



Digital Transformation in Global Supply Chains: Technology Driving Efficiency and Innovation

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ABSTRACT

The product or supply travels along a supply chain from supplier to manufacturer to distributors to transporters, and finally to consumers via retailers. Therefore, supply chains can be thought of as networks or webs. The global development and extension of supply chain management can be attributed in part to the exponential growth in information technology technologies. Information technology, which has an impact on every aspect of the supply chain, is therefore the primary force behind increasing responsiveness and boosting efficiency at the same time. These tools are used to collect data, analyse it, and make improvements to it so that any supply chain can operate more effectively. However, there are a number of risks connected to the supply chain's usage of IT. The likelihood of a detrimental effect on operations increases with the size of changes made to the information technology system. Industry 4.0's introduction of new digital technology has made it possible to control the supply chain more effectively. When we discuss the "digitalization of the supply chain," we mean the shift toward a more intelligent model incorporating digital technologies like blockchain, the Internet of Things, machine learning, etc. The ability to optimize sourcing, planning, and procurement strategies is really increased and enhanced by these technologies. This research attempts to explore the primary discussion topics surrounding supply chain digitalization utilizing a keyword-based organizing framework in order to find, categorize, and explore pertinent scholarly contributions in this area, given the topic's relevance to the scientific community. The key challenges with supply chain digitalization were identified by the results, along with promising directions for further research.

Keywords: Digital Supply Chain, Supply Chain Digitization, Supply Chain Technology, Big Data Analytics, Artificial Intelligence (AI), Blockchain, Cloud Computing, Machine Learning, Predictive Analytics Automation, Real-time Visibility, Data Integration, E-commerce Logistics, Smart Warehousing, Demand Forecasting Inventory Optimization, Supplier Collaboration, Transportation Management System (TMS), Warehouse Management System (WMS), Cyber-Physical Systems (CPS), Internet of Thing (IoT)

1. Introduction of the study

According to Hartley and Sawaya (2019), the digital transformation of the supply chain refers to a shift toward fully integrated production and planning solutions that cooperate to produce a more visible supply stream at every stage of the value chain. This results in an increasingly transparent, responsive, and agile supply network that is easily able to adjust to any changes or uncertainties. By means of this shift, companies can establish a completely digitalized supply chain, experience reduced production and operational costs, accelerate lead times, and enhance their data analysis proficiencies, all of which can contribute to more efficient planning, sourcing, manufacturing, and distribution procedures. The implementation of a digital supply chain can lead to increased flexibility, reliability, and effectiveness by facilitating broad information availability, increased connectivity, communication, and cooperation. Businesses can improve customer connections by better understanding the needs and preferences of their customers through the digitalization of the supply chain (Oswald and Kleinemeier, 2017). According to Gezgin et al. (2017), the digital transformation of the supply chain enables businesses to have real-time visibility into their operations and functions, create a more adaptable and agile supply chain, and convert the linear supply chain into an integrated supply chain ecosystem, which lowers costs, boosts efficiency, and—most importantly—promotes sustainable growth.

Literature Review

Greening and digitization are now hallmarks of social and economic progress. Academic and corporate communities have extensively acknowledged and acknowledged digital technology as a vital facilitator of green supply chain management. The introduction of the Industry 4.0 era and the quick development of digital technology have led to regular updates in this new sector of technology, which has increased but not yet reached saturation in academic study. A comprehensive review of 144 pertinent publications published during the last 14 years was conducted. To categorize, compile, and analyze the literature in two areas—digital technologies and green supply chain practices—we employed qualitative analysis. We then carried on classifying based on each dimension. Five digital technologies can be identified based on these fundamental traits: blockchain, cloud computing, big data,

Internet of Things, and artificial intelligence. Based on the fundamental supply chain procedures, the green supply chain can be further classified as green production, green consumption, green procurement, and green logistics. Which digital technologies are essential to a green supply chain is investigated in this study. The report also covers how these technologies can lower energy and resource input as well as pollution emissions, which will ultimately increase the green supply chain's operational efficiency and yield positive effects on the economy, society, and environment. The internal supply chain, which integrates business operations engaged in the flow of materials and information from inbound to outward ends of the business, is referred to as SCM (Oliver and Webber 1992; Houlihan 1984). A supply chain is created when a customer's request is satisfied through the direct or indirect involvement of numerous partners. Manufacturers, carriers, warehouses, suppliers, retailers, and even customers are included in this. As a result, in any supply chain, the product or supply travels from the manufacturer or supplier to the distributor via the use of transporters, and ultimately to the consumer via the store. As extended businesses, supply chains, in the opinion of some researchers (Jagdev and Browne, 1998; Jagdev and Thoben, 2001; Tan, 2001), are in charge of the entire product life cycle, from the sourcing of raw materials and supply management to production and manufacturing, product distribution, and customer support, and lastly, recycling and end-of-life product disposal. Therefore, supply chains can be thought of as networks or webs. The consumer of today has easy access to a wealth of information regarding the types, attributes, and costs of the goods that are offered. The global development and extension of supply chain management can be attributed in part to the exponential growth in information technology technologies. The creation of ITE (Information Technology Enabled) tools, such as VM, VMI, TAV, ERP, CPFR, MRP, and MRPII, has increased chainwide efficiencies. Information technology, which has an impact on every aspect of the supply chain, is therefore the primary force behind increasing responsiveness and boosting efficiency at the same time. These tools are used to collect data, evaluate it, and make improvements to it so that any supply chain can operate more effectively. However, there are a number of risks connected to the supply chain's usage of IT. The likelihood of a detrimental effect on operations increases with the size of changes made to the information technology system.

IT AND SCM

The latest advancements in information technology have brought about a significant transformation in the way businesses operate. The usage of the Internet and new business models that enable organizations to reduce costs through real-time electronic communications have boosted consumer intimacy today. SCM's primary goal is to maximize the system's overall performance. Studies have shown that although a huge manufacturer's factories and distribution centers may be running at maximum efficiency, the business as a whole may not be performing at its best. R. Prasad (2007). It's comparable to a sports team where a player has excellent individual numbers but the team is unable to win. The modern workplace should include semi-permeable membranes allowing information to flow between departments rather than airtight chambers where each department operates well in isolation. Supply chain management is no longer seen as a supporting role to provide any business a competitive edge in the marketplace, but rather as one of the core functions. It is a tactic to obtain an advantage by coordinating every step of the process, from material acquisition to delivering the finished product to the client. This necessitates the monitoring of all relevant activities by the effectively managed information system. Today, technology has advanced quickly in the fields of information and communication, becoming a crucial instrument for decision-making. Effective supply chain input has been made possible by the partners' shared information. The current developments in IT have made this much easier (Freeman, 1998; Lee and Whang, 2000). In Stadler (2005), integration, cooperation, and the usage of IT are all portrayed as "building blocks" of the "house of supply chain." The idea that "ERP provides the digital backbone in supply chain integration" and the emphasis on the "increased importance of information systems" to support supply chain integration and management for the new organization are frequently emphasized in the literature (Pant et al. 2003, Bendoly and Kaefer 2004, Gunasekaran et al. 2004, Gunasekaran and Ngai 2004). IT is utilized to enhance interorganizational cooperation, which has been demonstrated to have a favorable effect on company performance metrics like lead time, production costs, and customer service (McAfee, 2002; Sanders, 2008).

Supply chain digitalization

Legner et al. (2017) define digitalization as the process of transforming analog signals into a digital model as well as the effects that these technologies have on society as a whole as a result of their use and adoption. Organizations worldwide are beginning to pay close attention to digitalization because it offers so many advantages to a variety of businesses. The supply chain's digitalization allows for the best possible use of digital technology for the organization and execution of plans, communications, and activities (Sanders & Swink, 2020). Big data analytics (BDA), advanced manufacturing with sensors, decentralized agent-driven control, advanced robotics, augmented reality, advanced tracking and tracing technologies, and additive manufacturing/3D printing are some examples of the digital technologies used in the supply chain (Ivanov et al., 2019).

For instance, modules, parts, and even finished goods can be produced in one location, or virtually anywhere along the supply chain, thanks to additive manufacturing and 3D printing (Khajavi et al., 2014; Li et al., 2017). This process undoubtedly influences the architecture of the supply chain; for instance, a collaborative technology between UPS and SAP enables UPS to create products directly utilizing 3D printing at the distribution centers (UPS, 2018). The supply chain is becoming more resilient, efficient, and quick thanks to these digital technology solutions. By mapping the supply chain end-to-end, creating risk profiles, and identifying crucial hotspots to start mitigation operations and provide near-real-time notifications about occurrences that could disrupt the supply chain, DHL's Resilience360 enables full disruption risk management (DHL, 2018).

Supply chain integration

According to several studies (Flynn et al., 2010; Frohlich & Westbrook, 2001; Germain & Iyer, 2006; Leuschner et al., 2013), supply chain integration can be divided into two categories: internal and external. The term "external integration" describes the cross-border integration of a company's logistical

operations with its suppliers and consumers (Stock et al., 1998). While external integration recognizes the value of developing intimate, interactive relationships with suppliers and consumers, internal integration views a manufacturer's departments and functions as components of an integrated process (Flynn et al., 2010). The ability of a business to organize its organizational practices, procedures, and behaviors into coordinated, cooperative, and controllable processes in order to satisfy client needs is known as internal integration (Cespedes, 1996; Kahn & Mentzer, 1996).

The coordination, collaboration, and integration of logistics with other functional areas are referred to as internal integration from the logistics and supply chain perspective (Stock et al., 1998). Recently, more research has shown that internal integration is necessary before outward integration can occur (Errassafi et al., 2019; Zhao et al., 2011). The significance of internal integration has been emphasized by certain research that have only examined internal integration and not exterior integration (Swink & Nair, 2007; Swink & Song, 2007). For instance, Gimenez (2006) found that companies who have already attained the highest levels of internal integration between logistics, production, and marketing are the ones that achieve the highest levels of external integration in the Spanish food business. According to Germain and Iyer's (2006) study of over 2000 members of the Council of Supply Chain Management Professionals (CSCMP), a firm's ability to integrate externally will only be constrained in the absence of internal integration. Therefore, it can be concluded that pursuing internal integration is a useful strategy for improving external integration, as both conceptual arguments and empirical evidence clearly support internal integration as the facilitator for external customer and supplier integration (Errassafi et al., 2019; Zhao et al., 2011). Stated differently, good supply chain integration requires a high degree of internal integration. The supply chain of today is incredibly unstable. Every industry is being affected by the demand economy, which is pushing supply chains to become more inventive than ever. Customers' purchasing habits and demand patterns have altered dramatically as a result of widespread information availability, multi-channel availability, quickly expanding social networks, and high internet penetration (Moorhouse et al., 2018; Spero and Stone, 2004). Customers now enjoy an additional level of convenience because to digitization, since they can now access all available options worldwide, which causes demand to fluctuate more. Customers now have power, and businesses must adapt to meet the shifting demands of these customers in order to be competitive in the current digital market. Customers of today want doorstep delivery, personalized goods and services, and customer-centric operations. The complexity of the supply chain rises as a result of an organization's need to work with numerous partners, suppliers, and contract manufacturers throughout the globe to meet these clients' requests. According to Farahani et al. (2017), the two biggest issues facing organizations today are demand unpredictability and growing supply chain complexity. Traditional supply chains, which contain a number of distinct and compartmentalized phases ranging from suppliers to final customers, including product development, production, marketing, and distribution, are unable to handle these difficulties, according to Schrauf and Bertram (2016). According to Milovanović et al. (2017), a digital supply chain can only become a reality by utilizing new digital technologies to transform its traditional supply chain into a digital one. This requires seamless end-to-end visibility, transparency, and traceability across the supply chain in order to collaborate with a global network of partners. Digital supply chains are more agile, dependable, and successful because they can provide real-time data and information to all participants, improve communication, and foster better collaboration across digital platforms (Tiwari, 2020). In their discussion of the use of smart technologies in supply chain management, Nasiri et al. (2020) came to the conclusion that supply chain digitization will reduce costs and inefficiencies while boosting agility, visibility, and traceability throughout the chain. The next evolution of supply chain management in the modern era is the digital paradigm. The capacity to access vast quantities of digital data from several sources will enable enterprises to have a deeper comprehension of supply chain dynamics and take appropriate action to optimize their outcomes. Organizations will be able to better manage their supply chains and provide customer service by feeding digital data into intelligent software that learns, analyzes, and produces insightful data. The companies who approach this strategically will emerge victorious. Thus, it may be said that the supply chain will inevitably undergo a digital transition.

4.2 Background Of the Study

Growing industry is a sign of a developing economy, and the prosperity of industries depends on effective supply chain management. In a 1982 interview with the Financial Times, "Keith Oliver" coined the phrase "supply chain management," which gained popularity in the 1990s (Oliver and Webber, 1992; Sherer, 2005). Organizations prior to that period referred to their processes as "warehousing and transportation" and "operations and distribution management" (Markova and Mircevska, 2013). According to Mentzer et al. (2001), a supply chain is "a set of three or more entities directly involved in the upstream and downstream flows of products, services, information, and finances from a source to a customer." The authors also discussed the capabilities, impact, applicability, and necessity of supply chain management for the success of an organization. Procurement and supply management, which includes purchasing-related tasks, materials management, which includes forecasting, scheduling, inventory management, store management, etc., and logistics management have come together to form supply chain management (SCM) (Chopra et al., 2018). "That part of the supply chain process that plans, implements, and controls the efficient flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers' requirements" is how the Council of Logistics Management (CLM) defines logistics. An organization's success depends on its supply chain being managed well. According to Christopher (1992), supply networks compete with one another rather than with individual businesses. Organizations were forced to search for more efficient supply chain management techniques as a result of the disruption of two supply network functions, an increase in supply chain complexities and uncertainties, and the arrival of the fourth industrial revolution.

4.3 Problem Statement

The majority of DSC's potential for value creation is currently unrealized because it is still in its infancy. On the other hand, it has led corporations toward innovation and quick change. Businesses who don't jump at the chance to take advantage of DSC's prospects will find it difficult to stay competitive. Large-scale corporations are the only ones adopting this technology at a modest pace, despite its many advantages for both customers and organizations.

In Indian organizations, DSC adoption is not as widespread as peers had predicted. Choosing the right technology and executing it correctly is one of the largest problems facing organizations, even though doing so might increase their capabilities.

The majority of the research that is now accessible examines how new digital technologies can help businesses meet their needs and how supply chain operations are affected by them. The benefits, facilitators, crucial success factors, and obstacles influencing the digitalization of the supply chain have also been covered in the research that are currently available. However, the knowledge needed to fully execute the digital supply chain is lacking, necessitating further research to support the deployment. The shift to a digital supply chain is a challenging process that necessitates practitioners to concurrently alter their competitive strategies and business models. This suggests that additional investigation is necessary to evaluate the state of the market and organizational preparedness for the adoption of digital supply chain transformation, the resources and competencies necessary for its effective execution, and the tactics and approaches that should be used to convert the supply chain into a digital supply chain.

4.4 Objectives of the Study

The aim of this research study on the digital transformation of global supply chains is to investigate how technology may propel innovation and efficiency in supply chain management.

1. To determine the capabilities of the digital supply chain.
2. To identify the primary technologies influencing the global supply chain's digital transformation.
3. To discover data regarding supply chain concerns.

5. Research Methodology

5.1 Research Design

Research Design of the proposed project work, considering its objectives, scope and coverage will be exploratory and descriptive in nature. Exploratory research is defined as a researcher used to investigate a problem which is not clearly defined. It is conducted to have a better understanding of the existing problem, but will not provide conclusive results.

For such research, a researcher starts with a general idea and uses this research as a medium to identify issues, that can be the focus for future research. An important aspect here is that the researcher should be willing to change his/her direction subject to the revelation of new data or insight. Such research is usually carried out when the problem is at a preliminary stage. It is often referred to as grounded theory approach or interpretive research as it used to answer questions like what, why and how.

5.2 Source of Data

Source of data refer to the origin or location from which data is obtained. They can vary depending on the context of the data collection. Some common sources of data include, primary sources, secondary sources and tertiary sources. Data can be defined as the quantitative or qualitative values of a variable. In this study qualitative research is applied. Source of data is case studies, articles, books, publications, journals.

5.3 Data Collection Method

Data collection method refer to the techniques and processes used to gather information or data for research, analysis or decision-making purposes. Common data collection methods include surveys, interviews, observations, experiments and document analysis. The choice of method depends on the research objectives, the type of data needed etc. There are two sources of data collection techniques. Primary and secondary data collection techniques, primary data collection uses surveys, experiments or direct observations. Secondary data collection may be conducted by collecting information from a diverse source. This study is based on secondary data.

6. Data Analysis and Interpretation

Table 1: Identifying supply chain capabilities

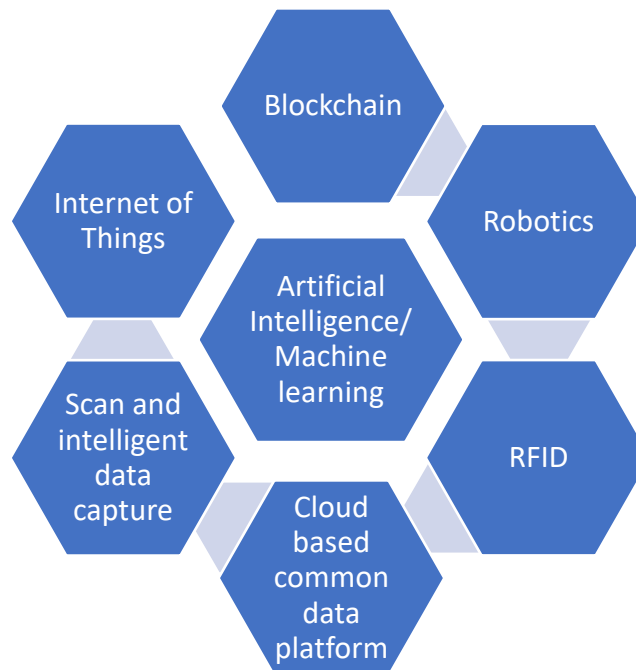
Capabilities	Description
Agility	The ability to quickly adapt and react to dynamic conditions in the market, customer, requirements and disruptions within the SC.

Connectivity	The ability to connect, interact and exchange information with different entities to enable co-ordination across the SC.
Flexibility	The ability to adjust SC processes, resources and operations to meet changing customer demands and market conditions.
Interoperability	The ability to integrate and exchange data seamlessly across different systems.
Proactivity	The ability to anticipate and address SC requirements, challenges and opportunities to mitigate potential risks.
Scalability	The ability to adapt the scale and scope of SC operations quickly and effectively without experiencing significant disruptions in performance and efficiency.
Sustainability	The ability to integrate environmentally and socially responsible practices and considerations throughout SC.
Traceability	The ability to track the movement and origin of products, components and materials throughout the SC.
Transparency	The ability to access accurate and real-time information across the SC.

A list of digital capabilities built for this research is presented in Table-1.

Digital chain capabilities refer to the technological abilities and effective management of the supply chain using digital tools and technologies. Key capabilities included in table-1. By harnessing these digital capabilities organizations can unlock new levels of supply chain efficiency, resilience and competitiveness. We have explained each of the capabilities in detail for the best applications, benefits and best practices for implementation in today's digital supply chain.

The supply chain technologies.



Technology is key to helping businesses reshape supply chain to mitigate risk and disruption, and here are some of the most important forms of it.

Table 1: To what extent have the following technologies have been adopted/applied in supply chain operations.

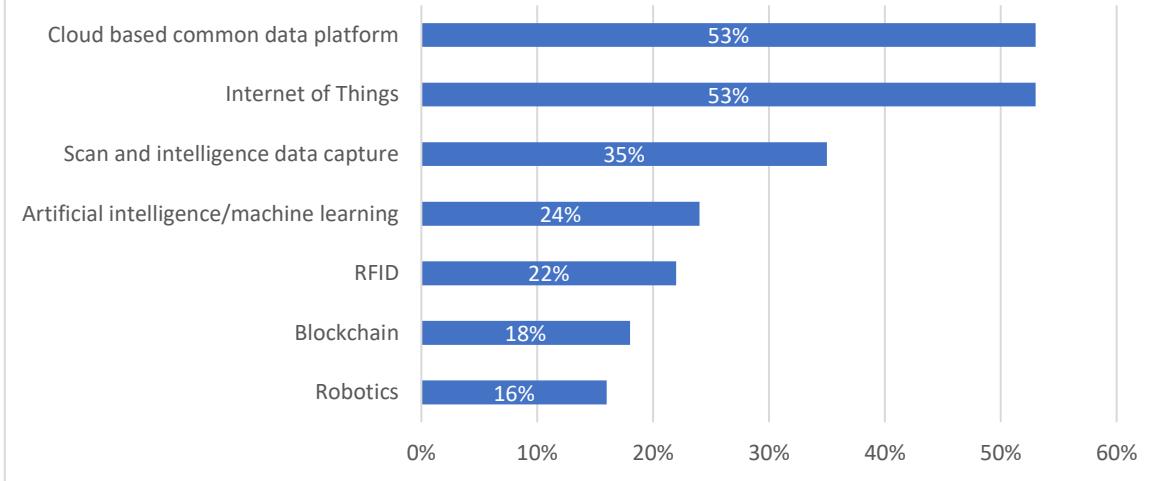
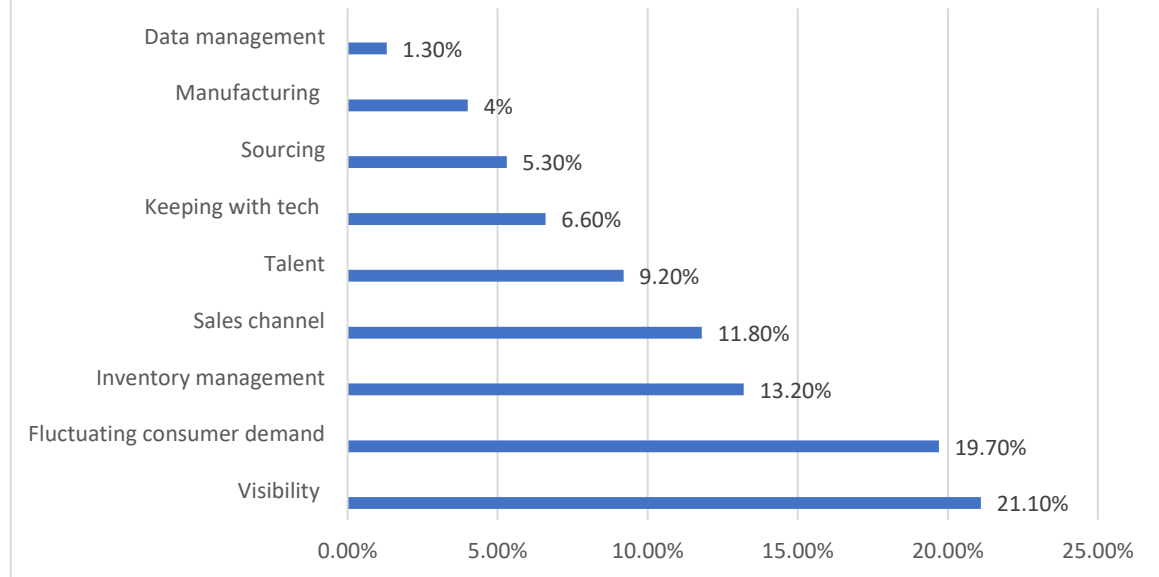
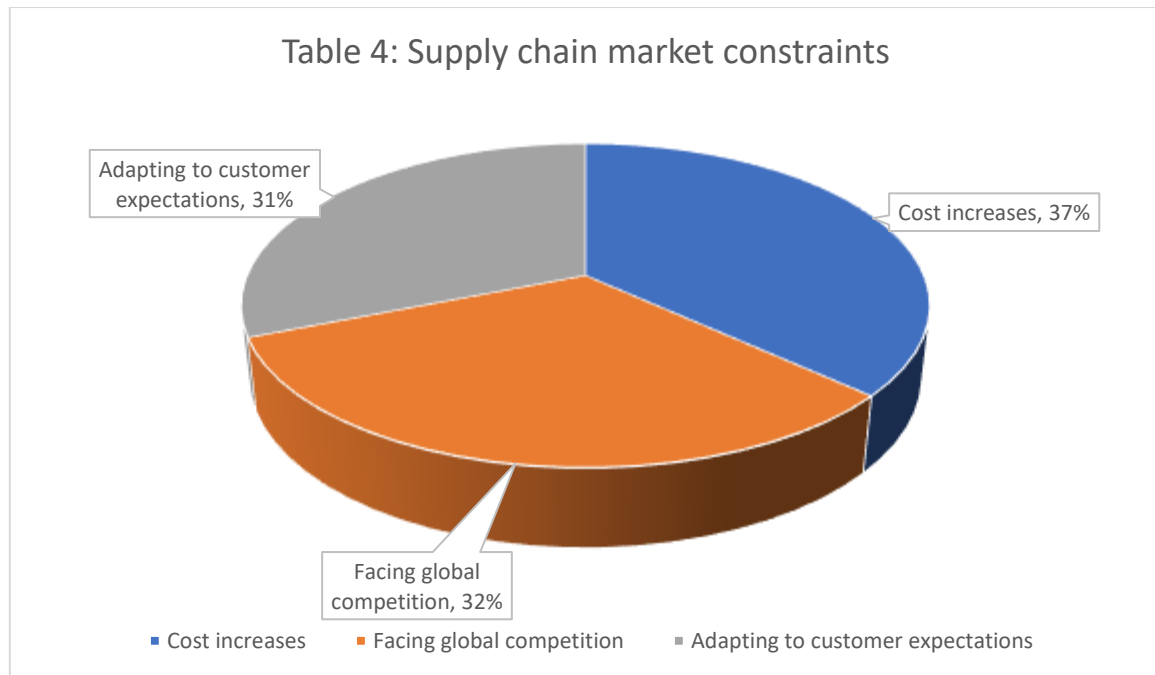


Table 3: Statistics on supply chain challenges

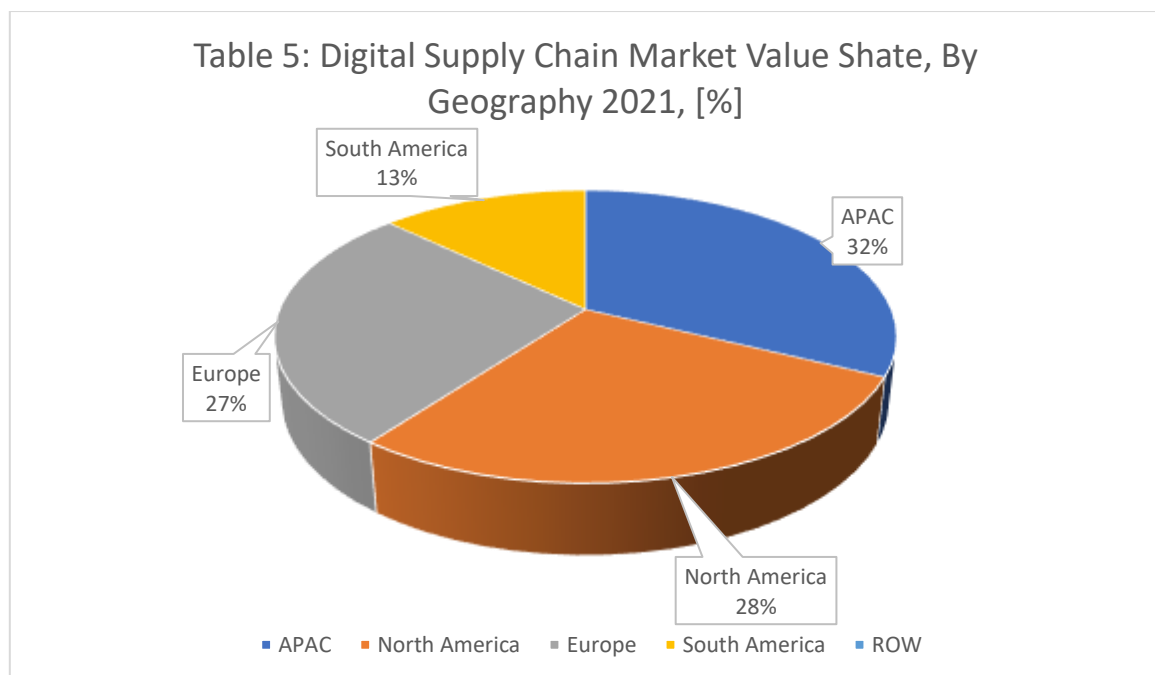


In 2018, the biggest challenges in supply chain management are visibility (21.1%), fluctuating consumer demand (19.7%), and inventory management (13.2%). Some also noted coordinating across sales channels (11.8%), finding talent (9.2%), and keeping up with tech (6.6%). Meanwhile, the sourcing (5.3%), ensuring an ethical supply chain (5.3%), manufacturing (4%), and data management (1.3%). (eft, 2018)



The leading supply chain market constraints are containing cost increases (32%), facing global competition (28%), and adapting to customer expectations (27%).

7. Results and Findings



Digital Supply Chain Market Overview

The Digital Supply Chain Market is estimated at \$4.1 billion in 2021 and is expected to reach \$13.5 billion by 2027 growing at a CAGR of 12.8% during the forecast period 2022-2027. The increasing use of analytics to derive critical insights from vast volumes of data and the rapid integration of advanced technologies such as Artificial Intelligence, the Internet of Things, and cloud-based supply chain management systems are going to drive the expansion of this market. The exponential increase in the number of supply chain disruptions due to the pandemic-induced lockdowns, rising demands for transparency regarding the supply chain movements, and digitization of various processes such as procurement, warehouse management systems and others are some of the key developments that are driving the growth of this market. The rising incidences of cargo congestion at major ports, terminals and other logistical nodes have resulted in the widespread adoption of radio frequency identification tags and autonomous vehicles to ease the congestion and ensure the smooth flow of the supply chain. Remote work, improving warehouse efficiency, reduced delivery time, and improved inventory visibility

has resulted in the widespread adoption of augmented reality and other related technologies which are revolutionizing and disrupting the supply chain industry in unprecedented ways.

50% of companies believe that technological advancements have a strong impact on the supply chain, logistics, and transportation operations.

8. Limitations of the Study

The digital transformation of supply chains is rapidly evolving in the global manufacturing sector. In addition, the interconnectivity brought by digital technologies also drives interest in developing services for the smooth functioning of emerging digital supply chains and networks. It represents an opportunity to integrate SC systems, improve SC relationships, and gain valuable data-driven SC insights. However, as a relatively new concept, the use cases for these strategic characteristics (capabilities) still need to be clarified for the emerging end-to-end digital supply chains. As part of their development process, several digital and analytical capabilities were identified and described when adopting digital SCM practices. A summary of key challenges and enablers is presented to demonstrate the digitally transformed supply chains' value. These characteristics can be used to plan the strategy to address these challenges and to integrate the enabling technologies at the operational level. One of the main challenges that focal companies and their SC partners face in their digital transformation process is the inconsistent categorisation between the main drivers and enabling technologies that contribute to the digital transformation of their supply chains and networks, which hinders strategic decision-making. Therefore, it is essential to establish a clear and comprehensive picture of the digital supply chain transformation that can guide their efforts to develop digital skills and build digital capabilities. In addition, further research is needed to align individual and coordinated supply chain efforts by exploring reference models and frameworks for developing DSCs at the operational level to understand the digital maturity of supply chains and their stakeholders. On the other hand, for this digital integration to be effective, DSCs must align the actors involved in this process. Rapid technological advances have brought about significant changes in the business landscape, requiring all SC stakeholders to develop digital skills and build digital capabilities to remain competitive. Failure to do so could lead to an asymmetry in the new digital markets, leaving certain supply chains and networks at a disadvantage compared to their digitalized counterparts or even forcing them out of the market.

Given the rapid growth in the digital transformation trend, not all suppliers are adequately equipped to support the achievement of digital supply chain objectives. Hence, supplier management becomes an essential practice to build new suppliers' capabilities and improve their performance. In this sense, one of the most promising avenues for aligning and developing digital vision is through new digital supplier development programmes, which are strategic initiatives by focal companies to improve suppliers' performance. This emerging approach remains largely unexplored in the context of the growing supply chains and networks digitalization trend and offers a mechanism to foster alignment and build suppliers' digital capabilities. This area of research holds significant potential for future exploration due to its contribution to enhancing SC performance, driving innovation, and fostering competitive advantage. The global manufacturing sector will continue to digitally transform in the coming years, with digital and smart technologies as essential enablers for developing/building new digital skills and capabilities in supply chains and networks. Furthermore, to develop competitive DSCs, new digital capabilities have the potential to elevate the sector's industries towards the use of advanced digital and smart technologies in which human skills are harnessed and complemented by advanced technologies. At the same time, applying these new digital skills will allow the optimization of current SC functionalities. While the discussion presented in this paper is a step forward in addressing this research and practice gap, several venues must be addressed going forward, including a typology that classifies the strategic drivers that address the emerging characteristics and capabilities to address efforts towards Digital Supply Chains Integration. In addition, based on the classification that can be built on the descriptions presented, a study can be developed at the operational level based on digital maturity models for supply chains, including their suppliers.

9. Conclusion

Technology makes the world go round. So, when it comes to dealing with complicated supply chain processes, companies are starting to utilize different types of tech to reinforce their efforts. However, it is best to note that not all technologies are created equal. While many companies see how the positive impact that these advancements may bring, they are only going to prioritize a handful of them. These include analytics, IoT, and cloud computing. This is especially true during the pre-pandemic era. Many challenges plague the supply chain industry. Several supply chain data sources reveal that many professionals are having problems with improving their operational visibility and meeting the changing customer demands. This is in addition to being constrained due to cost increases and the increasingly competitive business landscape. The competitiveness of companies in the logistics market is aided by efficient supply networks. Supply chain management, according to one research, provides businesses an advantage over rivals and allows them to grow their company. As a result of advances in data analytics and automation, the supply chain has never been more efficient. Companies, employees, and consumers all benefit from new technologies that spur innovation in supply chains across various sectors. Technologies with a high potential for transformation are now trending, and they seek to increase operations' resilience and resistance since we live in a digitally linked world. Even while the future is always unpredictable, it is probably more so today than ever before. A worldwide pandemic has damaged the supply-chain sector at the same time that it has reemphasized its significance and that it has spawned completely new objectives and outlooks for the foreseeable future.

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