customisation of products;
- shortening lifecycle times for packaging and delivery according to customer requirements;
- wide choice of product lines and stock keeping units;
- a wide range of outsourced manufacturing services;
- globalisation of supply chain activities (including sourcing, manufacturing, sales and marketing);
- use of third party logistics services in 3PL;
- common inventory management programmes such as Continuous Management Programmes (CMP);
- vendor managed inventory (VMI);

- agile manufacturing initiatives;
- supply chain integration;
- consolidation, acquisition fact.

Supply chain activities are focused on creating added value, reducing costs, and shortening response time in various supply chain processes.

The paper consists of two theoretical chapters which are dedicated to supply chain evolution in terms of the application of new technologies and concepts and outsourced services accordingly; one chapter with focuse to bibliographical research of contemprorary publications, and final chapter which is given to concluding remarks.

2. Theoretical Analysis of Supply Chain Evolution

The global SC has dramatically changed over the last 100 year period. Every way in which goods are sourced, produced, and transported has changed (MacCarthy, B. et al., 2016; Carter, C. & Easton, P., 2011). The changes in global supply chains are enormous: from introducing new handling procedures to using ocean-going vessels, from containerisation to computerisation, a host of innovations have also led to advances in SC (Flynn, B. et al., 2018). The size, shape, and configuration of SC that have evolved are undergoing fundamental changes, as are the ways in which they are managed, coordinated, and controlled. Existing supply chains may be either mature and relatively unchanging or may be subject to significant change, and new SC may emerge and evolve for various reasons (Park, H. et al., 2018).

Table 1: The supply chain evolution

Period	Characteristic feature	Description	References
Around 1900	Local and regional supply and production	Before the Industrial Revolution in Europe and the US, the vast majority of SC was local in nature and limited to regions.	Ville, S., (1880); Fishman, R. (1900)
1910	Industrial Revolution	The Industrial Revolution brought changes; goods began to be transported by rail, which was quicker, easier, and cheaper over longer distances, while SCs were still limited to countries. In the 19th century, rudimentary hand trucks and other tools made it easier to handle freights.	Hayes et al., (1910); Follansbee, R. (1910); Sutton, M. (1920)
1910-1920	Improvements to trucking	At the end of the 19th century, the internal combustion engine was invented, and trucks began to be developed to move goods faster on the roads. Trucks were initially powered by petrol, and from the 1920s onwards, diesel engines were introduced.	Page, V. (1917); Meade, A. (1918); Clapp, E. (1920)
Until 1930	Improvement to warehouses	An important change in supply chain warehousing occurred in 1925 with the introduction of pallets in warehouses. By stacking goods on pallets, space was saved, and goods were handled more efficiently.	Shideler, E. (1927); Palmer, J. (1929); Gras, N. (1930)
1930-1940	Importance of mechanization	The supply chain became particularly important during the Second World War, as military organisations needed efficient SC outside war and war zones. Improvements in pallet handling, racking, and warehousing systems were also continued to speed up the delivery and distribution of goods.	Jerome, H. (1934); Nguyen, P. (1936); Act, A. (1939)
1950	Standardization and the	The invention of the shipping container and all the logistics and transport modes it requires has	Timberlake, E. (1943);

	introduction of containerization	revolutionized global supply chains because the shipping container is intermodal and can be transported by several different modes of transport.	Robertson, A. & General, N. (1946); Flammer, J. (1946); Braithwaite, A. (1950)
1960-1970	Increase efficiency	Shifting the distribution of freight from rail to lorries. Continuous developments in pallets, handling equipment, containers, and other areas have made freight transport more reliable, time-efficient, and over longer distances.	Parker, D. (1962); Padberg, D. (1966)
1970-1980	Increase computerization	Before the 1970s, computerization began to gain popularity, streamlining the supply chain and creating opportunities in many areas, such as more accurate forecasting, better warehousing, truck routing, and stock management. Barcodes emerged.	Abernathy, W. & Townsend, P. (1975); Castruccio, P. et al. (1975); Maddaus, W. & McGill, J. (1976)
1980-1990	Global model / Consolidation	In 1983, the "SC management" terminology was coined, and the supply chain was further replaced by personal computing. New software made it easier to follow expenses and maximize profits. Radiofrequency identification (RFID) tags have been developed for easier tracking of goods.	Kriebel, W. & Sailer, F. (1973); Mula, J. & MacRae, D. (1979); Phung, K., & Mula, J. (1979); Houlihan, J. (1985); Jones, C. & Clark, J. (1990)
2000	True globalization /Value capture	The emergence of intelligent analytics (IA) is applied in analytical tools for better forecasting and order management. The SC is evolving towards a more data-driven, networked, and collaborative SC eco-system that creates real value and growth for all participants.	Bovet, D. & Martha, J. (2000); Lazzarini, S., et. al, (2001); Power, D. (2005); Vachon, S. & Klassen, R. (2006); Pisano, G. & Teece, D. (2007)
2010 - up to now	Automation/ Digital technologies	New technologies are opening up new business transformation opportunities that are changing supply chains and driving new ways of creating value.	Swaminathan, J. & Tayur, S. (2003); Salo, J. & Karjaluoto, H. (2006); Berman, S. (2012); Holmström, J. & Partanen, J. (2014); Pfohl, H., Yahsi, B. & Kurnaz, T. (2015); Seyedghorban, Z. et al. (2020); Bigliardi, B. et al. (2022)

Operations research, as well as industrial engineering, started in the field of logistics. Frederick Taylor, the founder of industrial engineering, wrote in Scientific Principles of Management in 1911 that he focused on improving the manual loading process. Operations research with analytical value began during the Second World War. He was looking for solutions for military logistics operations in the 1940s (Jerome, H., 1934; Nguyen, P., 1936; Act, A., 1939).

The 1940s and 1950s logistics research focused on mechanizing the lifting pallets on platforms, which would help to obtain more storage space and more appropriate distribution (Timberlake, E., 1943; Robertson, A. & General, N., 1946). In 1950, the concept of uniform load and pallet usage became popular. Expanding transport management with multi-modal containers connecting ships, trains, and trucks has given rise to a global approach to the supply chain (Flammer, J., 1946; Braithwaite, A., 1950).

Before the 1970s, logistics had independent functions of supply, storage, production, and distribution (Abernathy, W. & Townsend, P., 1975). Since the 1980s, new organizational and management principles have emerged, and the activities of the company have become more integrated in order to be able to meet the coming need for flexibility without increasing costs (Kriebel, W. & Sailer,

F., 1973; Mula, J. & MacRae, D., 1979; Phung Tran, K. & Mula, J. M., 1979)

In the 1990s, the logistic boom led to the development of enterprise resource planning systems. They came after the success of the material requirements planning systems of the 1960s and 1970s.

ERP software identified the need for planning and integration of logistics components. Globalised manufacturing and the growth of production in China in the mid-1990s popularised the term "SC."

In the 1980s, the term SC management was coined to express the need to integrate key business processes from the end user to the primary suppliers (Houlihan, J., 1985). A major trend in logistics in the 1980s was its reputation as critical to corporate profits. When globalisation in the 1990s led to functional integration and the emergence of true logistics, all supply chain elements became part of a single management perspective (Jones, C. & Clark, J., 1990). However, SC management only started to take off with the possibility of fully integrating ICT processes. The integrated management and control of information, finance, and the flow of materials made it possible to develop new production and distribution systems. SC management became a complex sequence of activities to create value and ensure competitiveness. The increasing automation of SC has been a dominant element in the evolution of physical distribution and materials management. Warehouses have experienced a major push towards automation, for example, in warehousing, material handling, and packaging, and automated delivery vehicles may become available in the future (Lazzarini, S., et al., 2001; Power, D., 2005).

3. Benefits and Challenges of 1 PL, 2 PL, 3 PL, 4 PL or 5 PL

A company's supply chains vary in complexity, defining the stages a product must go through to reach the customer's hands. Therefore, the proper management of supply chain processes, in which the company can decide which part of the process to outsource, plays a crucial role in the business's success (Boyko, I. et al., 2018). Enterprises are looking for ways to optimize production and delivery processes to meet customer needs and ensure efficient product delivery. To ensure smooth and proper processes, companies can abandon some or all of the SC control logistics management services and, depending on specific needs, turn to logistics management services with a spectrum of choices from the simplest first-party logistics (1PL) to advanced fifth-party logistics (5PL) (Gruchmann, T. et al., 2020).

In order to transport products around the world, companies use logistics management systems such as 1PL, 2PL, 3PL, 4PL, and 5PL, which, by engaging in a common process, help organize and implement supply chains (Kashley, V. et al., 2019). Each of the above serves different purposes at the logistics level, so companies choosing intermediaries need to companies choosing intermediaries need to understand the differences between 1PL, 2PL, 3PL, 4PL, and 5PL services (Akbari, M. et al., 2020).

Table 2: Benefits and challenges of 1 PL, 2 Pl, 3 PL, 4 PL, and 5 PL

Name	Description	Benefits	Challenges
First-party logistics (1PL)	It's a simple method of transportation where an enterprise or producer produces and moves products from one point to another without passing any supply chain. All elements of logistic management are handled internally, including manufacturing, transportation, picking.	The company is given more control over SC. The enterprise manages a fulfillment process that allows it to customize its packaging, freight transportation which best suits to its customer. When properly applied, supply chain control function could help to increase SC efficiency.	One of the most important factors for determining the best solution is cost. Payment to service provider is the cheapest. There is no external outsourced service provider to be paid.
Second-party logistics (2PL)	2PL helps businesses with transportation solutions by shipping goods. Using vehicles, ships, railways, and	As they outsource transport services, greater flexibility opens up new transport opportunities. A 2 PL has access	One of the most important factors for determining the best solution is cost. Payments

Name	Description	Benefits	Challenges
	airlines, 2PL moves and delivers inventory to different businesses.	to various modes of transportation and does not oversee the transportation of the company's goods. Providers access infrastructure resources at a lower cost than if enterprises build the infrastructure themselves.	to service providers are somewhat more expensive than 1PL. The payment is just for transportation costs.
Third-party logistics (3PL)	3PL handles more complex logistics needs, organizes and optimizes the supply chain: handles shipment, ensures warehousing, reverse logistics, and other processes while the firm maintains overall control of SC.	Outsourcing to a 3PL provider reduces logistics costs and increases supply chain efficiency, prevents product loss, damage or delays, increases delivery speed, and allows the enterprise to maintain overall control of SC.	Payments to service providers are more expensive than 2PL.
Fourth-party logistics (4PL)	4PL applies strategies and manages the entire SC by developing and implementing SC solutions to meet customer needs and help the business grow.	A 4PL completely oversees the supply chain, ensuring that companies can operate without any logistics-related disruptions and spend more time on overall business management and development. Logistics and its execution are outsourced. 4PL provider coordinates with external 3PLs to ensure a smooth SC, save time and money, increase efficiency, and reduce expenses associated with supply chain disruptions.	Payments to service providers are more expensive than 3PL because firms must coordinate their own SC and acquire the expensive infrastructure associated with logistics. This arrangement is not suitable for companies with small or streamlined supply chains.
Fifth-party logistics (5PL)	It is the most comprehensive and expensive form of SC management, with services that optimize the supply chain, including ordering, warehousing, and transportation management systems. Like a 4PL, a 5PL supplier controls every supply chain step, starting with manufacturing. However, the difference is that a 5PL manages multiple SC networks, implementing its solutions for various customers.	5PL takes over all logistics responsibilities from the firm. These suppliers work as strategic partners, managing every aspect of the SC and leveraging the advantages of 3PL and 4PL in their network. 5PL offers the best logistics solutions and the best possible prices. Companies can increase their efficiency by relying on these specialists, and 5PL providers develop new strategies to help the firm succeed.	Payments to service providers are the most expensive because enterprises must coordinate their SC and acquire the most expensive infrastructure associated with logistics activities. This arrangement is not suitable for companies with small or streamlined supply chains.

1PLs are usually small businesses that buy and sell in the same place. 2PLs provide services to one or more functions in the SC and emerge as the business expands geographically and the logistics boundaries of the producer expand accordingly. 2PLs have low barriers to entry, easy market entry, and high asset intensity but low returns (Boyko, I. et al., 2018). 2PLs provide new logistics opportunities by integrating their activities, which are becoming 3PLs as demand for one-stop solutions increases. 3PLs perform all or most of the logistics activities of a customer's supply chain, with added value based on information and knowledge, compared to non-differentiated transport services at the lowest cost. A 4PL provider can be characterized as a one-stop counter logistics integrator or a one-stop point of contact for a manufacturer's requirements of outsourced logistics (Akbari, M. et al., 2020). They are responsible for contracting, assembling, and managing these integrated solutions with the various 2PL and 3PL providers. The 4PL provider, with its comprehensive overview of the SC and its extensive

logistics and IT capabilities, can also offer the manufacturer high-value-added consultancy services. 5PL solutions are designed to provide shared logistics solutions for the entire supply chain often associated with e-business. A fifth party logistics provider (5PL) combines the logistics needs of large-scale different countries using technological solutions, plans, organizes and implements logistics on behalf of the contracting party.

4. Bibliographical Research of Supply Chain Studies

The researchers of this paper established 12 Clusters after bibliometric analysis. The methodology applied for the construction of clusters included such steps:

- VOSviewer program was used for the analysis of the articles published during 2022-2023,
- A bibliographic Coupling analysis was conducted, and the table following the cluster analysis was constructed,
- New criteria important for supply chain management papers are established based on co-occurrences of keywords mentioned in the title of papers.

After researching the keyword "supply," the authors with VOSviewer were able to create bibliographic maps and form clusters. Bibliographic maps were constructed by using papers in open-source databases, which mention related keywords in their titles. Bibliographic maps have some attributes. First of all, the circle on the map has various colors, which present separate clusters and identify which keywords are closely related. The line on the map indicates a link between keywords and the strength of the links. The distance between keywords is determined by how strong the connection is.

The results of the bibliometric analysis are presented below. The constructed 12 clusters of keywords are evident in Figures 1-13 and Table 1, which summarise the results of keyword clusterization.

The keywords such as "decision" from the first cluster with 70 links, "production" from the second cluster with links 74 links, "review" from the third cluster with 119 links, "blockchain" from the third cluster with 82 links "role" from the fourth cluster with links 129 and "covid" from the seventh cluster with links 119 are identified as the most popular keywords.

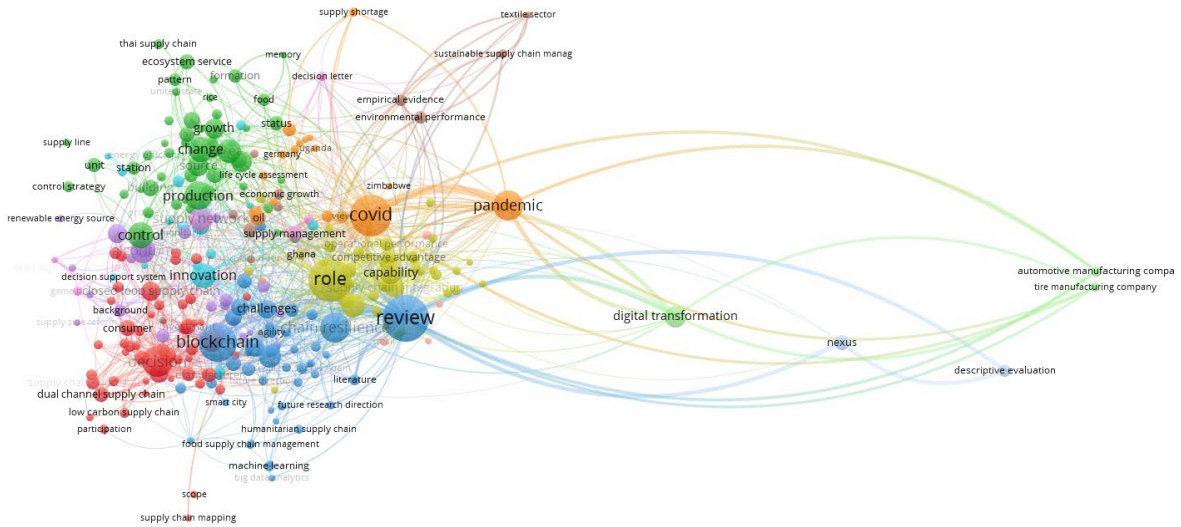

Fig. 1: Twelve clusters

The keyword "decision" has the main links with "role," "review," "chain resilience," "production," "pandemic," and other links like "trade," "closed loop supply chain," "green supply chain," and others. This cluster associates different supply chains via production and trade with the consumer.

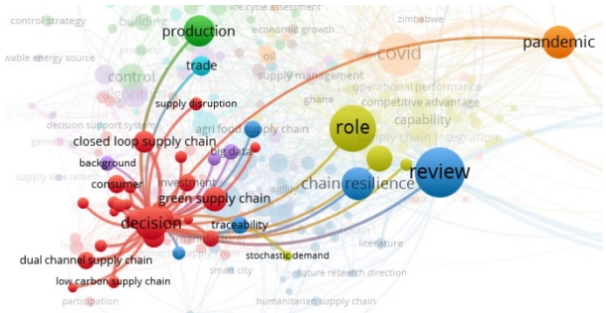

Fig. 2: The first cluster – decision

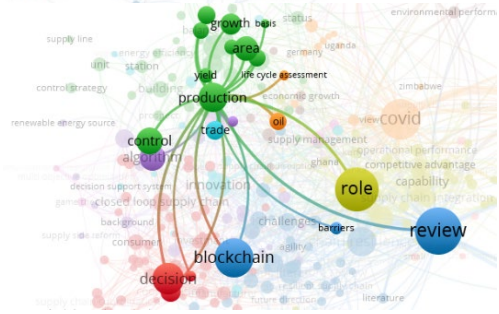

Fig. 3:The second cluster – production

In the second cluster, the main word, "production," has links inside clusters "control," "area," "growth," and with other clusters, keywords "review," "role," "decision," "blockchain," and "algorithms." This cluster is mainly associated with production growth and control and decisions made by using suggested results using algorithms.

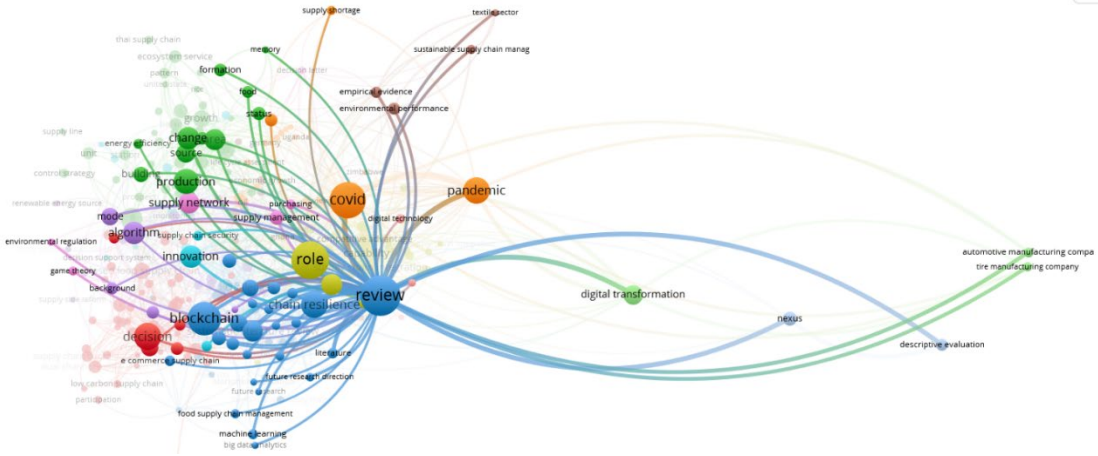

Fig. 4: The third cluster – review

The third cluster's main keyword, "review," has many links. However, the most important keywords are "blockchain" and "chain resilience," which are from the third cluster, and "role," "pandemic," "production," and "decision," which are the main keywords from other clusters. The third cluster is connected with the "supply network" and "algorithms" used for the review of activity.

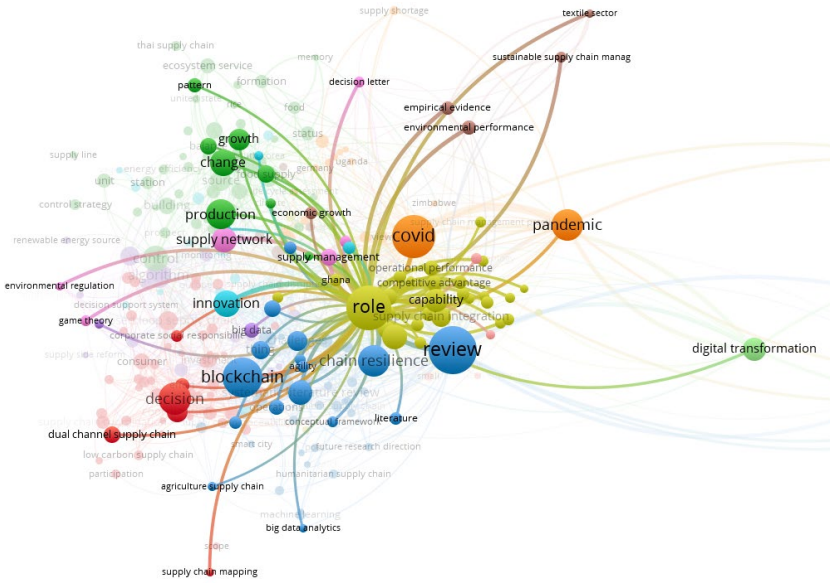

Fig 5: The fourth cluster – role

The fourth cluster main keyword, "role," has many links with such keywords as "review," "blockchain," "decision," "production," "change," "covid," "pandemic," "innovation," "supply network," "chain resilience," "sustainability performance." This cluster is oriented to increase competitive advantage through innovation, blockchain, and other means.

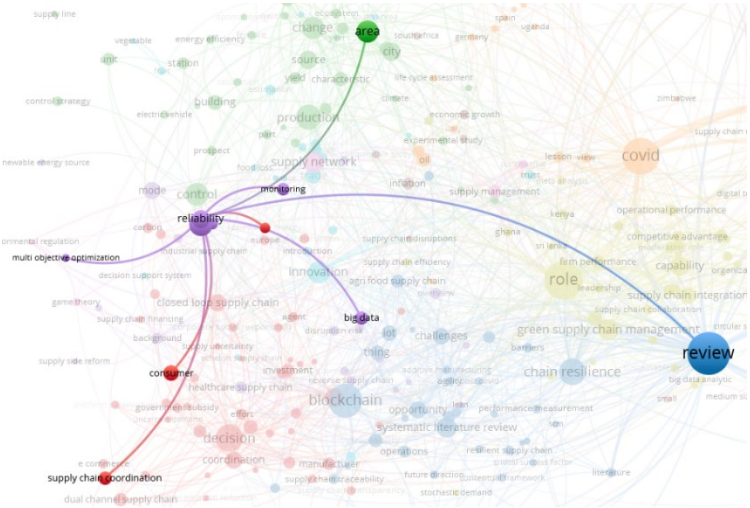

Fig. 6: The fifth cluster – reliability

The number of links is low. However, reliability is linked with "big data," "monitoring," "supply chain coordination," and "consumer." This cluster focuses on reliability aspects.

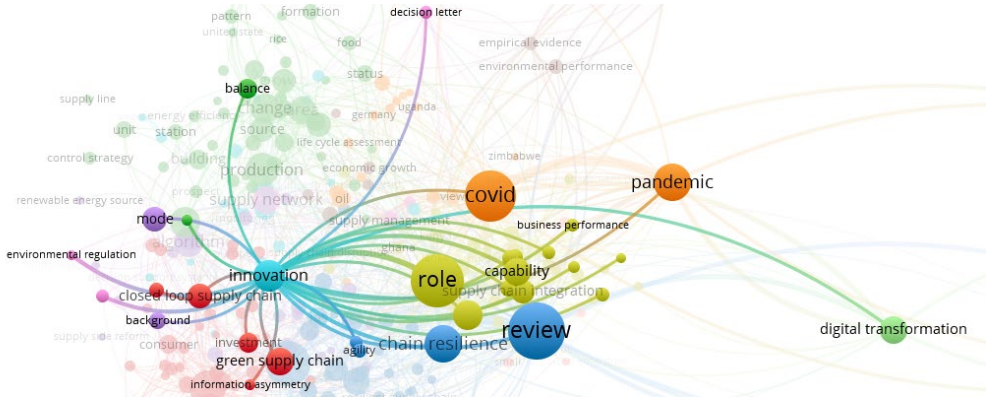

Fig. 7: The sixth cluster – innovation

This cluster has many links with innovation-oriented questions, such as these present main keywords: "digital transformation," "green supply chain," "investment," "chain resilience," "agility," and others.

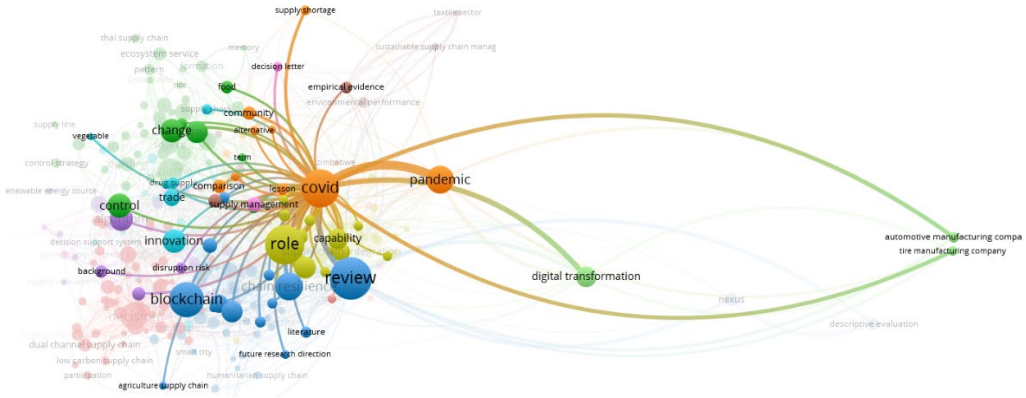

Fig. 8: The seventh cluster – COVID

The seventh cluster shows COVID-related links. The main links are associated with the keywords "pandemic," "digital transformation," "change," and other keywords from different clusters.

The eighth cluster focuses on empirical evidence and has links with different product-related supply chains (automotive, textile, and bread) and has links with environmental performance, sustainable supply chain management, and other ones "COVID," "pandemic," "chain resilience," "review."

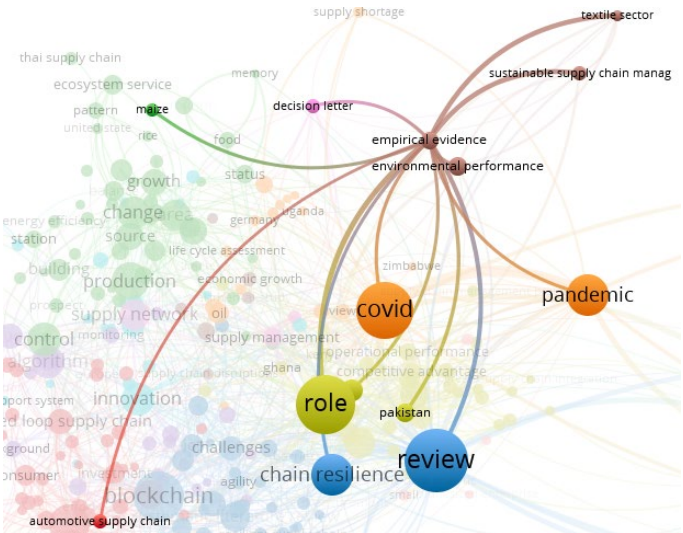

Fig. 9: The eight cluster – empirical evidence

This ninth cluster has links with "purchasing," "agility," "supply management," "role," "area," "control," "algorithm," and "review."

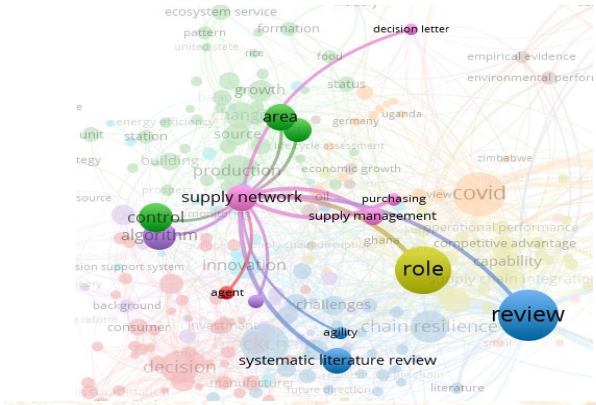

Fig. 10: The ninth cluster – supply network

Fig. 11: The tenth cluster – digital technology

The tenth cluster is oriented to digital technology, which is linked with several keywords from other clusters, such as "chain resilience," "role," and "review."

The eleventh cluster focuses on "digital transformation, which has links with such keywords as "blockchain," "innovation," "challenges," "covid," "pandemic," "competitive advantage," "capability," "chain resilience," and others sector-specific keywords.

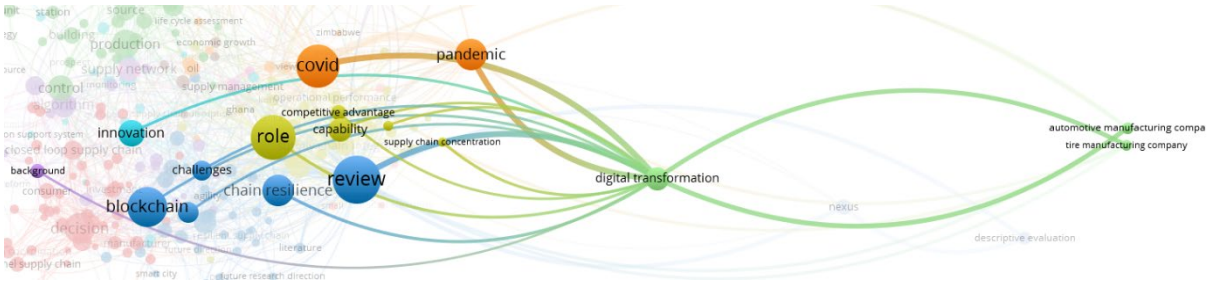

Fig. 12: The eleventh cluster – digital transformation

The last cluster is very small and has links with "capability," "chain resilience," and "review."

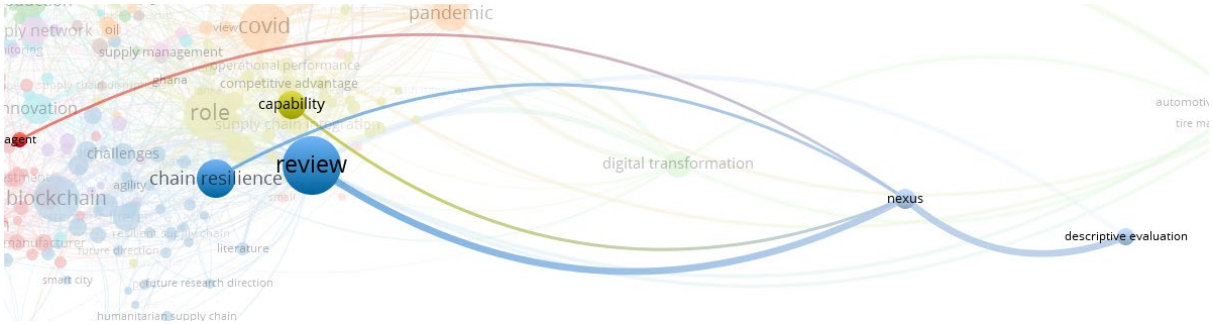

Fig. 13: The twelve cluster – nexus

Below is the table presenting all the most popular keywords and their links to different clusters. The main keyword of the cluster is marked in bold, together with key metric indicators provided from bibliometric analysis, such as links, occurrences, and strength.

Table 3: The summary of prioritised criteria in scientific publications published during 2022-2023

No of cluster	Keywords	Links	Occurrence	Strength
1 Decision	Decision	70	214	177
	Green supply chain	51	108	87
	Coordination	40	83	81
	Closed loop supply chain	33	82	55
	Competition	34	57	50
	Consumer	33	55	53
2 Production	Production	74	180	117
	Control	40	153	59
	Change	43	143	83
	Area	39	123	71
	City	38	96	60
	Source	33	95	48
	Growth	25	89	56
3 Review	Review	119	488	617
	Blockchain	82	322	227
	Chain resilience	69	202	191
	Systematic literature review	52	112	139
4 Role	Role	129	413	536
	Green supply chain management	66	122	141
	Capability supply chain	53	104	130
	Supply chain integration	39	77	82
5 Reliability	Reliability	34	77	45
	Algorithm	33	136	51
	Mode	28	85	53
6 Innovation	Innovation	69	137	145
	Trade	29	72	53
	Detection	11	32	15
7 Covid	Covid	119	385	546
	Pandemic	66	199	416
8 Empirical evidence	Empirical evidence	27	33	81
	Inflation	16	39	24
9 Supply networks	Supply networks	38	124	99
	Supply management	23	52	81
10 Digital technology	Digital technology	17	20	24
	Small	13	17	19
11 Digital transformation	Digital transformation	35	107	217

	Automotive manufacturing company	4	23	91
12 Nexus	Nexus	13	53	87
	Descriptive evaluation	2	37	73

This table represents the main criteria useful for supply chain management. These criteria are provided by scientists in the titles of their publications as the most important aspects to discuss in the topic of supply chain. Such research has limitations in that only papers published in 2022-2023 were examined, but in general, such criteria systems could be investigated further.

In future work, an expert system could be used to facilitate the decision-making process and be highly prioritised by researchers. Criteria can be examined in detail using multi-criteria methods.

5. Conclusions

The research of publications shows that the main directions support supply chain development. One of these directions is given to digitalisation, which was evident before and after the pandemic and is mentioned in two bibliographic clusters. Most of the publications were given to production as the results of the Industrial Revolution evident from 1910. This topic has also become highly important in recent years and was included in the fourth cluster.

The sustainability topic, which has had a considerable number of publications in the 21st century in recent years, got less attention and was included only in the 4th cluster representing the sustainable SC performance approach.

The lowest number of publications in the 21st century was given to the resilience theme; however, this was changed in recent years when the topic became highly pointed under the seventh cluster and linked to many other keywords.

The topics about competition and competitive advantage were highlighted more than before in recent years and were included under the first and eleventh clusters accordingly, where such keywords got greater attention, significantly increasing competitive advantage through the application of innovations and other technologies.

The closed loop SC was another keyword to which attention has increased recently, and it was included in the first cluster, which also included the customer keyword, having 18 percent popularity in the twenty-first century.

The research has some limitations. In the paper, open-access publications were analysed. However, other non-open-access publications could have different research topics than open-access publications. So, such an issue should be considered; however, the large size of analysed publications could present statistical significance of provided research. Further, the authors could analyse non-open access publications and their publishing trends associated with frames of different decades. Also, the authors could highlight more the associations with different disciplines, such as logistics, transport, warehouse, etc.

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