The Impact and Challenges of the Internet of Things (IoT) on Supply Chain Management

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ABSTRACT
Because of high-tech developments such as the Internet of Things (IoT), big data, and artificial intelligence, traditional supply chain management is confronted with the issue of transitioning to a digital economy, so the purpose of this paper is to investigate the information difficulties and challenges encountered in the use of IoT technology in supply chain management. Before delving into supply chain management, this article provides an overview of the rise of the Internet of Things. This paper employs a research strategy of a literature review summary. The literature is then thoroughly reviewed on four key topics: Industry 4.0, smart supply chains, the Internet of Things, and the challenges of implementing the Internet of Things in the supply chain. Finally, based on the investigation and analysis, some conclusions are reached. As a consequence of the study and analysis, it has been determined that the usage of IoT is speeding the changing trends in the supply chain, as well as enhancing the productivity and efficiency of the company's goods.

Keywords: *Internet of Things, supply chain management, Industry 4.0, smart supply chains, challenges of using IoT in supply chains.*

1. INTRODUCTION

In recent years, traditional global supply chain management has produced a major shift to a digital economy due to high-tech developments such as the Internet of Things (IoT), big data and artificial intelligence. According to a Deloitte report (2017), the global digital platform-based information technology market will reach $16 billion by 2023, with revenue from IoT and machine learning set to more than double by 2020 [1]. Existing supply chain systems will be reconfigured as IoT-enabled related systems provide unprecedented end-to-end visibility, monitoring, and control. The Internet of Things Association predicts that IoT-related industries will grow at an annual rate of 14%-16% by 2024 [1]. Modern businesses will compete in the future by leveraging these technologies to increase market share, improve efficiency and productivity, and reduce operational costs, all of which will be critical in the business world.

More research and studies are thus required on the transformation of supply chain management brought about by the Internet of Things, big data, or artificial intelligence, as well as information challenges encountered in supply chain management using IoT technologies. This paper will introduce and explain supply chain management in the following chapters.

2. DEFINITION OF SUPPLY CHAIN MANAGEMENT

Supply chain management involves both upstream (supplier side) and downstream (consumer side) supply chain partners, as illustrated in Figure 1. This is the most significant distinction between supply chain management processes and traditional logistics. The four main components of supply chain management are depicted proposed by Rushton in 2022 (as Figure 1) [2].

1. The supply chain process is considered as a whole, rather than a collection of separate components such as procurement, production, and distribution. Most advanced manufacturing industries use supply chains in this manner. All manufacturers and end users or end consumers must be involved in the planning stages of an

integrated supply chain that transcends the boundaries of a single company in order to prepare for the complete supply chain.

2. The supply chain management process is a strategic planning process that prioritizes strategic decisions over operational processes.

3. Supply chain management is a novel approach to inventory management. Historically, inventory was seen as a conduit separating the safety valves between components. In fact, a large and expensive commodity storage facility was also required. Supply chain management tries to improve this situation by focusing on inventory management as a key measure for balancing the various product flows in the conduit.

4. The utilization of integrated information systems as part of the entire supply chain, rather than dealing with each component separately, is an essential feature of efficient supply chain management. These systems provide new visibility into product specifications and product storage throughout the conduit by leveraging the latest in information management technology.

It also entails collaboration and communication with upstream and downstream stakeholders such as suppliers, intermediaries, third-party service providers, and consumers. In summary, supply chain management is the coordination of supply and demand within and between organizations [2].

A supply chain is also a set of operations that convey items from suppliers to customers, with three flows: information flow, material flow, and cash flow (as Figure 1).

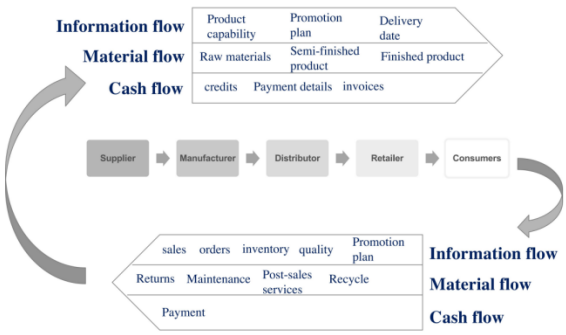

Figure 1 Supply Chain flow

As shown in the diagram, consumer information flows are used in sales, orders, inventory, quality, and promotion plans. These information can be used by businesses to improve their capabilities, marketing strategies and delivery dates.

As for the material flow, on the one hand, it is divided into raw materials, semi-finished products and finished products from the company's point of view. On the other hand, material flows are product returns and repairs, after-sales service, and material recovery as mentioned by consumers.

The most important aspect of the cash flow in the supply chain is the payment. Moreover, payments can be extended to include three types of data: credit, payment details and invoices..

In the context of the fourth industrial revolution, the next part of this paper will examine the evolution of the supply chain, especially in the most recent years.

3. LITERATURE REVIEW

3.1 Industry 4.0

The fourth industrial revolution, also known as Industry 4.0, is at the center of the Internet of Things (IoT), big data, and artificial intelligence, a topic that has gained much attention in academic and professional circles[3][4]. It also entails integrating factory production with the full product lifecycle and supply chain processes[5][6], as well as modifying people's work habits and supply chain management [7].

The ability of companies to use digital technologies to record and analyze data in real time and then provide critical information to industrial systems is a key element of Industry 4.0 [8][9]. As shown in Figure 2, the Internet of Things (IoT), big data, and artificial intelligence enable this, forming the cyber-physical systems paradigm of Industry 4.0 [10][11].

To remain competitive in their global supply chains, most supply chains are leveraging information technology to improve automation and manufacturing performance in this new dynamic business world. Businesses must embrace Industry 4.0 by leveraging on the Internet of Things (IoT), a concept initially advocated by Kevin Ashton in 1999, to alter the digital supply chain (as Figure 2).

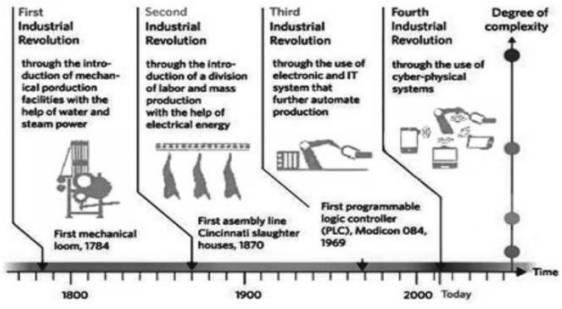

Figure 2 The stages of industrial revolution in human history

In 2011, the federal government, universities and private companies responded to the German proposal for Industry 4.0, a strategic step to improve the production system and increase the competitiveness and quality of the country's industry [13]. This definition implies the

emergence of a new industrial phase in the manufacturing systems. It refers to a collection of converging and evolving technologies that add value throughout the product life cycle [5][6]. To create human influence in the production system in this new industrial stage, social technologies are required. Throughout this phase, all value chain operations will be developed and carried out with the help of intelligent approaches based on information and communication technologies (ICTs)[14].

Industry 4.0 is currently focusing on information sharing and supply chain integration (also known as smart supply chains), the synchronization of data generation and analysis with manufacturers to reduce lead times, and the bullwhip effect caused by insufficient information [15]. This integration also enables companies to collaborate with industrial capital [16], allowing them to concentrate on key competitive advantages and share product-related engineering capabilities in internal industry forums, allowing them to co-create more valuable products, assets, and services [17][18][19].

Industry 4.0 considers both the transformation of manufacturing processes (smart manufacturing) and new delivery systems (smart products) based on new information technologies [6]. The distribution of raw materials and goods (smart supply chain) [20] is also considered, as are new forms of employee performance enabled by new information technologies (smart work) [7].

3.2 Smart Supply Chain

According to supply chain management standards, the most essential justification is that it is less expensive, quicker, and stronger. In today's digital world, supply chains are growing increasingly complicated, expensive, unpredictable, and fragile. As a result, supply networks must become smarter [21] in order to handle the expanding difficulties. The new supply chain paradigm will necessitate the creation of a plethora of new intelligent devices that enable the integration and iteration of data, information, physical parameters, products, and operational processes by leveraging technological advances in areas such as computer science, semiconductors, and other information technologies [22]. For example, there are clear benefits to overcoming physical distances and creating information value chains between factories outfitted with smart devices and tools for fulfilling accurate product delivery with global partners, computer analysis, and complex systems [23]. Companies that possess these abilities will undoubtedly gain a competitive advantage. Intelligent transportation management systems and smart factories are two common examples of intelligent supply chain systems in use today.

As a result, smart supply chains are a complex, interconnected framework that includes stand-alone, regional, and individual enterprise use, as well as broad, comprehensive supply chain implementations. These terms have unmistakably been applied to larger, more complex business networks like online supply chains, the Internet of Things, smart factories, and the Industrial Internet. Individual RFID applications are intelligently linked to fragmented IoT devices, smart factories, and eventually become part of a global supply chain network within the same company. Smart supply chains can also be defined as a contemporary business framework for interconnected enterprises, ranging from isolated, partially regional IoT implementations to larger systems with smart supply chains. In other words, the smart supply chain exhibits the aforementioned features through the use of different technologies such as the Internet of Things, smart machinery, and smart infrastructure.

The interconnected supply chains, effective data collecting, and real-time communication are all aimed at intelligent decision making, efficient and responsive operations [24]. On the one hand, technology is required outside the plant to enhance the distribution of raw materials and finished products in the supply chain via horizontal integration of the factory with external suppliers, cutting operating costs and shortening lead times. The smart supply chain, on the other hand, sees factory innovation as a tool to help employees work more efficiently and better adapted to the needs of industrial systems[7].

General Electric is a prime example of a smart supply chain. GE gathered relevant big data from industry systems and, after implementing a smart supply chain, installed vibration sensors in power plant turbines, saved 35% on global turbine maintenance and developed design improvements. This enabled the company to gain a competitive advantage when competing with other companies in the same industry[1].

3.3 Internet of Things (IoT)

The phrase "Internet of Things" refers to the wireless integration of sensors and computation in a networked world [25]. Recent developments in the Internet have effectively increased the possibility of multiple objects communicating to make this concept possible. Sensing any sort of item and connecting it to a wider network has become a reality in recent years, thanks to the decrease in the price of sensors[26]. Ultrasonic sensors in self-driving vehicles, such as the Tesla, employ sound waves to assess the distance between the vehicle and other objects in its surroundings. A range of IoT applications help with transportation and logistics operations. Thanks to IoT sensor data, fleets of automobiles, trucks, ships, and trains transporting commodities may be redirected based on weather, vehicle availability, or driver availability.

The Internet of Things (IoT) is a network of computers, hardware, software, applications, databases, objects, sensors, and systems that provide assistance to

humans. In addition, IoT is a revolution in computing and communication technologies that can trigger a vision of communication at any time, in any place, on any media, and on anything. As previously stated, the Internet of Things (IoT) enables the interaction of digital and physical entities, thus introducing a whole new class of applications and services [24].

As a result of the IoT digitization, many entities, whether governments, organizations, businesses, or individuals, have changed their working methods [27]. Due to the change in working method, data production has increased. According to a study by the International Data Corporation (IDC), the amount of data collected is expected to exceed 35 trillion gigabytes by 2020 [28]. The International Data Corporation (IDC) is a fully owned subsidiary of International Data Group, a market research, analysis, and consulting organization located in the United States that specializes in information technology, telecommunications, and consumer technology. In other words, during the manufacturing and delivery processes, a large amount of industrial data can be generated.

Faced with such a huge amount of data, informatics (IT) has a considerable impact on efficient supply chain management. IT can link multiple systems, suppliers and customers internally and externally through frequent communication, data and information collection and distribution, and subsequently improve the efficiency of the entire supply chain[29].

The Internet of Things (IoT) is one of the most significant advances in information technology (IT). In 1999, Kevin Ashton invented the concept of the "Internet of Things" [30]. It is described as a networked collection of physical and virtual things capable of communicating, sensing, and interacting with each other, as well as their interrelated internal and external surroundings. The Internet of Things includes several physical features that reflect a collection of physical metrics that may be utilized to analyze and regulate the supply chain by digitizing agility, visibility, knowledge exchange, and tracking requirements. These characteristics are used to assess the extent of detection, monitoring, and interaction inside and across organizations [29]. In other words, the Internet of Things (IoT) aims to address connection difficulties across all manufacturing artifacts and structures, as well as across various factories.

RFID is also an important component of IoT applications. RFID has been proposed and studied in a number of papers recently [31]. By incorporating short-range, easy-to-hold transceivers in new products, this technology has increased the potential for reliability, usability, and efficiency. The implementation of these procedures will provide a new perspective on information and communication with corresponding service for all supply chain participants, such as the unique value of smart devices and sensors, such as RFID tags, which have been shown to be effective in reducing product shortages, avoiding stock-outs, preventing over-stocking, and improving date accuracy [24].

3.4 Challenges of using IoT in supply chains

Thanks to the widely interconnected Internet of Things [32], Vast amounts of information and more advanced, smarter services are readily available. Significant corporate, political, and technological issues have arisen in the Internet of Things infrastructure, which must be replicated before these systems can be widely used. Determining how knowledge is accessed is one of the issues facing the IoT in supply chains[24].

To improve the efficacy and efficiency of the supply chains, IoT applications must be assessed in terms of the value created across the supply chain [33]. In contrast, the Internet is currently a vast and untapped resource for unstructured data [24]. Collecting and analyzing valuable data for reuse and improvement is critical to fully leveraging IoT in supply chains.

Another set of difficulties and challenges of IoT in supply chains identified by numerous professors is the security and privacy concerns raised by Bi et al [34]. The challenge of data dependency has been raised due to the massive rise of data in the supply chain [35]. Congestion has been identified as a stumbling block for scaling, extending, planning, research, and storing. These facts, such as noise buildup, misleading information, measurement inaccuracy, and other flaws, may have a gradual impact on the users and these facts may even compromise information and manufacturing security during the supply chain process. Furthermore, as information technology advances, the amount of cybercrime increases, potentially increasing the possibility of information leaks and jeopardizing the privacy of businesses and individuals.

All of the above issues and challenges are related to information. Aside from this, some organizational issues and challenges are considered. Because of the high labor costs and severe working circumstances in these sectors, the Internet of Things may readily be utilized to optimize production and distribution in mechanical engineering, automotive and discrete manufacturing, power generation, oil and gas, and mining [1]. To maintain production safety, stability, and efficiency, these manufacturing and heavy industries require the use of IoT in their supply chain. However, the use of IoT in the supply chain of light industry and service industries such as taxis and hairdressers has encountered obstacles. This is due to the high demand for personalization and humanistic care in these industries, which makes the replacement of machines and sensors difficult. Furthermore, technical advancements in IoT and artificial intelligence are still insufficient to entirely replace people in these light industry and service industries. Another reason is that national regulatory restrictions and traditional perceptions

of people are also key barriers to the implementation of IoT in light industry and service supply chains.

Another organizational difficulty is that various organizations store different types of data and utilize different operating systems, making the exchange of information across industries problematic.. Meanwhile, to maintain secuirty, some companies maintain tight information loops within their industries. Once an information exchange platform is in place, it can easily create uncertainty and risk throughout their industry. On the other hand, restrictions on data access stifle the development of IoT in the supply chain.

4. CONCLUSION

To recapitulate, with the development of the digital economy, new information technologies such as the Internet of Things and Big Data/artificial intelligence have steadily influenced the establishment of global supply chains. As a result, production efficiency has increased while costs have decreased. In the meantime, integrating IoT into the supply chain presents some organizational and informational challenges.

To begin, this paper defines supply chain in the introduction. In the literature review section, the causes of supply chain transformation (Industry 4.0), smart supply chain, IoT technology and IoT application issues were examined individually. Furthermore, issues related to the integration of IoT in the supply chain are carefully distinguished as organizational issues and informational issues. To support the claims of this paper, examples and figures are included where appropriate.

According to the observations in this paper, the use of IoT is accelerating the trend of changes in the supply chain. These can boost a company's product's productivity and efficiency. It is critical to understand the evolution of today's smart supply chain and to be knowledgeable about the application of information technology. In addition, the research community and industry need to thoroughly investigate the challenges and issues related to the use of IoT in the supply chain. If the research community and industry can conduct detailed and accurate investigations, we can see how corporations will rearrange their supply chains to obtain a competitive edge in global marketplaces in the future, which is demonstrated in product's productivity and manufacturing efficiency.

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