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# Latest Advancement of Technologies in Supply Chain Management: An Overview

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ABSTRACT

*Supply chain management (SCM) involves an interconnected structure of facilities that produces elements or compounds for transforming into a semifinished compound. After completion, the final compound is delivered to customers via a distribution system. Owing to ever-changing customer demands, increasingly efficient and resilient SCM is necessary, which requires support from the latest technologies. Therefore, this paper presents an overview of the latest technologies in SCM and logistics. The management of a supply chain and role of the different actors involved differ from industry to industry and company to company. Consequently, SCM has become a crucial issue to manufacturers, professionals and researchers. The latest technologies identified in this paper include radio frequency identification, vehicular ad hoc networks, the Internet of things, robotics and artificial intelligence and blockchain. Moreover, the application of the aforementioned technologies in different industries and systems is discussed to understand how the technologies impact practitioners. Although not discussed thoroughly, other recent technology trends in SCM and logistics, such as machine learning, autonomous vehicles/drones, advanced analytics, cloud logistics, supergrid logistics, anticipatory logistics, omnichannel logistics and additive manufacturing (3D printing), are also highlighted in this paper. By understanding the advancements in SCM technology, the possible direction of future innovations can be effectively planned and articulated.*

*Keywords: Supply Chain Management (SCM); Radio Frequency Identification (RFID); Vehicular ad hoc networks (VANET); Internet of Things (IoT); Robotic and Artificial Intelligent (AI); Blockchain.*

## INTRODUCTION

In the 1980s, owners of manufacturing factories controlled their production (Pounder et al. 2013) and had all the information on manufacturing limits, timetables and expenses. Presently, firms operating in the global environment encounter considerable vulnerabilities, making it difficult to comply with time constraints (Pounder et al. 2013). In the past decade, analysts focused on supply chain management (SCM) issues, including reducing costs and/or the response time of the different parties within the manufacturing supply chain (Habib 2011). According to Mohd Sudin et al. (2020), supply chain risks derive from a variety of events, such as supply shortages, making disruptions inevitable.

The definition of SCM was examined over the past 10 years (Habib 2011). Some authors characterised SCM in operational terms, including as a stream of materials and products and an administrative reasoning and in terms of the management process. Scholars reached a consensus that SCM incorporates coordination and integration, participation among supply chain actors and the movement of materials to the final customers. However, how SCM should be defined remains unanswered (Mentzer et al. 2001). According to Michael and McCathie (2005), SCM is the management and control of all the materials and information in the logistics process, from the acquisition of raw materials to the delivery of the final product to end users.

Although the concept of SCM has existed since the early 1980s, the meaning of the concept, especially its

execution, remains a perplexity (Barratt 2016). SCM has become a foremost and well-known concept in administration since its introduction in the early 1980s (Xia & Li-Ping Tang 2011). Firms in a supply chain facilitate and share benefits through market instruments, contracts and partnership arrangements, which lead to the improved proficiency of all the collaborators (Xia & Li-Ping Tang 2011).

Supply chains are successful networks of firms performing activities in a particular product/service value chain. For instance, SCM in the auto industry is one of the major factors determining the survival or success of the industry. In Malaysia, the textile industry and its SCM is one of the fastest developing businesses, with important contributions to the country's economic growth (Pang & Abdullah 2013). In addition, airport industries are among the numerous supply chains involved in the positive effects of blockchain technology (BCT). This paper highlights the importance of the application of the latest technologies in SCM as a successful strategy for achieving customer satisfaction.

## LATEST TECHNOLOGIES RELATED TO SCM

Owing to ever-changing customer demands, SCM must be supported by the latest technologies to ensure optimisation and the highest efficiency in all activities. Considerable pressure derives from customers in the form of individuals and enterprises demanding faster- and cheaper-than-ever products and/or services. Technology innovations facilitate the fast information sharing, accurate data analysis and high capacity of processes within a short period of time. For example, advancements in information technology (IT) in data sharing and communication are used to achieve synchronisation and coordination among SCM participants. Radio frequency identification (RFID) technology is based on information communication and was recently utilised in innovations and technologies in Hong Kong (Ali & Haseeb 2019). The RFID technology heralded a new era in SCM, which would be unachievable with existing barcode technology (Michael & McCathie 2005). Top corporations around the world recognised the advantages of RFID and recently moved to introduce the technology in SCM by establishing a mandate, leaving suppliers no choice but to also use RFID. The importance of advancements is discussed by Tigga et al. (2021), who explored the impact of IT capabilities (IT advancements and IT assimilation) on supply chain capabilities (flexibility, information exchange and coordination) and supply chain performance.

As intelligent transportation systems (ITSs) are aimed to provide safe and hassle-free journeys to commuters, vehicular ad hoc networks (VANETs) provide a distinct approach in which every vehicle is capable of communicating with other vehicles as well as fixed roadside units (Sun et al. 2007). VANETs are wireless communication networks that offer a new networking paradigm to establish cooperative driving applications (Pourghebleh & Jafari Navimipour 2019). Through short-range communication, VANETs allow the exchange of essential information on road conditions among vehicles (Oche et al. 2014). VANETs were introduced as a promising ITS technology to establish traffic safety and efficiency and provide Internet access whilst moving (Gozalvez et al. 2012).

For effective SCM, IT plays a crucial role. Specifically, IT can integrate different processes, suppliers and customers internally and externally by enhancing the communication, collection and transfer of data and information and improving supply chain performance. According to Hermawan et al. (2019), technological advancements and shopping behaviour are among the factors encouraging Small and Medium Enterprises (SME) retailers to adopt a technology information system. The authors investigated the priority (preference for) of criteria and alternatives using the analytic network process approach for small and medium-sized retailers in Jakarta.

One of the most important IT developments is the Internet of things (IoT), which is defined as a set of physical and virtual objects connected via a network to communicate and sense or interact with internal and external environments (Abdel-Basset et al. 2018). In the domain of SCM, the IoT can be defined as a set of physical objects connected digitally to facilitate sensing, monitoring and interaction within a firm and between a firm and its supply chain, cementing the agility, visibility, tracking and sharing of information to plan, control and coordinate supply chain processes.

This innovative field demands modern solutions; thus, some organisations are mobilising their systems according to their clients' need for speedy reactions and responses. As a solution, industries are introducing artificial intelligence (AI) to implement a supply chain agility system and robotic machinery and systems to enhance organisational performance (Panichayakorn & Jermsittiparsert 2019). Firms are also installing robotic systems to decrease organisational costs, as robots can better perform tasks originally assigned to human workers, thereby saving money and time (Fletcher 2018).

Introduced to the public through the cryptocurrency Bitcoin, BCT is an emerging computerised innovation that can be depicted as a decentralised public ledger in which exchanges are stored in a chain of blocks (Zheng et al. 2018). BCT can significantly transform numerous activities and operations in the supply chain that require increased

attention from scholars and practitioners (Kshetri 2018). For example, BCT enables the real-time improvement and tracking of merchandise and travellers from the beginning to the overall SCM process. Within a supply chain, the blockchain innovation empowers all the onscreen characters to know who is performing what activities by characterising and evidencing the time and location of all activities (Di Vaio & Varriale 2020). To examine the application of BCT in SCM, Blossey et al. (2019) discussed 53 applications of BCT in SCM derived from a systematic literature review and a secondary dataset of blockchain-driven SCM innovations. The immature state of blockchain practices and research provides opportunities to OSCM researchers to examine the technology in its early stages and shape its adoption (Cole, Stevenson & Aitken 2019).

## ADVANTAGES OF THE LATEST TECHNOLOGIES

RFID scanners can communicate with labels in milliseconds and check numerous elements simultaneously, thereby significantly helping the mechanisation of many labour-intensive SCM tasks, such as scanning and checking incoming inventory (Michael & McCathie 2005). Labour constitutes approximately 50% to 80% of total distribution costs, but RFID can help reduce this amount by automating the supply chain at an unprecedented level. Moreover, RFID allows items in the supply chain to be managed in real time, providing accurate and point-by-point data on all the items and enabling organisations to utilise the data to increase their efficiency. Equally important, RFID technology can track the movement, use and placement of assets, thereby improving asset utilisation (Michael & McCathie 2005).

VANETs are self-organised networks created by interfacing vehicles with drivers and programmers with Internet access to improve driving administration (Shringar Raw et al. 2013). Some VANET applications related to safety are collision avoidance, cooperative driving and traffic optimisation. VANETs are expected to collect traffic data from the road, update the data in the system and attempt to choose the most optimal path given the current traffic situation to create a navigational route, similar to Google Maps (Lee & Atkison 2020). Moreover, VANET systems should be able to track stolen vehicles to enable law enforcement officers to easily determine their current location (Toh 2007).

The IoT allows media communications anytime, anywhere with anything. Hence, when supply chain companies integrate smart IoT devices into their system, they will be able to reduce costs. A smart SCM system will have the following characteristics (Abdel-Basset et al. 2018):

i. Information in the supply chain is machine generated.
ii. SCM and process are interconnected using IT systems and smart objects.
iii. Performance is optimised via large-scale optimal decisions.
iv. Processes are automated to replace low-efficiency resources.
v. Supply chain stages collaborate among themselves.
vi. New values evolve via solutions to meet new requirements.

Robotics, automation and AI are being strategically implemented in the hospitality industry as an essential part of corporate functions to solve multiple daily management tasks (Das et al. 2018). Such tasks influence the efficiency of environmental performance, as environmental performance changes consistently as technology advances continuously. According to Perez et al. (2018), AI and robotic awareness increases with development owing to advanced AI lodging systems, which increase productivity and reduce costs, as human labour is replaced by robotic machinery. By contrast, robotic awareness and AI presence will highly affect employees' current workplace, relationship with coworkers and working hours (Vermesan et al. 2017).

Some of the key characteristics of BCT categorised as its main benefits include decentralisation, persistence, anonymity and audibility (Di Vaio & Varriale 2020). BCT allows users to keep a digital record, which cannot be viewed as merely 'a record', as it considers other characteristics, such as smart contracts, to respond to and prevent technological disruptions, such as fraud (Buterin 2014). With BCT, transactions can occur in a decentralised fashion, thereby considerably reducing costs and improving efficiency (Zheng et al. 2018).

## APPLICATION OF THE LATEST TECHNOLOGIES IN SCM

One example of the use of robotics in industries is robotic process automation (RPA), which allows organisations to automate tasks originally performed by human workers across applications and systems, as robots can interact with existing IT architectures with no complex system integration required (Jain 2019). RPA can be utilised to computerise workflow, infrastructure and labour-intensive back-office processes. Programme bots can connect with in-house applications, websites, user portals and so on. RPA involves a software programme that runs on an end user's PC, laptop or smartphone, and commands are in sequence, executed by bots under a defined set of business rules. The main objective of robotic process computerisation

is to replace human workers performing monotonous and boring clerical tasks with a virtual labour pool. Furthermore, RPA does not require the evolution of a code or direct access to a database or application codes (Jain 2019).

BCT and the IoT can be combined to create smart healthcare apps and services for the real-time observation and actuation of patients' healthcare needs and data analytics via a cloud to improve healthcare quality and patient experience whilst reducing healthcare service costs (Karthikeyyan et al. 2019). BCT is a model platform for confirming product authentication and transparency throughout the entire supply chain phase and can support the tracing and moving of a product in a real-time environment via a digital ledger (Karthikeyyan et al. 2019). The characteristics of blockchains make them especially suited for applications emphasising traceability. When goods and related documentation (e.g. bills of lading or ship notifications) pass from one individual in the supply chain to another, components are subject to counterfeiting or embezzlement. For protection against such activities, BCT associates digital 'tokens' with physical items when they are created. The last recipient of a component can then authenticate the token, which can trace the history of the item to its point of origin. End users have confidence in the information they receive, as no one entity or group of entities can arbitrarily change the information contained within the blockchain (Francisco & Swanson 2018). Kouhizadeh and Sarkis (2020) explored blockchain characteristics and green supply chain advancements and discovered that BCT incorporates four major characteristics, namely, transparency, reliability, smart execution and tokenisation. Meanwhile, the rapid development of the IoT can help the concerned authorities focus on ensuring the safety and welfare of consumers in the food industry (Nirenjena et al. 2018).

One case study involved automated robots in the business practices of the e-commerce giant Amazon Inc. In 2012, Amazon acquired Kiva Systems for the sole purpose of increasing its packing and picking procedure to save lead time. Although the e-commerce titan invested a bomb to bring in the automated robot manufacturer, the purchase seemed appealing. After less than two years, Amazon began using automated robots in several fulfilment centres (Jain 2019). The robots increased the productivity of Amazon's warehouses on an enormous scale. In an Amazon fulfilment warehouse, the Kiva robots help in transporting goods on shelves from one inventory store to another, where the ordered items are hand-picked, and automatically returning units left on shelves to the inventory store (Guizzo 2008).

In 2003, RFID technology gained popularity in supply chain operation (Delen et al. 2007). Large suppliers, such as Procter & Gamble, Gillette and Kraft, collaborated with Walmart and completely actualised RFID technology in the retail supply chain (Ali & Haseeb 2019). RFID is essential in retailer distribution centre management to facilitate short transit time and satisfactory staff service quality. Other benefits of RFID technology include increasing the productivity of operations in a distribution centre and reducing operational expenses and enhancing the accuracy of item traceability. Therefore, RFID is one of the systems based on information communication technology that can enhance delivery system and staff service quality to improve supply chain operation (Ali & Haseeb 2019).

VANETs are assigned a certain role in logistics. Firstly, one of the targeted subtasks of VANETs is to enhance port facilities by providing clustering solutions, such as tracking and tracing, security, information sharing and visibility (Coronado et al. 2009). Secondly, VANETs are required to provide enhanced visibility, control and connectivity across an entire supply chain (Coronado et al. 2009). Thirdly, to monitor the coordination of portside vehicular traffic, VANETs must be reliable in this task and provide an efficient solution for information sharing (Coronado et al. 2012). Lastly, VANETs should be able to perform logistic operations at the intra and interorganisational level by building communication links between enterprises and organisations around the world (Abdul Khaliq et al. 2016).

## OTHER RECENT SCM AND LOGISTICS TECHNOLOGY TRENDS

In addition to the advancements discussed in the previous sections, Eyob and Eyob (2019) listed other new technologies in logistics and SCM, such as AI technology, machine learning (ML), autonomous vehicles/drones and advanced analytics. AI technology is an important tool in service management, as organisations seek to become highly efficient and find ways to avoid repetitive tasks (Zach 2018). ML is data analysis technique that automates analytical model building by identifying, detecting, categorising and predicting data (Nevala 2017). Meanwhile, autonomous vehicles/drones use sensors, actuators and a central computer to assess surroundings to automate the driving process and assist vehicles to drive themselves with minimal human involvement. Advanced analytics involves the extensive use of digital technologies to generate huge amounts of data, doubling in volume every two years, and big data analytics is a tool employed by various companies to gain value from seemingly intractable data to gain a competitive edge (Wang et al. 2016).

Angeleanu (2015) examined the impact of new societal and technology trends on logistics and supply chains and determined how they help improve supply chain processes. In addition, the author listed five emerging trends, namely,

cloud logistics, supergrid logistics, anticipatory logistics, omnichannel logistics and additive manufacturing (3D printing). According to the US National Institute of Standards and Technology (NIST), cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (NIST, 2011). Logistic supergrids are logistic networks that integrate logistic service providers and enterprise customers, allowing providers to improve capacity utilisation whilst supporting cost reduction for beneficiaries. Anticipatory logistics relies on data aggregation and the use of predictive algorithms to anticipate demand (Angeleanu 2015). Omnichannel logistics focuses on 'a truly integrated approach across the whole retail operation that delivers a seamless response to the consumer experience through all available shopping channels, whether on mobile internet devices, computers, in-store, on television and in catalogues' (Saghiri et al. 2017). Finally, also known as 'additive manufacturing' or 'rapid prototyping', 3D printing is the printing of solid physical 3D objects. However, unlike machining processes, which are subtractive by nature, 3D printing systems join raw materials together to form an object (De Jong & Bruijn 2013). Drawing on a computer-aided design file, an object design is first divided into paper-thin cross-sectional slices, which are then 'printed' individually in sequence using liquid, powder, plastic or metal materials until the entire object is created.

## CONCLUSION

In summary, with the aid of the latest technologies, the supply chain process can be improved in many ways. The use of RFID in SCM can improve the scanning and checking of inventory and tracking of goods and items by decreasing operational expenses. Moreover, RFID can enhance supply chain operation, delivery systems and item traceability accuracy. Meanwhile, robotic machinery can automate tasks across applications and systems by interacting with existing IT architecture without complex system integration. Monotonous tasks performed by individuals can be eliminated through the use of robots, thereby saving time. Furthermore, VANET integration can provide control, connectivity and visibility across an entire supply chain and should be able to operate logistic operations at the intra- and interorganisational level. With BCT, organisations can authenticate product transparency throughout the entire supply chain phase. The main benefits of BCT include decentralisation, persistence, anonymity and audibility. Finally, the IoT consists of a set of physical SCM objects connected digitally for sensing, monitoring and interacting within firms. The IoT is used to facilitate the planning, controlling and coordination of supply chain processes. Other technology advancements in SCM and logistics include ML, autonomous vehicles/drones, advanced analytics, cloud logistics, supergrid logistics, anticipatory logistics, omnichannel logistics and additive manufacturing (3D printing).

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## DECLARATION OF COMPETING INTEREST

None

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