Impact of Digital Technology on Supply Chain Efficiency in Manufacturing Industry

Xuan Wang, Vikas Kumar*, Archana Kumari, and Evgeny Kuzmin

Abstract With the advancement of digital technologies, supply chain management is changing dramatically. However, the practice and application of digital supply chains are complex and challenging. Some studies claim that technology is the core element, while others believe that efficient configuration and collaboration of technical functions assure successful applications. To address this gap, this research conducts a systematic literature review to analyze how digital technologies particularly the Internet of Things (IoT) and Artificial Intelligence (AI) impact supply chain efficiency in Manufacturing Industry. The study also identifies some challenges of digital supply chain (DSC) implementation. Analysis of this study is based on a systematic literature review of 59 studies that were selected us-

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X. Wang
School of Management
University of Bristol, Bristol, BS8 1QU, UK
e-mail: 18895636939@163.com
https://orcid.org/0000-0001-8746-5182

* V. Kumar (✉)
Bristol Business School
University of the West of England, Bristol, BS16 1QY, UK
e-mail: Vikas.Kumar@uwe.ac.uk
https://orcid.org/0000-0002-8062-7123

A. Kumari
Gloucestershire Business School
University of Gloucestershire, Oxstalls Campus, Gloucester GL2 9HW, UK
e-mail: akumari@glos.ac.uk
https://orcid.org/0000-0003-1005-9543

E. A. Kuzmin
Institute of Economics of the Ural Branch Russian Academy of Sciences
Moskovskaya St. 29, 620014, Ekaterinburg, Russia
e-mail: kuzmin.ea@uiec.ru
https://orcid.org/0000-0002-8805-135X

ing a combination of relevant keywords and specified inclusion and exclusion criteria. The results show that both IoT and AI are the closest technologies related to the autonomy and predictive power of future supply chain expectations. The convergence of the two tech-nologies optimizes all aspects of manufacturing and opens up more possibili-ties for smart factories. This research also explored DSC challenges and problems that take into consideration to expand the approaches to DSC success factors derived from existing literature. Many papers have discussed DSC technology from the perspective of the ap-plication. They demonstrate the positive impact of those digital technologies to successfully achieve digital and intelligent supply chains on firm perfor-mance by improving the efficiency of SCM.

Keywords Digital Technology · Supply Chain Efficiency · Manufacturing

1 Introduction

With the continuous expansion and development of the manufacturing industry, an increasing number of enterprises begin to devote themselves to supply chain efficiency [1]. It depends on a smooth network chain structure formed by the upstream and downstream organisations in the process of production and transportation through organizational control of capital flow, information flow and logistics [2]. Specifically, it is aimed at optimizing the process, improving production quality and reducing unnecessary costs to satisfy customs and achieving the maximum economic benefit [1]. Mangan and Lalwani [3] claimed that effective supply chain management in the manufacturing industry is especially important to deliver the right product to consumers at the right time, in the right quantity, in the right quality, and at the right state. However, the rapidly changing market and diverse customer needs have brought unprecedented challenges to manufacturing supply chains, because it relies heavily on timely and accurate data analysis in a complex business environment [4]. Meanwhile, a dynamic and uncertain competitive environment, unpredictable social factors and other random environmental changes aggravate the complexity of supply chain management, leading to high production costs [2]. For example, COVID-19 has seriously affected the manufacturing supply chain on a global scale, such as labour shortage, material shortage, delivery delays and logistics stagnation and so on. The COVID-19 pandemic however has spawned the widespread use of digital technologies to improve the ability of the economy and society to respond to the impact of the pandemic.

Digital supply chain (DSC) is an intelligent, data-driven technology network that is based on massive real-time data processing, excellent collaboration, and communication capabilities to achieve information transparency, advanced planning, demand patterns prediction as well as maximizing the availability of assets

[5]. Many studies have acknowledged the positive effects of digital technologies on the efficiency of supply chains. Chase [6] pointed out that DSC has become an inevitable choice for enterprises to improve the ability to anticipate demand and risk through the application of digital technology, which improves not only the market response speed and operational efficiency but also the service level and economic benefits of enterprises. Similarly, Preindl et al. [7] claimed that the DSC enhances the information-sharing capability, which plays a vital role in this cooperation aimed at processing large amounts of information to coordinate related operations to improve efficiency. In addition, Banerjee & Mishra [8] argued that digital technologies improve supply chain collaboration, which requires internal and external coordination and unification amongst suppliers, manufacturers, retailers and customers. However, the practice and application of the digital supply chain are complex and challenging, which requires cross-industry, cross-sector and cross-field cooperation. Although the application of digital technology in the supply chain would effectively improve its flexibility and adaptability theoretically, there are still many obstacles in the practical process. According to the data, 80% of practices related to digital transformation failed [9]. Reyes et al. [10] argued that enterprises should identify whether these technologies could achieve their strategic and operational aims rather than blindly following technology for technology's sake. Tjahjono et al. [11] believed that improvement of organizational ability assures successful applications through efficient configuration and collaboration of technical functions. However, there is little theoretical research in this field. Therefore, it is imperative to explore challenges and the key factors that affect the successful application of digital technologies as well as potential risks to better adapt to enterprises' strategic goals to achieve the desired results after weighing those digital technologies' pros and cons [2].

This study, therefore, discusses and analyses the impact of digital technologies focusing on AI and IoT on the supply chain efficiency in the manufacturing context. AI and IoT are considered to have significant potential amongst the eight most influential digital technologies. IoT currently has a high utilization rate in the manufacturing industry, and its application is becoming mature and has achieved good results in terms of information communication, and AI is the most promising technology based on the Internet of Things. This research will use the systematic literature review (SLR) method to collect existing literature to answer the two research questions. The first one is *'How do AI and IoT improve supply chain efficiency?'*, aimed at identifying the principles working on SCM performance. The second one is *'What factors influence the successful implementation of the digital supply chain?'*, aimed at exploring the challenges and obstacles of the digital supply chain. The next section briefly introduces the three theoretical bases (IoT, AI and SCM) related to the topic. Section 3 describes the details of the SLR methodology for looking for publications that explicitly study IoT, AI, and the manufacturing supply chain. Section 4 presents the analysis of research results and findings and makes a comprehensive and critical analysis of the two research questions. Finally, section 5 concludes this study by recommending some future research directions.

2 Background

2.1 Internet of Things (IoT)

Ashton [12] came up with the term Internet of Things (IoT) firstly, which refers to identify an object uniquely by connecting physical things through technology and its virtual network [13]. Three elements are required to achieve the function of IoT, and they are data acquisition technology, data transfer technology and data analysis techniques [14]. Thus, different layers of sensors, storage and data transmission with the function of recognition, processing, communication and connection are imperative to achieve connections amongst things [15]. Gnimpieba et al. [16] argued that the connections and communication between physical and virtual 'things' enable transparency and collaboration between them by clear information network. Each sensing device is uniquely addressable by IoT Internet infrastructure, which has dynamic self-configuration capabilities with standard and interoperable communication protocols, standardized communication protocols [17], because each physical and virtual object is given a unique identity, physical attributes and virtual personalities [14]. Similarly, Reaidy et al. [18] argued that IoT is an intelligent internet-based network, which enables devices to collect, process, and transfer data within an interconnected physical global infrastructure. Meanwhile, it could identify, track, and manage products by transmitting real-time information through advanced technologies. Based on collected information by devices, it can not only trace, manage and control the internal and external state of an object but also continuously observe its surroundings [19]. Furthermore, it is expected to anticipate and perceive dynamic changes in the supply chain management to facilitate supply chain management effectiveness and sustainability with its information transparency, tracking and agility [2]. In the same way, this type of control and monitor reduce risks by timely response, control and adaption of the supply chain activities in an uncertain environment [20]. Nevertheless, a large amount of information obtained may hinder supply chain management efficiency due to the amount of useless information [21]. Therefore, information management and effective control are vital for making reasonable predictions for the future and reacting to achieve sustainable development and competitive advantages. Yet, the existing researches are limited and need to be expanded.

2.2 Artificial Intelligence (AI)

Artificial intelligence (Al) can think like humans and mimic human behaviour by simulating human intelligence characteristics in machines such as learning and self-thinking and problem-solving. By absorbing large amounts of unstructured data, such as text, images or video, the ideal characteristic of AI is that it can rationalize and take actions automatically without the help of humans to have the best chance of achieving specific goals. Calatayud [22] pointed out that AI is not a monolithic technology, which depends on the cooperation of various advanced technologies with hardware and software. For example, AI is effectively coupled with the large numbers of data collected by other digital technologies, especially the Internet of Things, to predict the future trends with advanced algorithms and take measures to avoid any deviations from expected performance with minimum error [23]. On the other hand, it focuses on developing computer programs that can learn, understand, reason, plan and act on their own to make decisions automatedly in SCM through the use of simulation models and powerful analytics [24]. Meanwhile, software algorithms automate complex decision-making tasks by analysing real-time data, anticipating and identifying risks as well as automatically taking action to continuously control supply chain performance and prevent risks before they occur. Robots are an excellent product of this combination. For example, in automated warehouses, robots help supply chain material handling automation through planned algorithms to pick, stack and unload after learning. The highly mechanized environment can change the supply chain and create a faster, safer and more efficient logistics supply chain [23]. Meanwhile, they are installed with planning programmes to monitor inventory status and order progress with high accuracy. These robots are safe and agile in predicting the relationship between demand and inventory in the warehouse to achieve higher productivity and lower costs, avoiding the risk of goods disruption with faster service and higher quality [1].

AI is primarily a smarter algorithm that learns more and more by itself through mimicking human thought processes and feelings. Its applications in supply chain management are in transportation, predictive maintenance and demand forecasting facilities autonomous prediction and decision-making of supply chain [25]. AI technology has huge potential in the manufacturing supply chain. Koot et al. [2] argued that AI applications would enable automated production systems and automated logistics systems to change decisions flexibly like the selection of suppliers when they receive real-time information about supply shortages or disruptions. However, there are some sceptical voices about AI like ethical questions. Tazhiyeva [26] claimed that the question of whether intelligent systems such as robots should be given the same rights as humans is controversial. In addition, the extraction of sensitive information may violate privacy security and even break politics [27].

2.3 Supply Chain Management (SCM)

A supply chain is a functional network structure that connects suppliers, manufacturers, distributors and consumers, starting from parts production, making intermediate products and final products, and finally sending the products to users through the sales network [1]. Alternatively, a supply chain is an interface formed between supply chain members through activities so that organizations can meet the internal and external requirements. As for Supply chain management (SCM), it includes a series of activities and processes that plan, control, coordinate and optimizes the whole supply chain system, so that enterprises can integrate and cooperate to address the volatile and complex situation of the external market [11]. SCM is an integrated and coordinated management mode, which requires the members of the supply chain system to cooperate to achieve corporate goals. The practice of SCM was widely used in the manufacturing industry firstly, focusing on logistics management tasks to reduce transportation costs, and over time it extends to all aspects of the supply chain [4]. The data shows that a company spends a lot on its supply chain, accounting for nearly 25% of its operating costs [10]. Thus, effective supply chain management is critical in reducing unnecessary costs to achieve better performance. Many researchers have been working on the efficiency of SCM. Singh et al. [28] agreed that effective supply chain management can help firms to improve their competitive advantages, which promote their performance and lead their competitors. In particular, it can help achieve four goals: shorten cash flow times, reduce the risks faced by organizations, achieve earnings growth and provide predictable revenue [29].

However, it is not easy to achieve efficient supply chain management in the challenging and complex market environment in the era of economic globalization. A large amount of information appears in the market all the time, which provides rich opportunities but also foreshadows risks. For instance, enterprises are unable to timely identify the changes and collect useful information in the supply chain accurately, leading to difficulty in making the right choice and failure of decision-making. Alternatively, in a traditional supply chain is hard to carry out sufficient information sharing to eliminate the communication barriers within the member enterprises. Thus, information development of the supply chain is appearing, which is a grand solution to this problem contribute to the digital supply chain (DSC). Nowicka [30] believes that the digital supply chain can effectively improve information transparency among supply chain members, which greatly promotes information communication efficiency by reducing the time cost, shortening the flow cycle, and reducing unnecessary costs. Effective and accurate communication ensures collaboration and trust among suppliers, manufacturers, and distributors, especially in the application of inventory and logistics, which greatly reduces unnecessary costs, which are not value-added activities [10]. On the other hand, the access of information and the speed of information feedback are also important to the efficiency of SCM due to a large amount of data available in and out of the market [31]. The digital supply chain can improve the traceability, reliability and response speed of the supply chain through real-time monitoring capabilities [32]. At the same time, this ability can predict the risk of the supply chain and make decisions through the high-speed collection, analysis and processing of relevant information organizations and supply chains can realize higher levels of efficiency by responding more quickly to observed internal and external disruptions [20].

3 Methodology

3.1 Systematic Literature Review (SLR)

This study aims to analyse the impact of digital technology on supply chain management efficiency in the manufacturing industry. Practitioners have long been enthusiastic about the impact of digital technology on the efficiency of supply chain management. Thus, a Systematic Literature Review (SLR) is used in this study focusing on the IoT, AI and SCM to show an overview of current related research studies by using search strings, keywords and statistics within the specified database and give an objective assessment by conducting qualitative and quantitative reviews of the existing literature to answer the research questions.

This study identified keywords and they are AI, IoT, efficiency, challenge and SCM. According to those keywords in different categories, combining the most common grouping of keywords carefully to identify the search string to screening in a search engine is vital, which ensures proper select coverage. After filtering, four types of search strings are selected and they are “Artificial Intelligence or Internet of Things AND supply chain”, “Artificial Intelligence or Internet of Things AND supply chain AND efficiency”, “Artificial Intelligence AND Internet of Things AND supply chain AND efficiency”, “Artificial Intelligence or Internet of Things AND supply chain AND challenge”. For the source selection, this research selected Springer, Wiley, Scopus, Web of Science, ScienceDirect, and Taylor& Francis, which are trustworthy and authoritative. The following Table 1 displays the initial number of papers in each elected database.

Table 1. The initial number of papers in each elected database

Databases	Entries	Initial number
Springer	44,500	207,800
Wiley	32,600	
Scopus	21,000	
Web of Science	63,700	
ScienceDirect	21,000	
Taylor& Francis	25,000	

3.2 Selection Criteria

To accurately locate the useful literature in the rough search of the specified databases based on different combinations of search strings, this research needs to further develop selection criteria to refine the "sample poor" by evaluating and discovering the relevance degree and potential contribution of each publication to the research problem. There are three layers of inclusion and exclusion criteria. First, the initial research results should meet the following three inclusion criteria.

(1) The articles should be fully published and written in English.

(2)The articles' subject topics should be consistent with the academic area of study being considered such as Supply Chain Management, Computer Sciences, Decision Sciences, Business Management, Technology Science, and Engineering.

(3) The articles are academic document types such as Doctoral Dissertation, Books (Chapters), Academic Journal/ Articles/ Papers, Review Articles and so on.

Further selection and screening are carried out for the articles that have met the above three requirements to evaluate the usefulness of the content itself. Articles that do not conform to the following three additional exclusion criteria are screened by title, abstract, keywords, and introduction screening.

(4) Focus on specific actions or applications or challenges of AI or IoT that affect supply chain efficiency. Specifically, remove all improved performance in SCM that is unrelated to the implementation of AI or IoT technology. Two reasons are provided. Firstly, the improvement in supply chain performance reflected in the article may be the result of iterative improvements of the covered technologies themselves. Secondly, the application of digital technologies may not be independent. So, it may be necessary to judge whether the application of these comprehensive technologies is causally related to those two technologies.

(5) The initial data should be processed to show a critical analysis of the impact on the efficiency of SCM.

(6) Besides theoretical support, the factors affecting the implementation of the digital supply chain should provide clear points or specific cases.

The third level is only consistent with exclusion criteria. The following criteria are defined to improve the articles' sample accuracy.

(7) Remove all duplicated articles from different databases and choose the latest version for further reading only.

(8) Remove all case study articles that are not in the manufacturing industry.

(9) The article should be available online (either open access or through a subscription).

3.3 Sample Selection

Following the selection criteria outlined in the previous section, 59 articles were selected from seven databases for the final bibliographic study. They are grouped and classified according to the two research questions posed and divided into two broad areas. The first category is to explore the specific application of the IoT and AI in supply chain management and there are 42 papers. It includes specific implementation cases of IoT and AI in manufacturing supply chains and performance evaluation related to the first research question. The focus of the study is on digital technology with specific enterprise implementation activities and impact on results. The second category is 18 papers (because some articles cover both areas) to identify causes of failure implementation and explore the reasons. This part concentrate on the challenges of implementing digital technology with analyses different angles of causation. This study conducted simple statistics based on the different keywords involved in each article to show the specific research areas and research issues, which provides convenience for the following research.

The scrutiny of the sample illustrates that most of the articles are from engineering and management. IoT is widely used in management accounting for 39% and most of them come from supply chain logistics management A small portion is computer science, focusing on the development and integration of technologies. it shows that most of the current researches on digital technology focus on technology development and innovation rather than application and practice realization. This provides a guide for research to fill in the gaps in the application of digital technology at present.

4 Findings and Discussions

A large number of academic literature has acknowledged that the application of digital technology in SCM has made great breakthroughs in supply chain management efficiency. The network is an imperative element of competition ability and the efficiency of SCM depends on the network connections and coordinated operation, which are based on information sharing and information technology applications between each member [30]. Paul [33] reported that nearly half of surveyed supply chain leaders have significantly accelerated their investments in digital technology to make their businesses more responsive and forward-looking during the pandemic. IoT and AI are the two most promising digital technologies in the manufacturing supply chain of the future [34]. IoT now accounts for 27% and tends to grow to 73% in the next 3 to 5 years. Similarly, AI is promising to increase dramatically from 17% to 62% [35]. Thus, the following sub-sections will focus on IoT and AI's applications using the selected 59 papers in response to the two research questions raised earlier.

4.1 How do AI and IoT improve supply chain efficiency

Calatayud et al. [36] argued that the development of AI and IoT has greatly promoted the emergence of industry 4.0 and intelligent factories. Those two technologies complement each other and are closely linked. AI is equivalent to application software, which needs IoT as the foundation. IoT is like hardware that needs AI to drive it [27]. Specifically, the Internet of Things produces a large amount of data collection with perception devices. Subsequently, Artificial Intelligence provides the suitable optimum proposal for the Internet of Things by using data and analysing data with its powerful data analysis capabilities. Tjahjono et al. [11] agreed with the argument and claimed that technologies are closely related, without boundaries or priorities, so it is important to work together to promote supply chain development, especially in supply chain management. [1] pointed out that the realization of DSC needs to integrate multiple technological advantages to obtain competitive advantages. In addition to improving the efficiency of SCM and reducing organization operating costs, DSC also provides a full-fledged decision foundation for enterprises to formulate the overall industrial development strategy. Similarly, Preindl et al. [7] agreed that the digital supply chain has broken the communication barriers of previous supply chain links, and improved the information transparency and reliability of the supply chain. Furthermore, the application of digital technologies has greatly changed the process of supply chain management, which collects and analyses large amounts of real-time data intelligently and then uses that information to make decisions and implement them [37]. This transformation improves the connectivity and collaboration of all parts of the supply chain members by sharing information more accurately and in real-time, improving the efficiency of supply chain management by making accurate decisions and optimizing operations [38]. At the same time, the prediction of potential risk and simulation of the feasible adoption of risk mitigation measures ensure sustainable and stable performance improvement in an increasingly changeable supply chain management surroundings [22]. This ability to monitor and predict not only improves flexibility and agility on risk management in the supply chain efficiency but also gain sustainable competitive advantages [39].

Nevertheless, Cui et al. [40] pointed out that digital technologies are not the only key elements contributing to the improvement of the efficiency of SCM. Instead, the improvements of collaboration between the supply chain members, the ability to collect and process information and the integration of management information systems are the basic reasons due to the application of those digital technologies. Thus, technology provides only one possible way for improvement. The important thing is how to obtain key capabilities to realise these expected benefits through integrating digital technologies with the realities of enterprises. Similarly, [41] believes that the essence of the Internet of things is to provide information and integrate information.

However, what really improves operational performance is data transmission speed and data transparency level, which promote cooperation between supply chain members and optimize the supply chain information flow, logistics, capital to gain competitive advantages of enterprise's key abilities [42]. The Internet of Things effectively provides a large amount of data, but the transformation of data into information still requires judgment, data processing, and autonomous decision making. Although IoT currently allows decisions to be made by machines without human participation [43], there are still few studies on autonomous supply chain decision-making and smart factories, which combine the Internet of things with autonomous decision-making, are novel and nascent in the field. Meanwhile, [44] argued that an intelligent supply chain needs the combination of different technologies to realize informatization and automation, which is the foundation for achieving a high degree of network-physical interconnectivity. In this case, Artificial intelligence plays a vital role to realize a smart supply chain and push the flexibility and agility of the supply chain to the undiscovered limit [22]. It makes decisions and takes actions to adapt to a rapidly changing environment by analysing information in real-time and monitoring operations on a global scale with predicting the future with a minimum error rate [36]. While artificial intelligence (AI) is on the rise, it also needs to consider how other technologies are coming together in valuable new ways [35].

4.2 IoT application in SCM & the impact

IoT technologies are widely used in the manufacturing industry like radio frequency identification, wireless communication technology, laser scanning, etc. Those information and communication technologies (ICTs) could improve supply chain connectivity due to the integration and visibility of information [45]. Supply chain connectivity reflects the impact of digital connections between stakeholders on and off the supply chain, which relies on the extraction of information around all related aspects [36]. [46] claimed that IoT achieves collaboration to optimise accuracy, integration and transparency of the information with its four aspects of characteristics and there are extracting data, transferring data, storing data and processing data. [40] identified 16 factors that have impacts on the supply chain and quantified them. Consistent with other researchers, IoT has made outstanding contributions to the supply chain in information processing capacity, information transparency, management system integration, industry standards.

The application in the automotive manufacturing industry provides automobile manufacturers with opportunities to optimize. A large amount of money has been invested in the digitization of various manufacturing processes from design to vehicle production, including design, manufacturing, quality inspection, logistics and inventory management [13]. According to [47], 60% of manufacturers worldwide used data generated by connected devices to analyse processes and make decisions in 2017. General Motors is a good example. In terms of manufacturing, it uses sensor data to determine the humidity of a car's paint environment. The sensor first detects humidity data by sensing the external environment and then transmits the detected data to an algorithmic device that has been set up in advance to determine if it is within the reasonable range. If the system decides the environment is inappropriate, it sends the car to another area in the manufacturing process, thereby minimizing repainting and maximizing plant uptime. This innovation alone saved GM millions of dollars per year [48].

In terms of logistics, [11] pointed out that information transparency and connectivity effectively enable timely and accurate information sharing, which eliminates communication and technical barriers across departments and areas by enhancing the transparency of the operation between suppliers, manufacturers and customers. There are many examples of this in logistics and inventory management. The cost of inventory management accounts for a large proportion of the cost of automobile manufacturers, which directly influences organizations' normal operations [41]. The poor communication among various departments of the enterprise will lead to the waste of resource deployment and other phenomena caused by the lack of real-time coordination and control of resources of all members in the supply chain of the automobile manufacturing enterprise, which will affect the benefits. IoT improves the inventory management level of automobile manufacturing enterprises from two perspectives. Firstly, establishing the inventory circulation network based on the Internet of Things technology facilitates the circulation of idle inventory among enterprises. The other one is to use IoT to monitor the whole process of materials in automobile manufacturing enterprises to improve the inventory management level. For example, providing available real-time data in SC by monitoring the movement of materials, equipment, and products through the supply chain efficiently allocates resources between inventories [16]. In addition, with Enterprise Resource Planning (ERP), Product Lifecycle Management (PLM) and other systems that effectively collect and deliver information to connect factories and suppliers,

All empowered departments in the SC can track inventory, product flow, and product cycles times. That information will help manufacturers reduce inventories and capital requirements by anticipating problems. According to data, smart factory penetration is expected to grow by 35% by 2025 through investments in real-time analytics and dynamic supply chain tracking [11].

On the other hand, IoT is used in the production process to upgrade manufacturing processes through monitoring and tracking. It will not only reduce unnecessary waste, contributing to the sustainable development of the factory but also improve the profit space in the long term. Moreover, information is important to improving supply chain operations [34]. A two-way flow of information not only improves the supply chain collaboration but also achieve the operational excellence of sustainable supply chain management by rapid feedback, interruption reduction, process optimization [40]. For instance, in terms of quality testing and monitoring, the automotive aftermarket has always been a core part of the automotive industry, covering all the services consumers need after buying a car [49]. The physical nature of a vehicle means that it is subject to unpredictable wear and tear and the hardware facilities face functional degradation, inflexibility and other potential problems. By implementing IoT components, vehicle status can be continuously monitored, enabling anticipation of potential damage or failure and then preventive measures. In addition, it can trace back to the production assembly process for optimization through manufacturing data on systems and components [50].

4.3 AI application in SCM & the impact

Michel [51] pointed out that with the rise of globalization and the continuous development of science and technology, supply chain management has gradually become a priority for all enterprises. Meanwhile, as sensor costs fall and the Internet of things advances, Al is expected to be one of the most promising technologies in the future of supply chain management due to the increasing access of data throughout the supply chain and improvement in computing technology [52]. A large amount of data is accumulated and deposited in the cloud. Thus, how to make use of big data and give full play to the value of data to predict market demand, assist the decision-making, optimize the operation process, and predict the risk points of each link in SCM are the new challenges. Some pieces of literature have acknowledged the fact that Artificial Intelligence has helped addressed those problems, which results in the in-depth, predictive, and credible understanding of business partners and even competitors in a complex and sprawling supply chain. Moreover, [52] argued that AI facilitates the sustainability of supply chain management in pursuit of improving quality, reducing cost and increasing efficiency. Hassija [27] supported those arguments by quantifying the benefits of AI for organizational in ten aspects of supply chain management.

So far, a lot of AI technology has been applied to supply chain management [53] including Artificial Neural Networks (ANN), Artificial Immune Systems (AIS), Virtual Reality (VR), Genetic Algorithms (GA) and so forth [54]. In supply chain management, these applications are significant for supply chain activities in terms of demand prediction, marketing decision support systems, pricing, product manufacturing and supplier selection. The most common and influential is ANNs, which is a data analysis technique mainly relying on a large amount of experimental data [29]. Li [55] believes that artificial neural networks are becoming more and more important in a changeable competitive environment because they can solve data-intensive problems in the era of big data to discover knowledge, rules or models [56]. Compared with human beings, AI is the computational intelligence related to the input and output streams of processing units, which can effectively solve the problems with complex and difficult algorithms that human beings are incomparable [57].

Amirkolaii et al. [58] claimed that AI effectively helps managers to make predictions and adjust the plan in SCM, which avoids the waste of resources and business risks like the "Bullwhip Effect". Specifically, when the information is transferred from the upstream and downstream of the supply chain without information-sharing in real-time, the information will be gradually distorted and amplified, which results in the increasing fluctuation of demand and supply information and the formation of false bubble space. However, AI can help companies accurately determine supply and demand relationships ahead of time and develop dynamic operational strategies by using historical data analysis, real-time data analysis, prediction model programming and other analysis measures [59]. At the same time, AI makes the optimal distribution of limited resources in the supply chain to achieve the maximum benefit and formulates mitigation strategies for changes [60]. In addition, Smart supply chains harness the power of AI and other emerging technologies to help companies make predictions and risk analyses to maintain business continuity in chaotic and volatile situations. This efficient supply chain control tower system based on artificial intelligence can respond quickly, smooth through or even completely avoid risk with minimal loss or minimize disruption damage when a disaster occurs [61]. Similarly, AI can also be used in daily operations through real-time Omni-directional monitor risks to promote the agility of SCM to respond quickly and mitigate risks by predicting supply chain disruptions risks and recommending solutions. For example, more than 30 counties in Thailand were hit by the worst flooding in 40 years overnight in August 2017. IBM's Singapore factory's supply chain division was immediately clear that the floods would have a huge impact on Thailand's hard drive makers from the purchase orders being executed and pending approval. Based on the potential risks in short supply, the Singapore factory quickly select the Singapore hard disk from the repository suppliers to place orders, lock and prepare goods and coordinate and deploy available transportation ensuring dedicated hard disk supply is in place and the production line is not interrupted [62].

However, correct forecasting is a complex process that depends on many internal and external aspects, such as an accurate database, highly integrated algorithms, market stability and so on [27]. And the wrong prediction will be a significant financial loss to the organization [63]. For example, Nike introduced a demand prediction programme but failed to implement it in 2001, which leads to insufficient inventory in Air Jordans and an excess of less popular types. This failure experience took an unimaginable financial hit to Nike, costing it around $100 million in lost sales [64]. In the process of production and transportation, AI improves the effectiveness and accuracy of logistics decisions by tracking the flow patterns of goods and services, simplifying activities to achieve efficient and transparent partnerships [25]. For example, in terms of inventory siting, planning and cost minimization, and supplier selection issues, Artificial intelligence can eliminate human conditions and personal feelings to build models by analysing historical stock data. The warehouse is the foundation of the development of modern logistics and warehousing location determines the efficiency of logistics. According to simulations and the filter criteria, Artificial intelligence systems forecast future data to select the most appropriate choices and make a decision [65]. In addition, the stand or fall of transport line planning can directly affect the operation of the modern material filling system of the whole with the introduction of AI, which greatly improves the efficiency of delivery batch business and expresses sorting business. There are many application scenarios of AI in the field of logistics, such as packaging material box algorithm recommendation, cargo space planning, vehicle and cargo matching, AGV scheduling, automatic intelligent storage and so on. Klumpp [25] believed that AI and algorithms occupy an increasingly crucial status in logistics. For example, intelligent logistics technology represented by digital and intelligent heavily rely on the core elements of intelligent storage including unmanned distribution, AGV (Automated guided Vehicle) and logistics robots [66].

Furthermore, AI can assist with cruise control, lane-keeping and collision avoidance to achieve high safety of unmanned driving to the destination of goods. It also offers machine learning, sensor fusion, computer vision technology, motion planning and control to autonomously select and improve road safety [48].On the other hand, AI effectively liberates part of human activity. Specifically, AI can maintain efficient operation for a long time for some simple programmed tasks [29]. For difficult and complex tasks, AI can objectively and intelligently perform fast calculations. Take Audi' parts logistics as an example, which is the key to ensure the efficient production of the whole factory. The Tungsten Network [67] reported that they waste an average of one hundred and twenty-five hours per week on trivial businesses like repeat and simple routines, dealing with supplier inquiries, accounting audits and so on. There are about 6,500 hours a year wasted on ineffectual work. Thus, some organizations have begun to adopt advanced AI applications like robots to complete repetitive activities automatically. Those AI applications also reinforce each other to optimise the real-time strategies and automatically adjust them according to the surroundings, which enables robots smarter and faster. Audi's intelligent factory is a typical example. The logistics and transportation of parts are all completed by the unmanned driving system. The forklift truck that transfers material also realizes automatic driving, realize true automatic factory [24]. Not only will unmanned vehicles be involved in material transportation, but drones will also play an important role [4]. In Audi's smart factory, miniaturized and lightweight robots replace manual labour to install and fix trivial parts. Flexible assembly cars will replace manual screw tightening. Many mechanical arms are arranged in the assembly trolley. These mechanical arms can be identified and screwed according to the established procedures. The assembly assistance system can inform workers where to assemble and can check the final assembly result. In some wiring harness assembly work also need manual participation. The assembly auxiliary system can prompt workers which positions need a manual assembly, and display whether the final assembly is qualified on the display screen to prevent defective products [68]. The flexible grasping robot invented by Audi Intelligent Factory is different from the current grasping robot. The biggest feature of this robot is the flexible tentacles, which are similar to the tongue of a chameleon and have more flexible grasping parts. In addition to grabbing ordinary parts, the flexible grasping robot can also grab nuts, gaskets and other fine parts.

4.4 Factors influencing the successful implementation of the digital supply chain

A digital supply chain is expected to strengthen competitive advantages through improved product quality, lower operational costs, faster market response and higher collaboration between supply chain members [69]. However, the introduction of digital technologies recently is exposed to various difficulties and obstacles that arise from internal and external factors such as increasing internationalization and interconnection of companies, uncertain demand changes and faster production cycles time [36]. Definitely, digital technologies can greatly improve supply chain management efficiency by avoiding the problems of errors, losses, and costs associated with manual management to achieve better business performance. According to [70], organizations with a digital supply chain and highly digital operations are expected to improve efficiency by 4.1% per year and increase revenue by 2.9% per year. Based on these obvious motivations, manufacturing supply chains are investing more in digital technologies and obtain great results. Around three-quarters of manufacturing, enterprises tend to speed up their digitalization process and will achieve comprehensive and basic digital advances by 2020 around the world [71]. Taking China as a specific example, The Ministry of Industry and Information Technology proposed that digitized manufacturing enterprises above the scale will be popular, and intelligent transformation will be preliminarily realized in key industries by 2025 (more than 2,000 smart scenarios for the application of new technologies, more than 1,000 smart workshops, and more than 100 benchmark smart factories leading the development of the industry). By 2035, digitisation will be universal in all manufacturing sectors above scale [72]. In terms of performance returns, the results are remarkable. The income of the intelligent manufacturing business gradually increased from 73.467 million yuan in 2017, 147.12 million yuan in 2018, and 264.348 million yuan in 2018 to 413.252 million yuan in 2020. Smart manufacturing in 2020 operating revenue growth of 56% and revenue rose to 29.83% from 24.58% a year earlier [73].

However, in practical application, many enterprises, which spend high cost and are equipped with the most advanced automation technology such as Manufacturing Execution System (MES), Web Mapping Service (WMS), Transport Monitor System (TMS) and other information systems are still not satisfied with the output results in SCM. Furthermore, there are obviously greater difficulties and obstacles to further digitization and intelligent process. Although many enterprises have realized the importance of DSC, only 5% were satisfied with their digital transformation approaches. Thus, it is important to explore how smart supply chains can be successfully applied and what reasons influence their implementation [35]. Ageron et al. [74] believed that technological, organisational and strategic challenges remain to overcome to achieve the success of the DSC implementation. Agrawal et al. [75] identified 12 barriers to the implementation of DSC including the fear of loss of confidential information, lack of budget, lack of digital skills and talents, lack of strategic guidance and so on. From a quantitative perspective, [27] analysed and presented different 13 possible obstacles. The next section explores some of the potential obstacles.

4.4.1 Lack of budget and management support

The lack of sufficient financial support will greatly hinder the digitalization process of DSC such as the improvement of infrastructure, the cultivation of corresponding talents, the integration of introduced digital technologies and so on. According to the data, the information technology (IT) system is critical to DSC, so improving infrastructure is an effective way to promote the digital supply chain. However, since enterprise on large-scale information technology and equipment needs a large number of investments to support, improvement of the infrastructure is a huge barrier to the implementation of the digital supply network [76]. In addition, new digital technologies and resources need to be constantly updated and integrated to drive connectivity of various technologies with appropriate organizational structure [26], which requires financial support setting the threshold for the productization of digital technologies. Those changes also face huge risks such as structure, culture, capabilities, policies and so forth. Specifically, DSC requires organizational structure transformation to provide effective means of communication between organizational members and between the organization and its environment through creating and sharing knowledge. With greater data transparency and synchronization, machines are empowered to make operational decisions to allocate resources for optimal utilization as well as capturing the highest utilization value of investment [77]. Although those activities are designed to improve the efficiency and accuracy of information communication, they may cause disruptions due to the need to redesign the supply chain operation process [1]. In addition, they do not directly present the most direct revenue return, because their return on investment is difficult to calculate [68]. So, they are often underfunded by trade-offs between implementation and running costs and their Return on Investment.

Another important barrier is the lack of relative talents. [74] argued that the talent gap is huge and the scarcity of talent and human consumption may lead to the failure of digital transformation. Large sums of money have been paid to find potential talents since digital transformation requires the training of new talents related to digital technology including data analytics, cloud computing, data security, mobile technology and so forth. Similarly, [75] claimed that new talents such as advanced engineers, data scientists and software programmers in information and communication technology need to be trained in the latest programming languages. At the same time, it is vital to attract experienced software developers, product managers and other technical specialists from Apple, Google, or Facebook to ensure the speed and quality of reform. In addition, behavioural competencies related to personality traits such as business process management, responsibility, social acceptability, innovation, and negotiation are also important, which adapt to the characteristics of the digital supply chain such as agility and flexibility. All of those activities require sustainable purchasing ability and are fundamental to the success of the digital supply chain.

4.4.2 Lack of guidelines, strategic orientation and knowledge

Although many enterprises are equipped perfect in terms of infrastructure (MES, WMS, TMS, OMS information systems), there are greater difficulties and obstacles to further digitization and intelligent process in DSC due to the lack of industry-specific guidelines, strategic orientation and relevant knowledge. [75] pointed out that there's not just one way to digitize a supply chain and companies at different stages have different digital goals. specifically, each enterprise should be based on their specific needs, according to the existing infrastructure and talent reserves, corporate culture and technical requirements for formulation and implementation of the corresponding digital supply network planning [9]. From selected researches, we found that there are many studies on how digital supply chains achieve specific advantages (collaboration, information transparency and so on) from a broad perspective. However, few papers have explicitly focused on the specific activities and implementation steps of the digital supply chain in the industry through case studies [75]. Therefore, the lack of specific route guidance has influenced the successful implementation of DSC. Many organizations recognized the purpose and significance of digital supply chain transformation, but do not have a specific map explaining the approach and sequence in terms of ways of cooperation, internal and external operations and so on. Organizations must thoroughly consider existing procedures and processes to identify areas of improvement to address digital transformation, then define their digital strategy and develop appropriate actions [78]. In this case, the digital strategic plan provides a clear roadmap for DSC adoption and helps managers identify the stages and locations of DSC deployment in the supply chain to avoid inconsistent, fragmented and ineffective activities. organisations could make the cost of input to get the greatest economic benefit [79].

In addition, the lack of professional knowledge and digital vision among leaders and employees about digital means is part of the reason for the slow adoption of the digital supply chain [76]. DSC is a way of managing core operations in the supply chain rather than owning digital products and services. In other words, the decision point that determines the efficiency of SCM is not the application of digital technology, but the matching degree of operation mode and information technology [5]. Several well-known research institutions, such as Accenture, IDC, Deloitte, etc., pointed out that the transformation of business model is the foundation of the success of digital enterprises. A successful digital transformation should leverage emerging technologies to increase stickiness and strengthen connectivity as well as creating an integration platform for digital and non-digital technologies. Therefore, technology is not the end, but the capabilities of real-time visibility, continuous collaboration, organizational flexibility, enhanced responsiveness and prevention. For example, most manufacturing enterprises tend to choose to invest in advanced technology, which is the most popular but may not be the most appropriate choice [80]. When they embrace shiny new technologies such as Robots, machine learning tools, etc., these technologies act as separate parts rather than putting them together to deliver value, which puts companies in an integration dilemma [81]. These technologies become fragmented and fail to build the enterprise into a cohesive platform to obtain the advantages of DSC. Furthermore, a deficient view on the integration of digital technologies may even damage their adaptive strategies [76].

4.4.3 Social human rights and environment

The MIT Sloan Management Review [75] conducted a survey aimed at answering the question of why most companies are failing to reap business benefits from digitization. They found that people play a key role in digital transformation. On the one hand, some business leaders like to be in their comfort zone and resist change, in which case change can be challenging. Hudnurkar [82] claimed that it's hard for people to change because they develop vision and power with familiar things. In fact, 43% of 4,500 CIOs in the Harvard Nash/KPMG CIO survey identified resistance to change as the biggest obstacle to a successful digital strategy.

On the other hand, people are unwilling to share information due to safety, security privacy, interests and other restrictions. Digital supply chains rely on information transparency and cross-departmental collaboration. To achieve the smooth operation of the supply chain, a data-sharing system is needed. However, for some sensitive data, such as inventory, life cycle, etc., it damages the privacy of the supply chain and even makes it vulnerable to malicious attacks. Therefore, network security risks become one of the obstacles to the promotion of the digital supply chain [83]. Due to business interests or narrow thinking, departments and companies are not willing to share information, which artificially brings "department wall" and "enterprise gap". For example, to leave room for cost reduction, purchasing fails to share the true cost with finance and sales, sales exaggerate the forecast, and purchasing overstates the demand for suppliers, etc. In this case, when they passing information adding their understanding and selfishness, the information will be distorted and the digital supply chain would be out of shape. All of these have brought obstacles to digitization. Thus, it is imperative to establish a holistic view, more synergy thinking to promote the flow of information.

Munirathinam [84] claims that more than 25% of cyber-attacks come from IoT devices. Although AI has greatly increased the capability of processing data and increased the reliability of decision making, the available way of collecting data can be a security risk. In addition to ensuring the quantity and quality of data, Ethics and a sound sense of responsibility are important for digital development. For example, some applications and devices have been empowered to make decisions automatically through algorithm settings, model parameters, data permissions, etc., which have become “black boxes” [27]. In this case, transparency and accountability are very low. Security loopholes are existing and connections between devices are still immature, which will give many criminals many opportunities to commit crimes. Therefore, there is still a lack of relevant laws and regulations to ensure security issues and increase trust.

In summary, there are three levels of obstacles to the implementation of the digital supply chain. Financial support is the key factor from the first beginning to the whole process, which is the premise and basic guarantee to ensure continuous follow-up. The lack of clear guidance and management knowledge is the root cause why the implementation effect is not achieved in the process of transformation. The lack of acceptance from human beings and the imperfection of legal protection aftermath would hinder the sustainable development of DSC.

5 Conclusions

Many papers have discussed DSC technology from the perspective of the application. They demonstrate the positive impact of those digital technologies to successfully achieve digital and intelligent supply chains on firm performance by improving the efficiency of SCM. However, few studies have explored the causes and mechanisms that promote this effect. This study found that information transparency, accuracy information and decision-making, and collaboration amongst supply chain members directly affect the efficiency of SCM. The realization of these functions depends on the innovative advantages brought by digital technology. The study shows that digital technology is key to the improvement of management efficiency through bringing about the change of supply chain mode, functional advantages, ability improvement and so on. This research selected two key technologies (IoT & AI) to discuss their specific contributions to supply chain management efficiency in the manufacturing industry. The results show that both IoT and AI are the closest technologies related to the autonomy and predictive power of future supply chain expectations. IoT promotes supply chain collaborative management by improving real-time information transparency, information systems integration, and big data processing capabilities. In addition, the ability to track, predict and independent decisions provide suggestions and guidance for enterprises to make decisions. Al accompanied with its analysis, learning capabilities enhance the accuracy of autonomous prediction, classification, decision-making and risk aversion. It enables IoT to generate index values, while IoT will provide AI with an information base and a basis for autonomous decision-making, among other things. The convergence of the two technologies optimizes all aspects of manufacturing and opens up more possibilities for smart factories.

This research also explored DSC challenges and problems that take into consideration to expand the approaches to DSC success factors derived from existing literature. One is the capital barrier, which includes the improvement of infrastructure, the introduction of new technology and the training of talents. These are important foundations of the digital supply chain and require substantial ongoing financial support. The second is the management implementation barriers such as the lack of knowledge of relevant personnel, no clear guidelines, no strategic plan and so on. These are the most common difficulties in the process of digital transition as well as key reasons why companies have invested so much money while it doesn't work. In this case, organizations recognize the necessity of change, but lack specific implementation methods and steps, resulting in the waste of a large number of financial, material and human resources in worthless activities. In addition, they may be eager to achieve financial returns without objectively combining their circumstances and strategic planning. The last one is personal barriers including fear of changing from the comfort zone, inadaptability to changes in working style and reluctance to divulge privacy due to security concerns. Privacy security remains a huge challenge due to technological uncertainty, lack of trust, unwillingness to give up power.

However, our study has certain limitations. In terms of the type of research itself, a systematic literature review is a research method that provides an overview and critical discussion of previous studies and may not cover the details of every research question. Therefore, such analysis from a relatively macro perspective lacks in-depth survey and research. Although it identified the importance of digital technology efforts to improve performance and how they improve supply chain capabilities, there is no specific quantitative analysis to delve into the impact of digital technology on management efficiency into quantitative relationships. All discussions are based on secondary data from cited samples, without collection and analysis of primary data. This study noted the importance of having clear guidelines and roadmaps for the supply chain during the implementation phase. But these need to be developed in the context of a large number of specific enterprises to guide DSC adoption. By understanding the strategic purpose, the different stages and locations of DSC implementation to deploy and develop a clear roadmap. The study also does not examine the status quo of the current supply chain to identify the gaps of practices as well as predicting potential risks.

Based on these research limitations, the following suggestions are proposed for future study. Firstly, design and calibrate specific digital supply chain transformation strategies and routes according to different environments, different industries and different enterprises' specific digital stages; In addition to researching the creation and development of models, frameworks, methods, solutions, etc., attention should also be paid to researching and testing their usability, application or generalization, and possible risks as well as corresponding solutions and optimizations. Secondly, any progress could not be achieved by a single technology, but by their cooperation to improve the level of information system integration. Alternatively, it is the unavailability of a single technology. Thus, a quantitative evaluation framework is needed, which enables us to monitor, control and reflect the performance of digital supply chain implementation in the different applications by combining technologies together in valuable new ways. Thirdly, Strengthen the research on how to solve the supply chain information security. At present, the integration of many technologies has been developed to a certain extent, such as the contribution of blockchain technology to information security compared with AI & IoT [28]. Fourthly, it is necessary to anticipate future developments. For example, the transparency of information between supply chain partners is not only for commercial interests but also provides supervision for the social responsibility of enterprises, which reflects the social responsibility of enterprises. This transparency encourages supply chain partners to develop and share best practices for green operations and logistics. Supply chain partners can demonstrate compliance with industry best standards for worker safety, environmental protection and business ethics [85]. In addition, anticipate potential risks and threats in advance is imperative. Those issues, for example, how to strengthen the improvement of policies and relevant laws in the context of gradually transparent information to prevent criminals from speculating in crimes and how to guarantee people's basic employment, technical authorization and other sensitive issues regarding human rights are expected to be noticed.

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