Employing the Internet of Things
to Attain Resilience Across Supply Chain

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Abstract

Development in the field of IT and competition in the market forces companies to increase their market share and revenue. To satisfy this goal, companies can apply and adopt plans that may lead to making the supply chain (SC) lengthy and too rigid to control/monitor. The longer the SC the more it can be disrupted by expected and unexpected events (e.g., Digital security incidents, climate). For that purpose, the SC must be built in a way to respond fast to disruptive events in an effective way and to bounce back to its original state to be considered a resilient SC, which gives a competitive advantage to the companies.

To achieve SC resilience, several studies have discussed enablers. Some of these studies, focused on increasing velocity through the SC, others argued that high adaptability leads to SC resilience, and others mentioned information sharing as a key to achieving SC resilience. In addition, applying technology in the SC processes can add strength. As such, the Internet of Things can support/enhance the level of Velocity, Adaptability, and Information sharing, which leads to enhancing SC resilience. This research explores the opportunities that IoT presents to enhance resilience enablers and boost SC resilience.

Keywords
Supply chains, Supply chain resilience, IoT, Internet of Things, Velocity, Adaptability, and Information sharing.

1. Introduction

With the increasing shifts in business environments and the importance of maintaining trust, performance and responsiveness across the business, innovative approaches to control and manage supply chains are required. Firms must pay attention to the vital role Information Technology plays in improving the performance of business processes. Technologies such as the Internet of things (IoT), big data, and cloud computing technologies across the supply chain to achieve supply goals and bring tangible business rewards to the supply chain.

Supply chain resilience (SCRes) is defined as *"The supply chain's ability to anticipate and respond to unforeseen occurrences, as well as recover from them, by maintaining operations at the required level of connectivity and supervision over structure and function."* (Ponomarov & Holcomb, 2009). The resilience of Supply Chains is one of the promising subjects in supply chain management literature which directly affects performance and risk management (Verdouw et al., 2016).

Resilience across the supply chain is increased by various enablers, many enablers have been studied to support and assist in reaching a resilient supply chain. This paper will shed light on the role and importance of three vital enablers of SCRes: velocity, information sharing and adaptability.

To achieve the goals of a resilient supply chain through applying enablers, many factors help in supporting each enabler. Brandon-Jones et al., 2014 discussed the importance of Information sharing which is facilitated through collaboration, enabling communication among individuals and departments which results in effective decision-making (Scholten & Schilder, 2015). Velocity signifies the timely delivery of information to handle disruptive events and respond quickly. Ahimbisibwe and Ssebulime, (2016), show how velocity is positively impacted by increasing visibility, collaboration, and trust between partners (Christopher & Peck, 2004).

Adaptability is considered a critical enabler to attain supply chain resilience; adaptability enhances the smooth flow of products and the ability of partners to respond to unexpected needs and demands (Ireland & Bruce, 2000). Srimarut and Mekhum, (2020) demonstrate multiple enablers and methods that can be used to gain adaptable supply chains, such as flexibility, visibility, connectivity, and collaboration.

While developing resilience enablers can increase SC resilience for complex times. Introducing the internet of things and the increased automation and digitization in supply chains are potential long-term changes in supply chain processes that have significantly altered supply chains.

The IoT's capabilities can capture the information, and support resilience enablers to attain supply chain resilience in the case of a disturbance (Al-Talib et al., 2020). IoT technology allows for remote control of the whereabouts and condition of goods and products from the manufacturer to the end-user (Verdouw et al., 2016; Klaib et al., 2021). IoT provides better solutions to avoid risks, information security management systems, and generate concrete financial returns by increasing transparency and responsiveness across the supply chain (Birkel & Hartmann, 2020).

Despite this, there is limited research demonstrating a link between IoT and SCRes with a focus on velocity, information sharing and adaptability. The goal of this study is to analyse the impact of IoT on SCRes enablers, as well as how adopting IoT can help overcome difficulties with advanced technologies.

2. Literature Review

Resilient supply chains have the advantage to overcome potential disruptions and/or vulnerabilities in the supply chain. On the other hand, IoT is a growing technology that has a huge potential to improve supply chain processes and activities, such as enabling organizations to elevate connectivity between departments and enhance supply chain resilience enablers (de Vass et al., 2021).

In this scope, the following research inquiries have been identified to explore the existing literature:
- Exploring how the SCRes and IoT concepts have been researched in the literature to identify the current gap and possible research possibilities with its effects on the field of supply chain resilience.
- Identifying the key elements SCRes and IoT and how they are linked according to the existing literature.
- Exploring the potential impacts, advantages, and tasks by implementing IoT in the field of SCRes.

During the search, keywords were used, such as "Supply chain resilience" to search for journal articles/conference papers and words like "IoT" within the journal articles to show the IT side. This paper used several defined keywords as search criteria. The keywords consisted of the phrase "supply chain" combined with the following keywords: "SC Velocity," "SC Adaptability," and " Information sharing in SC " with other keywords from the IoT fields such as "Internet of things," "IoT, " "RFID," "Radio-frequency identification," "Big data," and "Sensors,".

This research found an increasing trend in the number of published papers in recent years, almost 80% of the selected papers were published between 2017 to 2022 as shown in Figure 1, this observation is also cited by (Ali et al., 2017) and (Kamalahmadi & Parast, 2016). This development proves research in these areas will continue to increase, as it is becoming more important to firms' competitiveness as it can help to maintain organization operations.
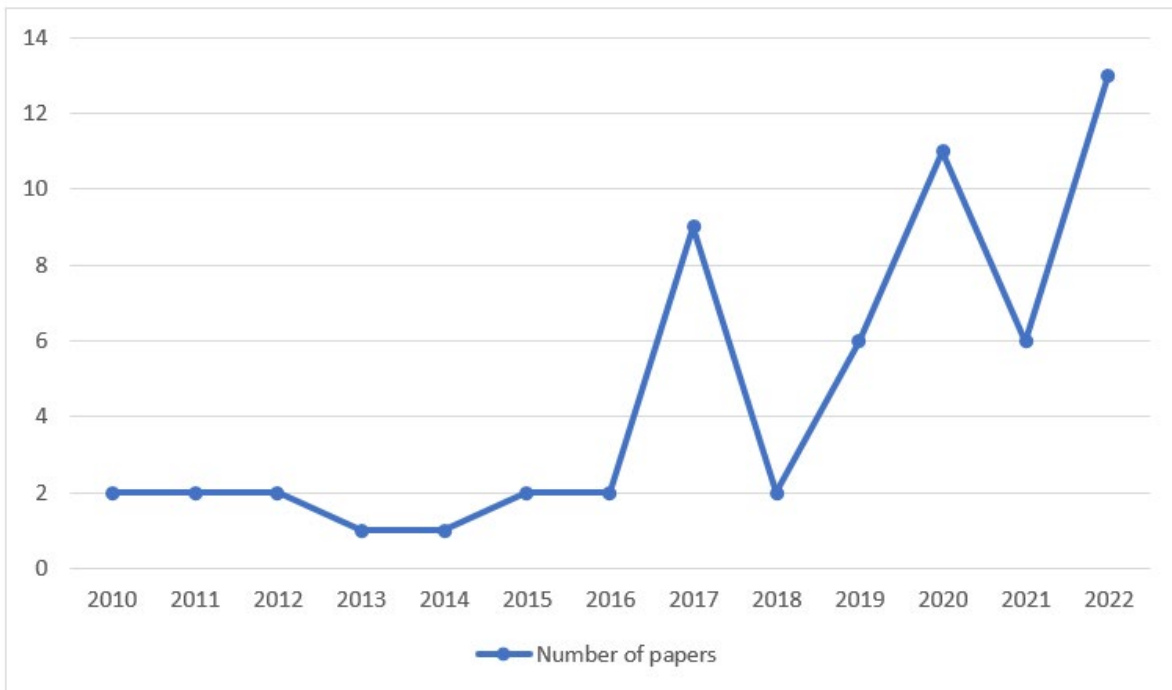

Figure 1: Year of publication

The results show the importance of IoT technology (see Figure 2), where 41% of the papers found used IoT to improve resilience enablers in the supply chain. Regarding that, this research will discuss how IoT technology can improve resilience enablers, therefore increasing the supply chain resilience level. On the other hand, the results show the papers done in the field of resilience enablers, where information sharing was the popular enabler in the supply chain area, with 43% of all papers, followed by adaptability and velocity with 35%, and 22% respectively.
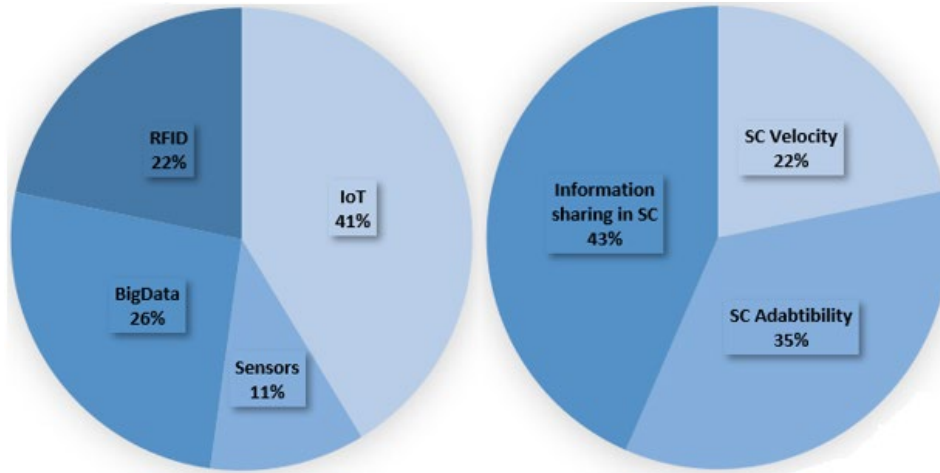
Figure 2: Percentage of journal articles/conferences based on keywords

3. Supply chain resilience enablers

To achieve resilience across the supply chain, several numbers of enablers need to be fulfilled. For example, if the level of collaboration and visibility has been improved, that will help achieve resilience in the supply chain (Mandal et al., 2016).

To meet satisfying performance and customer requirements, supply chains must be able to adapt to and overcome disruptive events. This can be attained by ensuring a set of enablers have been applied across the supply chain (Hosseini et al., 2019).

Many studies have been conducted to investigate the enablers of supply chain resilience. Al-Talib et al., (2020) discussed SCRes enablers in terms of Visibility, Flexibility, Collaboration, and Control, whereas Stone & Rahimifard, (2018) explored Agility, Adaptability, and Robustness as supply chain resilience enablers. The enablers of SCRes and their interdependencies were investigated (Jain et al., 2017).

The effect of IoT on supply chain resilience will be discussed in this paper, by using the supply chain resilience enablers represented in Figure 3. However, these enablers will be discussed in greater depth in the sections that follow.

Figure 3: Supply chain resilience enablers

3.1 Information sharing

Information sharing is a critical component of supply chain coordination. By minimising stock levels and straightening production, information sharing can improve supply chain efficiency. It is critical to have readily available, reliable, and meaningful information to reduce risks in the supply chain. This helps in making strategic decisions throughout the supply chain (Li et al., 2017; Mandal et al., 2016).

Information sharing is considered a very important resilience enabler because it has a positive impact and enhances the level of many other resilience enablers, such as (Adaptability, Collaboration, Flexibility, etc.) (Ponomarov and Holcomb, 2009; Raweewan and Ferrell, 2018; Scholten and Schilder, 2015). Furthermore, Brandon-Jones et al., (2014) in their considered research information sharing is an intangible resource in the supply chain.

3.2 Adaptability

Adaptability indicates the ability to adjust to new states effectively by restructuring operations and aligning strategies across SC entities. It also describes the tendency to change supply chains as required, without being constrained by previous issues or the way the supply chain is managed. Carvalho et al., (2012) and Collins et al., (2010) claim that achieving adaptability allows business processes to adapt progressively or completely transform in response to a changing operating environment without incurring setbacks from the previous method. As well it is referring to the system's ability to organise itself internally rather than being driven by external forces (Dubey et al., 2018). Additionally, Dubey et al., (2018) claim continuous visibility throughout the supply chain, may greatly enhance adaptability.

3.3 Velocity

Velocity is another key resilience enabler that has been mentioned in the literature as one of the most important for the supply chain (Al-Talib et al., 2020; Spieske & Birkel, 2021). Velocity is defined as the ability to cover needs quickly. It is the amount of time it takes for goods to travel from one end to the other through the supply chain (Francis, 2008). As a result of achieving and improving velocity levels, warehouses can respond faster or teams of pre-trained experts can respond more efficiently, including logistics, water, and telecommunications (Charles et al., 2010).

Manuj & Mentzer, (2008) defined velocity in three ways: first, the rate at which a risk event occurs. The second factor is the frequency with which losses occur. The third factor is how quickly risks are identified. Across the supply chain, velocity and visibility are regarded as aspects of agility. Increased velocity throughout the supply chain can have an impact on the reduction of vulnerabilities (Rajesh, 2017).

4. IoT and supply chain resilience enablers

The purpose of this research is to investigate the concepts of supply chain resilience and the internet of things (IoT) to benefit supply chain companies. Traditional supply chain challenges have a direct impact on the SCRes enablers (shown in Figure 3), which requires the supply chain to manage changes and reduce disruptions. Traditional supply chains faced issues such as uncertainty, rising costs, inaccuracy, and increased risks (Abdel-Basset et al., 2018; Adeseun et al., 2018).

Although the approaches to both concepts (IoT and supply chain resilience) differ. However, further research will assist in the identification of the interconnection between IoT and supply chain resilience, as well as their potential benefits in improving resilience enablers and, as a result, enhancing the company processes.

IoT technologies offer SCRes with forecasting capabilities to manage risk as the supply chain obtains self-learning abilities, or to reduce the effects of threats, for example in cases of disasters in production, transferring alarm signals to people in charge, then by monitoring real-time and circulating information effectively, the situation can be handled quickly.

4.1 Information sharing

In the beginning, IoT enhances elements of information sharing inside the supply chain, permits efficient information exchange and the use of interoperable systems to mitigate risks, and enhances decision-making and coordination.

Moreover, it significantly influences the quality and range of information communication, enabling successful knowledge collection from SC partners. As a result, the degree of information sharing, and the quality of transmitted information will improve.

4.2 Adaptability

IoT improves information sharing through the SC, allowing for more precise forecasting and faster responses, which can help improve supply adaptability. It can also help the supply chain recover more quickly following an interruption. Furthermore, IoT improves the seamless flow of products and partners' ability to adapt to unforeseen needs and demands due to the knowledge and information provided.

4.3 Velocity

IoT technologies help managers to receive accurate information in a timely manner ensuring velocity, allowing process modifications to be applied as soon as possible. Moreover, IoT enables easy access to resources and information without requiring formal requests. As a result, this allows for production continuity and on-time delivery. IoT has a positive impact on collaboration between supply chain partners, which leads to improves velocity in the SC and therefore their reaction to the market changes will be better. As well helps modify operations to handle disruptive actions and respond to changing events quickly. Figure 4 summarized the IoT contributions on SCRes enablers (Information sharing, Adaptability and Velocity).
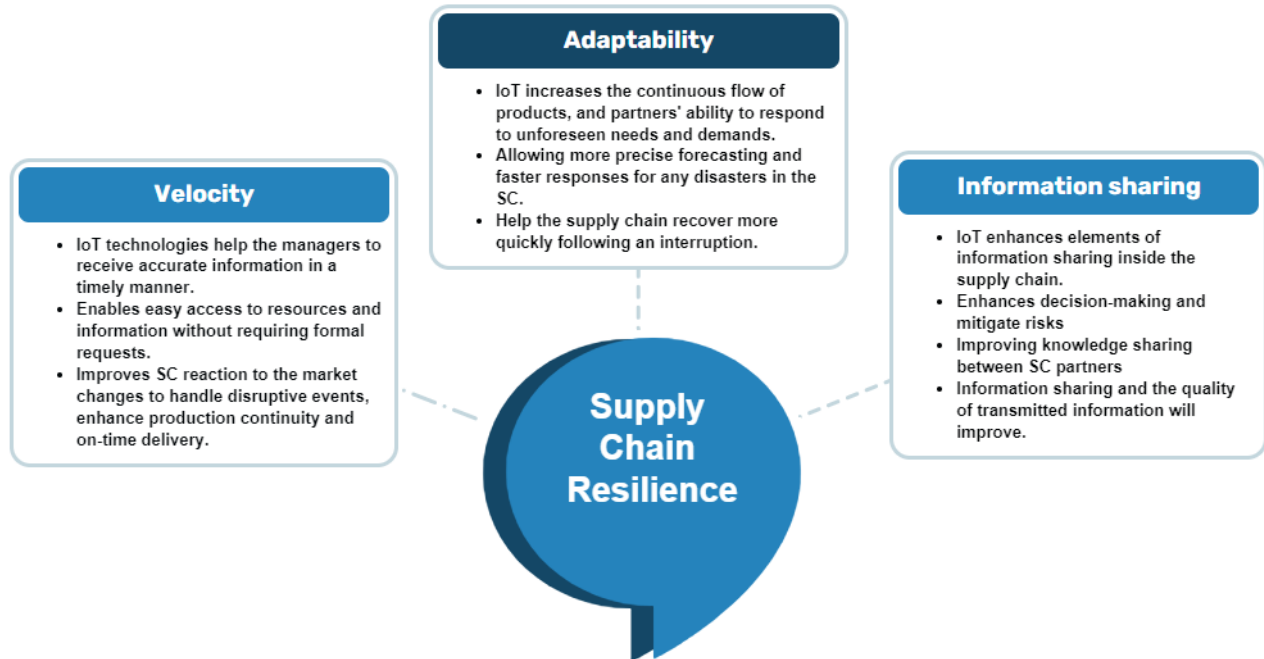
Figure 4: IoT contributions in supply chain resilience enablers

5. Conclusion

Many different enablers may fit in a particular supply chain better than others in terms of resolving hazards and increasing resilience. As a result, a list of specific enablers tailored to the domain, criteria, and needs of the business may be focused on to ensure supply chain resilience.

In this paper, a module has presented the benefits of utilising IoT for resilience enablers in the supply chain. To achieve high-performance supply chain processes and gain future robustness to achieve resilience. We focused on three key enablers of supply chain resilience: velocity, Information sharing, and adaptability.

Our research has emphasized the use of smart devices and IoT technologies in rebuilding traditional supply chains by focusing on three enablers that deliver resilience across the SC, Moreover, due to the limited research discussing the effect IoT has on SCRes, this study focuses on implementing smart technology on supply chain functions such as product tracking and tracing,

With data and sharing information in real-time, IoT promises quick and accurate information throughout the supply chain. When it comes to resilience and the supply chain, it's evident that there are various areas and prospects for further research when it comes to Internet technology.

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