IMPLEMENTATION OF DISRUPTIVE TECHNOLOGIES IN SUPPLY CHAIN MANAGEMENT

Editor

Prof. Dr. Erkut AKKARTAL

DUVAR

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853 Sokak No:13 P.10 Kemeraltı-Konak/Izmir/ Turkey

Phone: 0 232 484 88 68

www.duvaryayinlari.com

duvarkitabevi@gmail.com

PREFACE

Disruptive technologies emerge from all walks of life. These technologies, which play an indispensable role in both daily life and business life, have completely changed the structure of supply chains and business models. It is inevitable for institutions and organizations that want to gain competitive advantage in the future to adapt these business models and technologies to themselves. Although it is difficult at first to keep up with these technologies, which will provide time and cost advantages in the supply chain and logistics processes in the long run, this difficulty can be overcome with a good vision and qualified human resources. I hope that both academic and industry representatives will enjoy this book, which talks about disruptive technologies that play the most important role in supply chain processes and are game changers.

Erkut Akkartal, June 2023.

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Chapter 1

Sustainable Agricultural Supply Chains: The Role of Drones in Improving Efficiency and Reducing Environmental Impact

Naz TÜRKSOY[1]

[1] PhD.; Yeditepe University,Sosyal bilimler Fakultesi,uluslarasi Ticaret ve Logistic;
naz.turksoy@std.yeditepe.edu.tr ORCID No: 0000-0003-4443-9595

ABSTRACT

The logistics and supply chain management industry faces increasing complexity in managing various components and stakeholders. Unmanned aerial vehicles (UAVs), commonly known as drones, have gained popularity in logistics and supply chain management due to their ability to deliver goods, collect data, and perform various tasks. This research examines the potential of drones in enhancing the sustainability of agricultural supply chains and aims to explore how drones can improve efficiency and reduce the environmental impact of supply chain operations in agriculture. It focuses on analyzing the benefits and challenges associated with using drones in agricultural logistics, inventory management, last-mile delivery, monitoring, and inspection. The study highlights the significant contributions of the Lean approach in utilizing drones for supply chain management in agriculture. The findings indicate that drones optimize last-mile delivery, providing timely and efficient transportation while reducing costs and overcoming challenges faced by traditional vehicles. They also enhance inventory management by providing real-time information, leading to cost reduction and improved supply chain operations. Furthermore, drones play a crucial role in crop monitoring, facility inspections, and precision agriculture, improving overall productivity, reducing environmental impact, and promoting sustainability in the agricultural sector. This research provides valuable insights into the potential applications of drones in agricultural supply chains. By understanding the benefits and challenges associated with their use, stakeholders in the logistics and supply chain management industry can make informed decisions and develop strategies to incorporate drones into their operations. Ultimately, the integration of drones in agricultural supply chains can contribute to a more sustainable and efficient industry.

Keywords: Drone, Sustainability, Disruptive Technologies, Supply Chain

1. INTRODUCTION

Supply chain management has become increasingly complex in recent years, with companies having to manage a variety of moving parts and stakeholders to ensure timely and efficient delivery of goods and services (Koberg et al., 2019). In recent years, unmanned aerial vehicles (UAVs), commonly referred to as drones, have rapidly become popular in various industries, including the logistics and supply chain management sectors. Drones are small, remotely piloted aircraft that can be used to deliver goods, collect data, and perform a range of other tasks (Rejeb et al., 2021).

The logistics and supply chain management industry is constantly seeking innovative ways to streamline operations, reduce costs, and improve efficiency. Drones have the potential to revolutionize the way logistics and supply chain operations are carried out (Akkartal et al., 2019). They can be used to deliver packages directly to customers, monitor inventory levels, and even inspect equipment and facilities (Udvaros et al., 2022). The COVID-19 pandemic has also accelerated the use of drones in logistics and supply chain operations. The pandemic has created numerous challenges for the industry, including supply chain disruptions, labor shortages, and increased demand for contactless delivery options. Drones have emerged as a solution to these challenges, allowing businesses to continue operations while maintaining social distancing measures and reducing the risk of virus transmission (Özkanlısoy et al., 2020; Craighead et al., 2020)

The objective of this paper is to investigate the potential of drones in enhancing the sustainability of agricultural supply chains. The focus will be on exploring how drones can improve efficiency and reduce the environmental impact of supply chain operations. Specifically, the paper will analyze the benefits and challenges associated with the use of drones in agricultural logistics, inventory management, last-mile delivery, monitoring, and inspection.

One sector that has begun to explore the benefits of drone technology is supply chain management. With the ability to transport goods and materials quickly and efficiently, drones are proving to be a game-changer for supply chain companies. Traditional methods of transportation, such as trucks and planes, have limitations that drones can overcome, making them an attractive option for businesses looking to streamline their operations (Abdelhadi et al., 2019). In this context, the use of drones in supply chain management offers the potential to improve delivery times, reduce costs, and increase the accuracy of inventory management (Tiusanen et al., 2023). As such, supply chain companies need to consider the advantages that drones can offer to stay competitive in today's rapidly changing

business landscape. Figure 1 depicts the predicted investment on UAVs and the projected economic effect of UAVs over the next decade.

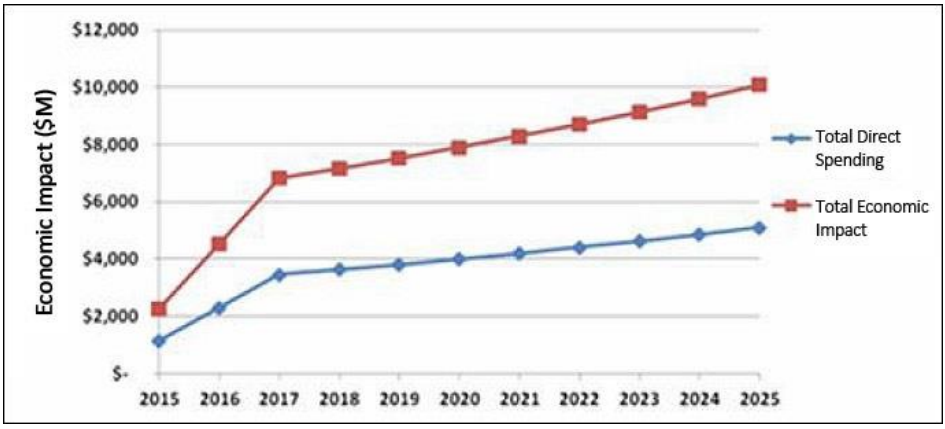

Fig 1. The predicted investment on UAVs (source: www.financialsense.com)

Drones can be used in a variety of ways in supply chain management. One of the most promising uses of drones is for last-mile delivery, which refers to the final leg of the delivery process, from the distribution center to the customer's doorstep. Last-mile delivery is often the most expensive and time-consuming part of the delivery process, as it involves navigating through traffic, finding the customer's address, and making the actual delivery. Drones can significantly reduce the time and cost of last-mile delivery by flying directly to the customer's location, bypassing traffic and other obstacles (El Jiati, 2021; Akkartal, 2018). Drones can also be used for inventory management and monitoring. Drones equipped with cameras and sensors can be used to monitor inventory levels in real-time, ensuring that the right products are in the right place at the right time. Drones can also be used to monitor the condition of goods during transportation, ensuring that they are not damaged or lost. Furthermore, drones can be used for emergency deliveries in situations where traditional transportation methods are not possible (Tolooie et al., 2022). For example, drones can be used to deliver medical supplies to remote areas or to deliver aid to disaster-stricken regions. In such situations, drones can provide a lifeline for people in need, saving lives and reducing suffering (Hewett et al., 2022).

The first uses of drones in supply chain can be traced back to around 2013 when Amazon announced its plan to use drones for package delivery, a move that generated significant media attention and sparked interest in the potential of drones for supply chain management. However, the first actual use case of drones in supply chain was in the mining industry (Douglas, 2019). In 2013, Rio Tinto,

a multinational mining company, began using drones to survey its mining sites in Western Australia. The drones were equipped with sensors and cameras that could capture detailed images and data of the mining sites, providing Rio Tinto with real-time information on production levels, equipment performance, and safety hazards.

The use of drones in the mining industry quickly spread to other sectors, such as oil and gas, agriculture, and construction. In these industries, drones were used for tasks such as inspecting pipelines, monitoring crops, and surveying construction sites. In the logistics and transportation sector, the first use cases of drones involved the delivery of medical supplies and humanitarian aid to remote or hard-to-reach areas. For example, in 2014, a South African startup called The Flying Donkey used drones to deliver medical supplies to rural areas in Africa (Damoah et al., 2021). Overall, the early uses of drones in supply chain were focused on gathering data and delivering goods to areas that were difficult to access using traditional methods. As drone technology continues to advance, we can expect to see more innovative use cases for drones in supply chain management.

2. LITERATURE REVIEW

Drones have been increasingly popular in the logistics and supply chain management sectors due to their potential to improve efficiency, reduce costs, and streamline operations. In recent years, there has been a growing body of literature exploring the benefits and challenges of drone technology in the supply chain context (Troudi et al., 2018; Aslan et al., 2021). One of the most promising areas of drone use in supply chain management is last-mile delivery. Research has shown that drones can significantly reduce the time and cost of last-mile delivery by bypassing traffic and other obstacles, leading to faster and more efficient delivery (Aurambout et al., 2019; Stolaroff et al., 2018; Malang et al., 2023). Studies by Borghetti et al. (2022), Mora et al. (2022), Mahroof et al. (2021) found that using drones for last-mile delivery could reduce the delivery time, while also reducing transportation costs. Studies also showed that using drones for last-mile delivery could reduce carbon emissions by up to 43%, which can be beneficial for companies aiming to achieve sustainability goals (Eskandaripour et al. 2023; Damoah et al., 2021).

Drones can also be used for inventory management and monitoring, allowing companies to track their inventory levels in real-time and make informed decisions about restocking and replenishment (Özkanlısoy et al., 2021). The literature showed that using drones for inventory management could improve inventory accuracy, while also reducing labor costs (Cristiani et al., 2020;

Companik et al., 2018; Piramuthu et al., 2022; Macoir et al., 2019;). Drones can also be used for quality control and monitoring during transportation, ensuring that goods are not damaged or lost (Akkartal et al., 2021; Tolooie et al., 2022; Tran et al., 2022;). However, there are also challenges associated with the use of drones in supply chain management. One of the main challenges is regulatory compliance, as drones are subject to regulations related to safety, privacy, and airspace management (Clark et al., 2014; Lee et al., 2022). Moreover, drone technology is still evolving, and companies may face challenges related to technical malfunctions, security, and maintenance (Chen et al., 2020; Nassi et al., 2019; Alwateer et al., 2020). Drones have become increasingly important in the agricultural sector due to their ability to provide a bird's eye view of crop fields and identify crop health issues, monitor plant growth, and collect data for precision farming. Drones can also be used for crop mapping, irrigation management, and the delivery of pesticides and fertilizers in a precise and efficient manner (Dileep et al., 2020). Drones have the potential to revolutionize the way farmers manage their crops and increase yields, as shown in Figure 2.

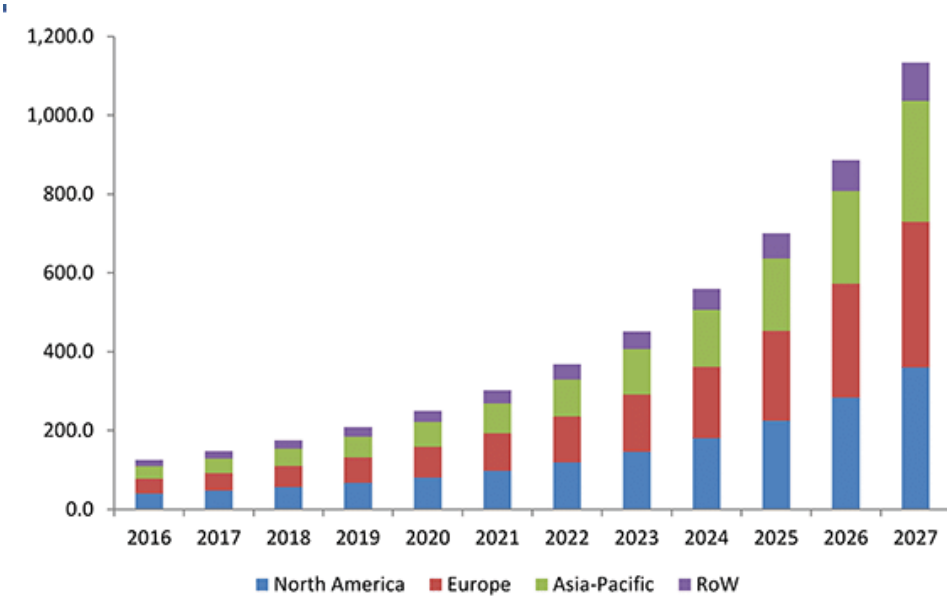

Fig 2. Potential Use of Drons in Agriculture (Source: www.visiongain.com)

Despite these challenges, the use of drones in supply chain management is expected to grow in the coming years. The COVID-19 pandemic accelerated the adoption of drone technology in the logistics and supply chain sectors, as companies seek to maintain operations while complying with social distancing

measures (Koshta et al., 2022; Daud et al., 2022; Dutta et al., 2021; Kolter et al., 2022; Ayakwah et al., 2022). The potential of drones to enable contactless delivery and monitor inventory in real-time is particularly appealing in the current context. Overall, the literature suggests that the use of drones in supply chain management offers significant benefits, particularly in the areas of last-mile delivery and inventory management. However, companies need to be aware of the challenges and limitations associated with drone technology and develop strategies to ensure regulatory compliance and address technical issues. The future of drone application in agriculture is bright as drones become more advanced and cost-effective, leading to widespread adoption in the industry. Drones will continue to revolutionize the way farmers manage their crops and improve overall efficiency and productivity in agriculture. According to the IoT Solutions for Farming and Agriculture report by Guidehouse Insights, the global expenditure on drone technology for agriculture is projected to surge from $8.5 billion in 2021 to $26.2 billion in 2030 (Figure 3).

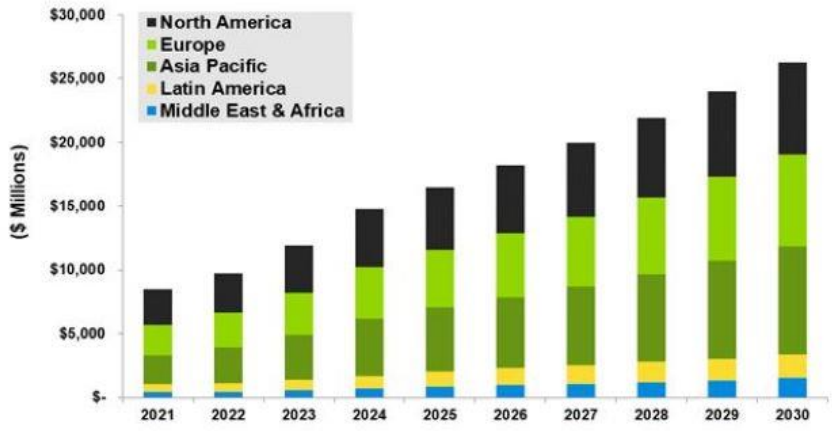

Fig 3. The global expenditure on drone technology for agriculture (Source: Guidehouse Insights)

3. METHODOLOGY

This study employs the Lean approach, a systematic and iterative method that emphasizes waste reduction and continuous improvement, to investigate the role of drones in logistics and supply chain management. The first step will be to define the problem statement and objectives of the study. Next, the value stream of using drones in logistics and supply chain management will be identified and mapped out to locate bottlenecks and areas of waste. Waste will then be eliminated, including excess inventory, unnecessary transportation, and

overproduction. Continuous improvement processes will be established to regularly optimize the process. Ultimately, the Lean approach will allow for a streamlined analysis of the benefits, challenges, and potential future applications of drones in logistics and supply chain management. Figure 4 shows the conceptual model of the study.

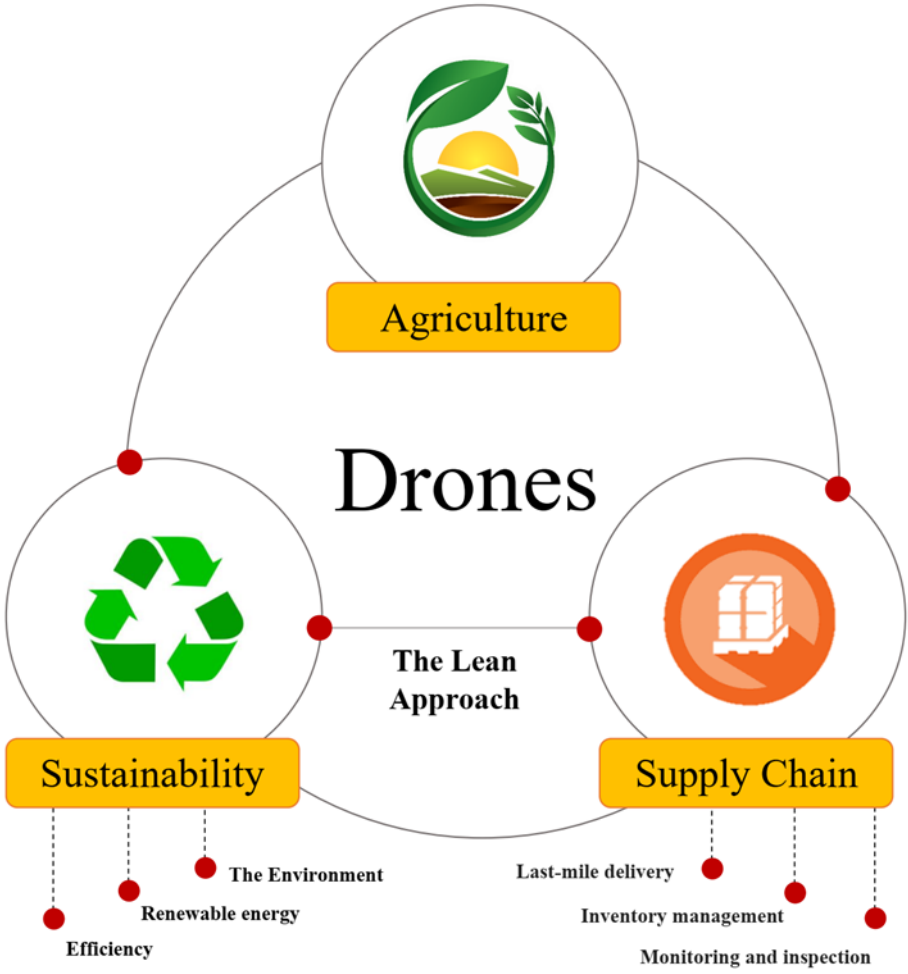

Fig 4. The conceptual model

4. DRONES IN AGRICULTURE

4.1. The Lean Approach

The Lean approach, also known as Lean Thinking or Lean Management, is a systematic methodology focused on maximizing value for customers while minimizing waste. It originated in the manufacturing industry but has since been widely applied across various sectors and disciplines (Orji et al., 2020). At its

core, the Lean approach aims to optimize processes, eliminate non-value-adding activities, and continuously improve efficiency. It focuses on creating value, eliminating waste, improving flow, and constantly seeking perfection, and has been successfully applied in manufacturing, services, healthcare, software development, and many other domains, offering a systematic framework for achieving efficiency and delivering value to customers (Gargalo et al., 2021).

The Lean approach is applied to analyze the role of drones in agriculture. It is adapted to assess how drones can improve various aspects of agricultural processes, including crop management, yield optimization, and resource utilization (Caicedo et al., 2020). To apply the Lean approach in agriculture, the study investigates how drones can enhance pest control, irrigation management, or crop monitoring. The study analyzes how drones can contribute to waste reduction, optimize resource allocation, and improve overall agricultural productivity. This involves understanding the entire agricultural process, from planting to harvesting, and pinpointing areas where drones can potentially add value and improve efficiency. Agricultural activities often involve excessive use of resources such as water, fertilizers, and pesticides. Drones can help minimize waste by providing precise and targeted application of these resources, reducing excess usage and environmental impact. For instance, drones can be deployed for aerial surveillance, data collection, and mapping of crop health, enabling farmers to detect early signs of diseases or nutrient deficiencies. Continuous improvement is an integral part of the Lean approach. In the agricultural context, this entails regularly evaluating and refining the use of drones. Farmers can collect data and monitor the effectiveness of drone-assisted practices, identify areas for improvement, and make adjustments accordingly (Muñoz-Villamizar et al., 2019). For example, if the data collected by drones suggests a suboptimal irrigation pattern, the study can explore ways to optimize water usage by adjusting drone flight paths or irrigation schedules.

4.2. Supply Chain

Drones have the potential to significantly improve the efficiency of supply chain operations in agriculture by leveraging advanced sensors, communication capabilities, and artificial intelligence. By applying the Lean approach to the agricultural sector, drones can facilitate timely and accurate delivery of goods, reduce logistics and inventory management costs, and improve overall productivity. Farmers can also optimize supply chain operations, improve inventory management, monitor crops and facilities more effectively, and increase overall productivity. These benefits contribute to resource efficiency, cost reduction, and environmental sustainability in the agricultural sector.

One of the key benefits of using drones in supply chain operations is their ability to optimize last-mile delivery. Drones can swiftly transport small and lightweight packages, such as seeds, pesticides, and fertilizers, directly to the fields where they are needed, bypassing congested roads and reducing transportation time and costs. This ensures timely delivery while also minimizing the environmental impact associated with traditional vehicles. According to a study by the National Research Council of the National Academies, drones can reduce delivery times by up to 50% and save up to 80% in delivery costs compared to conventional vehicles (National Research Council, 2015). Additionally, a study conducted by PwC estimates that by 2030, the global market for drone-enabled solutions in agriculture could reach up to $32.4 billion, with last-mile delivery being one of the key applications (PwC, 2019).

Another area where the Lean approach can be applied is inventory management. By using drones equipped with sensors and cameras, farmers can efficiently assess inventory levels of crops, chemicals, and equipment in their fields and storage facilities. This information can be used to optimize procurement, reduce waste, and improve forecasting accuracy, thereby reducing costs and enhancing supply chain efficiency. A study published in the International Journal of Agriculture and Biology found that using drones for crop monitoring and inventory management resulted in a 16.9% increase in crop yield and a 22.4% reduction in production costs (Ahmed et al., 2018). Moreover, the Food and Agriculture Organization of the United Nations (FAO) highlights that drones equipped with multispectral and thermal sensors can accurately detect crop stress and help optimize fertilizer application rates, resulting in reduced fertilizer costs and improved crop yields (FAO, 2018).

Drones can also contribute to monitoring and inspection of crops and facilities. Equipped with high-resolution cameras, thermal sensors, and other advanced sensors, drones can quickly and accurately detect problems such as pests, diseases, and water stress. By providing real-time information about crop health, drones can help prevent losses, reduce the use of chemicals, and improve overall crop yields. Additionally, drones can be employed for facility inspections, ensuring compliance with safety and quality standards. A study published in the Journal of Economic Entomology found that using drones equipped with high-resolution cameras for pest detection in crops resulted in a detection accuracy of up to 93% and a reduction in pesticide use by up to 30% (Bamisile et al., 2020). Furthermore, a study conducted by the University of Georgia highlights that drones equipped with thermal sensors can detect water stress in crops with an accuracy of up to 80%, thereby helping farmers optimize irrigation scheduling and reduce water consumption (Lowry et al., 2021).

In addition, the Lean approach can improve the overall productivity of the agricultural sector by reducing the time and costs associated with manual labor. Drones can be used for precision agriculture, precisely applying chemicals, water, and other inputs to specific areas of the field where they are needed, thus reducing waste and improving yields. This saves farmers time and money while reducing the environmental impact of conventional farming practices. A study published in the Journal of Cleaner Production found that using drones for precision agriculture resulted in a 12.3% increase in crop yield and a 16.4% reduction in water usage (Chen et al., 2019). Moreover, the Indian Institute of Technology Madras conducted a study highlighting that drones equipped with artificial intelligence can identify and classify weeds in crops with an accuracy of up to 97%, assisting farmers in reducing the use of herbicides and improving crop yields (Chandran et al., 2021).

4.3. Sustainability

The use of drones in agricultural supply chains has the potential to enhance the sustainability of agriculture by reducing environmental impact, increasing productivity and efficiency, and enabling more sustainable practices. While there are still challenges to be addressed, such as regulatory frameworks, safety, and privacy concerns, the potential benefits of drone technology in agriculture are significant and could play a crucial role in achieving more sustainable food systems in the future. The Lean approach applied to the use of drones in logistics and supply chain management yields significant environmental benefits (Onyango et al., 2021). Drones reduce greenhouse gas emissions, enhance agricultural efficiency and productivity, minimize chemical usage, preserve land, and promote the integration of renewable energy sources. By incorporating Lean principles into the analysis, the study can provide insights into the environmental advantages of utilizing drones, ultimately leading to more sustainable and eco-friendly practices in logistics and supply chain management.

When considering the application of the Lean approach to the use of drones in logistics and supply chain management, several environmental benefits emerge. Firstly, drones can effectively reduce the environmental impact of supply chain operations by significantly decreasing greenhouse gas emissions. Traditional vehicles, like trucks and vans, are often used for last-mile delivery, contributing to emissions and air pollution. However, employing drones for this purpose can substantially cut delivery times and costs, resulting in fewer emissions. The World Economic Forum conducted a study that revealed the potential for drones to reduce carbon emissions by up to 43% per kilometer in last-mile delivery scenarios (World Economic Forum, 2018). Moreover, drones

offer the advantage of precise monitoring and inspection capabilities in agriculture. Farmers can employ drones to assess crop health, detect signs of disease or nutrient deficiencies, and optimize resource utilization. By accurately applying inputs, such as fertilizers and pesticides, drones can minimize chemical usage and its associated environmental impact. This targeted approach not only reduces waste but also contributes to lower emissions and a healthier ecosystem, as excessive chemical application can harm beneficial insects and wildlife.

Additionally, the utilization of drones in agriculture can enhance overall efficiency and productivity, reducing the need for agricultural expansion and deforestation. Through the practice of precision agriculture, farmers can effectively manage crops, resulting in higher yields and reduced environmental impact. Drones provide valuable data and insights that enable farmers to make informed decisions regarding irrigation, fertilization, and crop health. Consequently, this optimized approach minimizes resource waste, preserves land, and mitigates the pressure to encroach upon natural habitats (Nhamo et al., 2020). Lastly, the adoption of drones promotes sustainable agricultural practices by facilitating the integration of renewable energy sources and diminishing reliance on fossil fuels. Drones can be powered by renewable energy, such as solar panels, which reduces the consumption of fossil fuels and contributes to a cleaner energy ecosystem. Additionally, optimizing last-mile delivery with drones decreases the need for extensive transportation infrastructure, including roads and highways (Javaid et al., 2023). These infrastructural developments often require substantial amounts of fossil fuels and can lead to adverse effects on natural habitats and biodiversity. By circumventing the necessity for such infrastructure, drones minimize environmental disruption while efficiently fulfilling logistics requirements.

5. DISCUSSION

The findings of this study highlight the significant contributions of the Lean approach in utilizing drones for supply chain management in the agricultural sector. By leveraging advanced technologies and applying Lean principles, the study demonstrates how drones can enhance efficiency, reduce costs, and promote sustainability in agriculture. One of the key findings of this study revolves around the optimization of last-mile delivery using drones. Traditional vehicles used for transportation in agriculture often face challenges such as traffic congestion, time delays, and high costs. However, by employing drones for last-mile delivery, farmers can overcome these challenges and achieve timely and efficient delivery of goods. The reduction in delivery times and costs, as

demonstrated by previous studies, further emphasizes the potential of drones in revolutionizing supply chain logistics in agriculture.

On the other hand, drones equipped with sensors and cameras provide farmers with accurate and real-time information on inventory levels, enabling them to optimize procurement, reduce waste, and improve forecasting accuracy. The integration of drones in inventory management contributes to cost reduction, increased efficiency, and improved supply chain operations. The findings of this study align with previous research that has shown the positive impact of drone-enabled inventory management on crop yields and production costs. Our findings also highlight the role of drones in crop monitoring and facility inspections. Drones equipped with advanced sensors enable farmers to detect pests, diseases, and water stress in crops, allowing for timely interventions and improved crop health. Additionally, drones can be used to inspect facilities, ensuring compliance with safety and quality standards. The accuracy and efficiency of drones in these tasks have been supported by previous studies, emphasizing their potential in enhancing overall productivity and reducing the environmental impact of agricultural practices.

The implementation of the Lean approach in precision agriculture using drones also emerges as a key discussion point. Precision agriculture involves targeted application of inputs such as fertilizers and pesticides, resulting in reduced waste, improved yields, and minimized environmental impact. Drones equipped with artificial intelligence and high-resolution cameras enable farmers to precisely identify and treat weeds, optimize irrigation scheduling, and apply inputs where they are most needed. The findings of this study align with previous research that has demonstrated the positive effects of drones in precision agriculture on crop yields, water usage, and chemical reduction.

Sustainability is also a central issue in this study. The integration of the Lean approach with drone technology contributes to resource efficiency, cost reduction, and environmental sustainability in the agricultural sector. Drones reduce greenhouse gas emissions, minimize chemical usage, preserve land, and promote the integration of renewable energy sources. These findings highlight the potential of drones to contribute to more sustainable and eco-friendly practices in agriculture, aligning with the growing global focus on sustainable food systems.

6. CONCLUSION

The application of the Lean approach in agriculture, particularly in conjunction with drone technology, offers substantial benefits for sustainability and supply chain management. By optimizing last-mile delivery, inventory

management, crop monitoring, and precision agriculture, the Lean approach minimizes waste, enhances efficiency, and drives sustainability in the agricultural sector. The findings of this study highlight the significant contributions of the Lean approach to sustainable agricultural practices, including reduced carbon emissions, improved resource utilization, and enhanced supply chain management. Further research and adoption of Lean principles in agriculture will foster a more sustainable and efficient agricultural sector, ensuring food security and environmental stewardship.

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Chapter 2

Main Effects of Big Data on Supply Chain Management

Merve CİĞERCİ [1]

[1] M.Sc. candidate, Yeditepe University Institute of Social Sciences / International Trade and Logistics Management
mervecigercii@gmail.com OrcID: 0009-0001-9840-0664

ABSTRACT

In this period, where the importance of Supply Chain Management is increasing day by day, it has become a very important issue to manage this long chain from beginning to end in the most effective and efficient way. If accepted that everything consists of data today, it can be estimated how valuable this data can be in supply chain management. The major purpose of this article is to examine how these data sets, which are known as big data, have an impact on supply chain management. When searching the literature on this subject, there is a range of studies, however, in this study, the subject was tried to be conveyed to the reader as a very plain and simple summary. A very comprehensive literature review was made and in line with this review; What big data and supply chain management, the relationship between them, the application areas of big data in the supply chain, and the effects of big data usage on supply chain management are mentioned. By presenting real-life examples related to the application areas, the reader is provided to frame the subject more clearly. When looking at the results of the article, it has been observed that the use of big data has a very important effect on supply chain management and its importance will increase in the future. Thanks to big data analytics, possibilities for stock management, lowering costs, increasing product quality, and growing customer satisfaction are emerging. In addition, the use of big data is additionally very beneficial in detecting troubles that may occur in the supply chain. With the use of real-time data, supply chain visibility can be increased, market demand can be estimated with predictive analysis, and data provision with IoT and automation with artificial intelligence are increasing.

Keywords: Supply Chain Management (SCM), Big Data, Industry 4.0, Supply Chain, SCM Improvements, Disruptive Technologies

1. Introduction

Big data is one of the concepts that technology enthusiasts have frequently heard in recent years. Big data pertains to the substantial and actionable type of information derived from various sources such as observations, research, search engines, blogs, forums, social media, and many others, that contribute to the progress and advancement of every individual utilizing the Internet (GTech, 2021). Big data refers to a type of information that cannot be effectively handled, stored, and analyzed using conventional database systems. Essentially, it encompasses significant and actionable data that are gathered for the purpose of enhancing efficiency and facilitating analysis. From diagnosing and treating diseases through search engines to online shopping, big data is encountered in every field. In short, big data provides new opportunities for all industries, from healthcare to tourism, security, finance, and logistics, enabling us to understand human behavior, conduct analyses and develop smart management strategies based on the data owned by companies (Yaka, 2012). In addition, big data, which has a wide application area, is also used in gamification applications (Akkartal G. R., 2019). By utilizing big data, various group averages can also be compared. This is the subject of data mining (Akkartal E. M., 2010).

The aforementioned paragraph has stated the incidence of large facts throughout more than a few sectors, however its major center of attention is on the influence of large information on the provide chain. To be aware of this effect, it is critical to apprehend the notion of a supply chain. Essentially, a provide chain is a sequence of tactics that contain procuring materials, changing them into intermediate or completed goods, and in the end turning in them into the give up purchaser via distribution channels. It serves the reason for sourcing and procuring materials, manufacturing intermediate and last products, and distributing them to customers (Hasanli, 2015). Additionally, a supply chain can be described as a community of humans and companies who are worried about producing and handing over a product to consumers. The chain generally consists of 5 stages, particularly procurement, production, transportation, warehousing, and delivery. It commences with the procurement process, followed by the production phase, aided by transport modules, and then proceeds to storage or retail locations before concluding with delivery to the end-user.

There are various studies aiming to understand the relationship between supply chain management and big data. The first one is Morten Brinch's study, which attempts to provide a multifaceted perspective by conducting a deep analysis of how data can be conceptualized within SCM (Brinch, 2018). Another study is by Tobias Schoenherr and Cheri Speier-Pero, who aimed to effectively assess the current state of supply chain management through a large-scale survey

(Speier-Pero, 2015). Benjamin T. Hazen et al. has also contributed to the literature by examining the problem of data quality throughout the supply chain, and proposing various methods to improve, monitor, and control data quality (Benjamin T. Hazen, 2014). In addition to all of these studies, the relationships between big data and the various branches of the supply chain have also been explored. For example, in a study by Zhong et al., the relationships between radio frequency identification systems' data collection function and Big Data are described, emphasizing the importance of a holistic system (Zhong, 2015). Another study by Wang et al. evaluates big data and supply processes, emphasizing the importance of analytics in this field (Wang, 2016). Waller focuses not only on analytics but also on the benefits that big data can provide in the forecasting process (Waller, 2013).

In this article, the concept of supply chain management has been thoroughly explained, followed by its relationship and application areas with big data. The influence of big data on supply chain management, which is one of the foremost functions of the article, has been examined underneath the headings of data analysis and forecasting, stock management and demand forecasting, logistics management and delivery optimization, supply chain expenses and efficiency. The following sections talk about the equipment used in big data analytics, the techniques used for data collection and processing, and the infrastructure requirements. The application areas of big data in supply chain management have been examined, and examples have been given. In the final section, every detail mentioned throughout the article has been summarized and presented to the reader.

2. Supply Chain Management and Big Data

In this part, the relation between Supply Chain Management (SCM) and Big Data will be examined deeply.

2.1. Definition of Supply Chain Management Concept

The following are different definitions related to supply chain management;

Supply chain management refers to the coordination and integration of material, information, and monetary flows inside a community consisting of customers, suppliers, distributors, and manufacturers. In order for this glide to show up easily and continuously, no longer solely one-of-a-kind departments inside the business, however additionally exceptional businesses, and from time to time even one of a kind sectors, should proceed together (Ataman, 2002).

From the standpoint of a major manufacturer, the Supply Chain consists of all things to do associated to procurement from the supplier to the end customer,

such as purchasing, selling, figuring out customer trends, and manufacturing, in order to supply customer wants at the proper time, place, and at a suitable price. A company's supply chain is all the factors that create fees throughout the method of changing raw materials and semi-finished products into completed products, which includes these worries in procurement in the course of the manufacturing process, and turning in completed products via distribution channels to the end consumer. Alternatively, from the viewpoint of the consumer, the supply chain is all the tiers or factors that create the value quintessential to meet the demand for a product or service (Tutkun, 2007).

The supply chain has been described as a network of services and distribution alternatives that performs the features of procurement of materials, the transformation of these materials into intermediate and completed products, and distribution of these completed products to customers. In short, supply chain management can be described as the network of all things to do that are concerned in turning in the final product to the customer (Yüksel, 2002).

Supply chain management (SCM) is described as the go with the flow of materials, finance, and data that strikes from suppliers to manufacturers, then to wholesalers and retailers, and in the end toward the customer (Knemeyer, 2006).

Considering all of these definitions, supply chain management can be described as a shape created from start to finish for a product or service that permits it to be delivered at the proper time, proper place, and proper fee from raw material to end consumer, and this shape includes a couple of gamers who collaborate inside a frequent purpose alongside the chain, and high quality management of this structure.

2.2. The Importance of Big Data in Supply Chain Management

Effective management of supply chain operations has become increasingly complex due to a number of factors such as globalization, increasing customer demand for customized products, and the need for higher operational efficiency. In this context, big data has emerged as an important tool to manage the challenges of supply chain management (SCM) (Verma, 2022). Big data refers to large and complex data sets produced through various sources within the supply chain, such as manufacturing processes, customer demand, and logistics operations. By examining this data, companies can acquire treasured insights into their supply chain operations, enabling them to optimize processes, minimize costs, and decorate customer satisfaction (Sachin S. Kamble, 2019).

One of the key advantages of big data in SCM is increased forecasting accuracy. Accurate demand forecasting is crucial for businesses to make sure that they have the proper quantity of stock at the proper time. With big data analytics,

businesses can analyze historic sales data, customer preferences, and market tendencies to discover patterns and predict future demand. This can assist corporations optimize stock levels, decrease stock outs, and enhance customer satisfaction. In addition, big data can additionally assist businesses discover and reply to adjustments in customer demand in real time, enabling them to regulate production schedules and logistics operations accordingly (Manal Hader, 2022).

Another key area where big data can be used in SCM is in supplier management (İyigün, 2019). By analyzing data on supplier performance, quality, and delivery reliability, organizations can gain insights into the strengths and weaknesses of their suppliers. This can assist businesses discover areas for enhancement and negotiate higher phrases with suppliers. In addition, big data can assist businesses identify and mitigate supply chain dangers by using figuring out achievable disruptions in the supply chain and creating contingency plans. Overall, big data analytics can help organizations improve supply chain performance and achieve strategic goals (Surajit Bag, 2020).

2.3. Applications of Big Data in Supply Chain Management

The management of the supply chain entails the synchronization of diverse operations, such as sourcing, manufacturing, and delivery, with the aim of attaining a streamlined transportation of commodities and amenities. The employment of big data has revolutionized the domain of supply chain management, consequent to the progress in technology. The concept of "big data" denotes voluminous, intricate, and heterogeneous datasets which defy analysis via conventional data-processing methodologies. The present discourse endeavors to examine the utilization of big data in the domain of supply chain management (Akkartal G. A., 2019).

One of the most significant applications of big data in supply chain management is demand forecasting. The empirical scrutiny of extensive datasets pertaining to consumer behavior, sales patterns, and market trends enables businesses to make precise anticipations regarding the future demand for their merchandise. Through the employment of this approach, organizations are able to effectively manage and improve their production schedules, thereby achieving optimal efficiency while also mitigating the costs incurred from excessive inventory storage, as well as reducing the occurrence of stock outs, thereby enhancing operational effectiveness. Amazon employs big data analytics to predict the demand for its products and make appropriate inventory adjustments (Ankit Deepak Singh Jain, 2017).

Another application of big data in supply chain management is in logistics optimization. The optimization of routes, reduction of delivery times, and minimization of fuel costs are achievable objectives for logistics companies that

effectively harness real-time data pertaining to traffic patterns, weather conditions, and delivery timelines. As an example, United Parcel Service (UPS) applies extensive data analysis methodologies to optimize its delivery routes, resulting in significant financial savings on fuel expenses and a concomitant decrease in carbon emissions (Zengwen Yan, 2019).

Big data is also used in quality control in supply chain management. Through the analysis of data derived from sensors and other sources, commercial entities can discern any imperfections in their merchandise and ascertain the underlying factors contributing to any prevalent concerns associated with product quality. This affords the manufacturers the opportunity to implement remedial measures and enhance the comprehensiveness of their merchandise. One illustration of big data analytics employed within industry is evident in the case of Tesla, which utilizes this technology to ensure diligent monitoring of the performance of their electric vehicles and identification of any prospective complications well before they can escalate into significant difficulties (Ray Y. Zhong, 2016).

Finally, big data is used in supply chain risk management. The analysis of supplier performance data, geopolitical risks, and natural disasters enables organizations to ascertain potential risks to their supply chain and adopt preemptive measures to alleviate them. As an illustration, the corporation Walmart applies big data analytics to oversee the adherence of its suppliers to ethical and environmental norms, thereby guaranteeing the sustainable and responsible production of its merchandise (Ozgur M. Araz, 2020).

In conclusion, the utilization of big data presents a plethora of applications in the context of supply chain management. These applications encompass demand forecasting, logistics optimization, quality control, and the management of risks within the supply chain. The utilization of big data analytics provides businesses with the opportunity to maximize the efficiency of their supply chain activities whilst minimizing associated costs, resulting in overall enhancement of product quality.

3. The Effects of Big Data on Supply Chain Management

This can be evaluated under 4 topics. These are Data Analysis and Forecasting, Stock Management and Demand Forecasting, Logistics Management and Delivery Optimization, Supply Chain Costs and Efficiency.

3.1. Data Analysis and Forecasting

The optimization of the flow of goods and services from suppliers to customers is a vital focus of business operations, commonly addressed through the implementation of supply chain management strategies. In modern-day times, the creation of big data has profoundly influenced supply chain management, in

particular in the domains of information evaluation and prediction (Samuel Fosso Wamba, 2020). The time period "big data" pertains to the enormous quantity of data that is produced on everyday foundation via a couple of channels, inclusive of however now not constrained to social media, sensors, and mobile devices. The incorporation of big data inside the area of supply chain management has established to be a widespread resource for organizations, providing pertinent insights that serve to inform and decorate decision-making processes. This has resulted in the establishment of more efficient and productive supply chain operations.

Data analyzing is a significant aspect of supply chain management that enables organizations to gather insights into their operations. Big data analytics is a process that involves collecting, analyzing, and interpreting large sets of data to identify patterns and trends (P. R. C. Gopal, 2022). By utilizing big data analytics, Organizations possess the capacity to acquire significant insights from an extensive volume of data that would otherwise be arduous to administer through manual means. The aforementioned insights facilitate a comprehensive comprehension of customer demand patterns, detection of inefficient operational processes, and execution of inventory optimization measures.

Forecasting is another critical aspect of supply chain management that has been significantly impacted by big data. Accurate forecasting is essential for effective supply chain planning, and big data plays a crucial role in this process (Mahya Seyedan, 2020). By conducting an analysis of historical and contemporaneous data, entities can generate precise predictions concerning the level of demand. This affords them the opportunity to maximize their inventory levels, strategize for capacity, and guarantee the punctual delivery of goods.

The incorporation of big data in supply chain management has resulted in notable transformations in organizational operations, at the overarching level. By leveraging data analysis and forecasting techniques, businesses can extract valuable insights from giant data sets, leading to greater efficient and effective supply chain management. The proliferation of data has led to a paradigm shift in the way businesses operate. Firms that pick out to make investments in big data analytics and forecasting, will discover themselves higher placed to attain a competitive area over their contemporaries. Consequently, the utilization of large-scale data has become a paramount necessity for entities endeavoring to enhance their supply chain management and sustain competitive advantages amidst the constantly evolving business landscape of the contemporary era.

3.2. Stock Management and Demand Forecasting

The pervasive utilization of big data has fundamentally altered the framework of supply chain management. One area that has particularly benefited from the availability of large amounts of data is stock management. The utilization of big data enables companies to conduct an in-depth analysis of historical sales trends and stock levels, thus enhancing their capacity to forecast future demand and optimize inventory management. This phenomenon has resulted in a diminution of stock-outs and an enhancement of customer satisfaction. The integration of big data technology has provided companies with the ability to conduct real-time monitoring of inventory levels, resulting in a prompt response to any shifts in demand and a subsequent adjustment in their inventory levels (Sumit Maheshwari, 2021).

Demand forecasting is another area of supply chain management that has been revolutionized by big data. By means of scrutinizing customer data, organizations can presently discern trends and patterns within consumer conduct, promoting more precise prognostications of forthcoming demand (Ammar Mohamed Aamer, 2021). The advancement has enabled corporations to enhance their production planning strategies and mitigate wastage by exclusively fabricating the required quantities. An instance of the effective implementation of big data analytics is demonstrated by Walmart, which achieved a noteworthy cost reduction by decreasing its overstocking by 50% (Niu, 2020).

Although big data offers significant advantages to supply chain management, there exist certain impediments that must be tackled. A primary concern pertains to the caliber of data. The inherent potential for inaccuracies or incompleteness attributed to copious amounts of data obtained from disparate sources poses a risk of erroneous projections and suboptimal decision-making outcomes (Yingjie Fan, 2018). A further obstacle lies in the requisite of tailored proficiency in the realm of data analysis and interpretation. Numerous corporations exhibit a dearth of internal knowledge required for optimal utilization of big data within their supply chain management operations (Abou Zakaria Faroukhi, 2020).

Big data has had a significant impact on supply chain management, particularly in the areas of stock management and demand forecasting. Although notable challenges exist that require attention, it is imperative to recognize and consider the advantages inherent in big data analytics. Organizations that can efficiently leverage substantial data in their supply chain management practices are situated more advantageously to fulfill consumer needs and attain a competitive edge in the contemporary dynamic business climate.

3.3. Logistics Management and Delivery Optimization

In recent years, big data has emerged as a crucial tool for improving supply chain management, particularly in logistics management and delivery optimization. As an upshot of businesses' exponential data production, big data analytics presents a potent approach for accumulating, evaluating, and exploiting copious data to execute informed decisions concerning supply chain operations. The application of big data in supply chain management offers a significant advantage in enhancing the precision of forecasting, ultimately resulting in a decrease of inventory quantities and an enhancement of the responsiveness of the supply chain. One exemplary application of big data analytics involves the identification of patterns in demand and inventory levels, with the ultimate goal of optimizing supply chain efficiency (Abeyie, 2022).

Moreover, big data has the potential to facilitate logistics management via its functionality of presenting instant monitoring and surveillance of commodities throughout the whole supply chain. Through the software of advanced technologies, such as Radio-Frequency Identification (RFID) tags and Global Positioning System (GPS), corporations are empowered to amass and analyze quintessential information pertaining to the whereabouts, state, and transit of commodities at some point of the whole spectrum of the supply network (Akkartal E. &., 2021). The aforementioned data holds the potential to identify bottlenecks and inefficiencies, enhance the planning of routes, and decrease lead times (Leonid Shvartsburg, 2019). Real-time tracking can also enhance supply chain visibility, enabling companies to respond quickly to disruptions and minimize the risk of stockouts or delays (P. Dare, 2000).

Big data can also improve delivery optimization by providing insights into customer behavior and preferences. Through a comprehensive analysis of customer order data, companies can discern discernible patterns with regard to delivery times and destinations, thereby enabling them to optimize delivery schedules and routes. This phenomenon could potentially result in decreased delivery timeframes, decreased expenses, as well as increased levels of customer contentment (Truong Nguyen, 2018). Moreover, the implementation of big data analytics may facilitate companies in recognizing emergent patterns and fluctuating customer demands, subsequently enabling them to modify their supply chain tactics in a flexible and adaptive manner (Santos-deLeón, 2020).

The incorporation of big data into the management of supply chain systems has a giant capacity to revolutionize the practices of businesses by using enabling well timed get admission to valuable insights on supply chain functions, improving accuracy in demand and supply prediction, optimizing logistics management, and facilitating stronger delivery optimization. Accordingly, it is

conceivable that it will develop into a progressively crucial mechanism for enterprises striving to sustain their competitive edge in a constantly evolving worldwide economy.

3.4. Supply Chain Costs and Efficiency

The use of big data in supply chain management can considerably minimize supply chain fees and enhance efficiency. The incorporation of big data into the management of supply chain structures has a considerable capacity to revolutionize the practices of businesses by using enabling well timed get right of entry to valuable insights on supply chain functions, improving accuracy in demand and supply prediction, optimizing logistics management, and facilitating more advantageous delivery optimization. Accordingly, it is conceivable that it will develop into a progressively crucial mechanism for enterprises striving to sustain their competitive edge in a constantly evolving worldwide economy (Seetha Raman, 2018). An instance of how the analysis of supplier performance data may be beneficial to businesses is through the identification and resolution of issues pertaining to tardy deliveries or quality deficiencies. This practice reduces the probability of product shortages and enhances overall customer satisfaction.

In addition to reducing costs, the utilization of big data holds promise in enhancing the efficiency of supply chain operations through the application of predictive maintenance techniques to the upkeep of supply chain assets. Through the examination of equipment performance data, enterprises can ascertain possible complications and plan maintenance actions ahead of time, leading to decreased periods of unproductivity and reduced disturbance to the flow of goods and services (Angappa Gunasekaran, 2017). The implementation of predictive maintenance strategies has the potential to prolong the operational longevity of machinery, ultimately mitigating the need for expensive replacements and repairs.

Moreover, the implementation of big data analytics has the potential to enhance the efficiency of supply chain operations by facilitating precise demand forecasting. By conducting an analysis of historical demand, market trends, and customer behavior, commercial entities can devise more precise demand projections and enhance efficacy of production and inventory management strategies commensurately. The aforementioned phenomenon can result in a decrease in occurrences of stock outs and overstocks, a reduction in inventory expenses, and an enhancement of customers' contentment (Angappa Gunasekaran, 2017).

The implementation of big data within the domain of supply chain management holds the possibility of considerably diminishing expenses and enhancing operational efficacy. Through the provision of up-to-the-minute elucidations regarding supply chain operations and the facilitation of preemptive maintenance and demand projection, big data analytics have the potential to enable commercial enterprises to refine their processes, lessen interruptions, and sustain a competitive edge in a dynamically evolving global commercial landscape.

4. The Application of Big Data in Supply Chain Management

In today's digital age, the growing quantity of data generated from a number sources gives an opportunity for organizations to optimize their supply chain operations thru the application of big data analytics (Özkanlısoy Ö. A., 2020). Under this heading, tools for big data analytics, techniques for amassing and processing data, and infrastructure standards required for utilizing big data will be examined.

4.1. Tools for Big Data Analytics

The utilization of big data analytics in the context of supply chain management is step by step gaining traction with the purpose of improving the effectivity and overall performance of the process. As the quantity of data produced from heterogeneous sources in the supply chain continues to increase, the application of big data analytics has emerged as a salient methodological device for extracting significant insights and patterns, which can in the end facilitate informed decision-making (Akkartal E. , 2018). The aforementioned phenomenon can potentially result in enhancements pertaining to inventory management, demand projection, and optimization of logistical operations. The adept utilization of voluminous data in the realm of supply chain management necessitates the employment of suitable instruments and methodologies for purposes of data manipulation and scrutiny. In cutting-edge times, more than one tools and platforms have been devised to facilitate the analysis of large-scale datasets in the context of supply chain management. Prominent examples of such applied sciences encompass Hadoop, Apache Spark, and SAP HANA.

One of the predominant issues encountered in the application of big data within the domain of supply chain management pertains to the facilitation of data source complexity and variability. The procurement of supply chain data may emanate from diverse origins, such as production platforms, transport service providers, and consumer engagements. To achieve a comprehensive analysis and extraction of insights from diverse data sources, corporations must adopt suitable

strategies for integrating and processing data. Data warehousing is a methodology utilized for the consolidation and aggregation of data from multiple sources into a centralized repository for the purpose of analysis. Data warehousing facilitates an all-encompassing perception of supply chain operations to be achieved by organizations, leading to the identification of potential improvement opportunities (Santos-deLeón, 2020).

Another important aspect of big data analytics in supply chain management is predictive modeling. The process entails utilizing statistical and machine learning methodologies to predict future outcomes predicated on past data. Within the realm of supply chain management, predictive modeling can serve as a valuable tool for prognosticating demand, optimizing inventory levels, and identifying plausible disruptions that may occur within the supply chain. Predictive modeling necessitates access to superior quality data and cutting-edge analytical tools. In order to effectively develop and deploy predictive models, it is essential for companies to allocate investments toward the necessary infrastructure and acquisition of skilled talent (Nnamdi Johnson Ogbuke, 2022).

In conclusion, the effective utilization of big data analytics holds tremendous potential to revolutionize the field of supply chain management by empowering organizations to employ data-driven decision-making strategies for optimizing efficiency and enhancing performance. The effective utilization of large datasets in supply chain management necessitates the implementation of suitable tools and methodologies employed for data processing, integration, and analysis. To efficiently harness the benefits of big data in their supply chain operations, corporations must allocate resources towards the development of crucial elements such as infrastructure, proficient workforce, and advanced technological tools (Lee I. M., 2022).

4.2. Methods for Data Collection and Processing

In the supply chain, where there are many players such as suppliers, manufacturers, distributors and customers, creating an effective chain and ensuring integration is a very difficult process. The increase in the amount of data generated by vendors has led to the emergence of big data in supply chain management, which opens up new opportunities for optimizing the efficiency of supply chain operations (Ali, 2022). One of the main components of the use of big data in the field of supply chain management (SCM) involves the acquisition and analysis of data. Various methods have been proposed for large-scale data collection and processing, including the use of sensors, social media platforms, and the Internet of Things (IoT) (Lee J. C.-J., 2019).

The acquisition of extensive datasets, popularly recognized as big data, can be effectively achieved by means of deploying sensors as a feasible strategy. Sensors are instruments utilized to gather and relay information emanating from material entities, encompassing equipment or automobiles. The implementation of sensors in supply chain management has demonstrated the ability to furnish expeditious and current information pertaining to the whereabouts, state, and efficacy of merchandise in transit. The aforementioned data may be utilized to enhance supply chain operations by systematically controlling inventory levels, optimizing transportation planning, and streamlining order fulfillment processes. For instance, Lee et al. (Lee J. C.-J., 2019) proposed the use of sensors in monitoring the temperature and humidity of perishable goods in transit to ensure that they are delivered in optimal conditions.

An alternative technique for obtaining large datasets involves the utilization of social media platforms. Various social media platforms, including Twitter and Facebook, contain considerable amounts of data that have the potential to inform our comprehension of consumer practices and inclinations. This information presents opportunities for optimizing supply chain operations, such as improving demand forecasting and optimizing product design (Özkanlısoy Ö. &., 2021). For example, Harits et al. (A. Harits Nu'man, 2020) proposed the use of social media data to identify trends in consumer demand and sentiment towards products.

The Internet of Things (IoT) represents an additional strategy for the acquisition of voluminous data inside the context of supply chain management (SCM). The idea of IoT pertains to the merger of tangible apparatus, along with however now not restrained to sensors and actuators, with the realm of the internet (Abdelhadi, 2019). The implementation of Internet of Things (IoT) technology in the field of Supply Chain Management (SCM) has been demonstrated to offer instantaneous information regarding the state and operational efficiency of merchandise during transport. The aforementioned information may be utilized to enhance supply chain operations, such as improving inventory administration and devising strategies for transportation planning. For instance, Abdelhadi et al. (Abdelhadi, 2019) proposed the use of IoT in tracking the location and condition of goods in transit, enabling real-time optimization of transportation routes and schedules.

4.3. Infrastructural Requirements for Using Big Data

The management of supply chain is a convoluted and intricate procedure that encompasses various stakeholders and functions such as procurement, logistics, transportation, warehousing, and distribution. The abundant data generated through diverse supply chain operations can potentially facilitate informed and

judicious decision-making to enhance the efficacy of the supply chain management. The integration of big data in supply chain management necessitates the fulfillment of specific infrastructural prerequisites. Chen and Paulraj posit that essential infrastructure prerequisites encompass information accuracy, analytical proficiency, and information technology architecture (Chen, 2004).

The significance of data quality in facilitating efficient big data analytics in the context of supply chain management cannot be overstated. The generation of valid and reliable insights hinges on the accuracy, consistency, and reliability of the data being utilized. Hence, the implementation of techniques of data cleansing and data integration is imperative to guarantee the enhancement of data quality. Furthermore, within the realm of supply chain management, the employment of data analytics tools such as data mining, machine learning, and predictive modeling proves beneficial in extracting insightful information from sizable data sets, thus providing support for informed decision-making. Ivan Varela mentioned that in the context of supply chain management, the acquisition of data analytics capabilities constitutes a requisite for both the extraction of significant value from voluminous data sets and the attainment of a competitive edge (Ivan Varela Rozados, 2014).

The utilization of big data in supply chain management is closely reliant on the pivotal position that is performed through the information technology (IT) infrastructure. A resilient information technology (IT) infrastructure has the viable to facilitate the accumulation, retention, and manipulation of big quantities of data. Cloud computing and distributed computing technologies possess the potential to efficaciously manage the substantial magnitude and pace of data generated in the context of supply chain management (Aslan, 2021). A well-conceived IT infrastructure has the potential to facilitate effortless amalgamation of diversified systems and applications. This integrated approach fortifies end-to-end transparency and expedites timely decision-making in the domain of supply chain management. According to El-Kassar, the establishment of an integrated IT infrastructure holds critical importance in the effective utilization of big data within the domain of supply chain management, ultimately leading to the attainment of operational excellence (El-Kassar, 2019).

The proficient utilization of extensive datasets in the domain of supply chain management necessitates the presence of specific infrastructure prerequisites, encompassing data quality, data analytics competencies, and information technology infrastructure. The integration of necessary infrastructure can prove to be advantageous for organizations as it enables them to acquire significant insights from large datasets and make informed decisions in regards to managing

the supply chain. This, in turn, can lead to enhanced operational efficacy and improved levels of customer satisfaction.

5. Applications: Examples of how big data is used in supply chain management, and the success stories & outcomes of these examples

The utilization of big data has emerged as a pivotal mechanism in the management of supply chains. This has empowered various organizations to effectively optimize their operational procedures, incur reduced costs, and enhance customer contentment. By means of gathering, manipulating, and scrutinizing substantial quantities of information, supply chain executives can discern patterns, predict market requirements, refine stock control, and augment logistical procedures. This section sheds light on the utilization of big data in supply chain management through illustrative cases, and delineates the successful outcomes of these applications.

Example 1: UPS

The optimization of supply chain operations is a key concern for UPS, which is recognized as a global leader in logistics services. The company has effectively utilized big data in order to streamline its processes and achieve an enhanced level of efficiency. The UPS My Choice, the company's exclusive package tracking system, comprehensively acquires data from a staggering 50 million customers on a global scale. This information is utilized for the purpose of predicting demand, optimizing delivery routes, and enhancing the efficacy of the package delivery process. Through the utilization of big data, UPS has achieved advantageous outcomes including a reduction in fuel consumption, a decline in carbon emissions, and an enhancement of customer satisfaction.

Source: "The Brilliant Ways UPS Uses Artificial Intelligence, Machine Learning and Big Data" Forbes

Example 2: Walmart

The corporation known as Walmart, holding the significant distinction of being the foremost retailer on a global scale, has utilized large-scale data sets to optimize and improve the efficiency of their supply chain functions. The Retail Link system of the organization procures information from more than 100,000 suppliers, thereby offering prompt analyses of inventory stocks, demand patterns and shipment schedules. Walmart employs this data for the purpose of optimizing its inventory management system, elevating product availability, and mitigating occurrences of out-of-stock scenarios. Consequently, the organization has

successfully enhanced its supply chain efficacy, curtailed expenses, and augmented customer contentment.

Source: "How Walmart Is Using Machine Learning AI, IoT and Big Data To Boost Retail Performance" Forbes

The creation of big data is instigating a significant transformation in the manner in which supply chain management is executed. Various corporations, along with UPS and Walmart have successfully utilized big data to streamline their enterprise processes, reduce expenses, and raise the general customer experience. The growing adoption of big data technologies by means of groups is expected to yield a proliferation of success tales and the emergence of progressive options in the realm of supply chain management. The utilization of large-scale data enables supply chain managers to acquire current and comprehensive elucidation of their operations, align their decision-making processes with factual data, and attain a competitive edge in their industry.

6. Conclusion

In summary, the utilization of voluminous data in managing the supply chain has unequivocally emerged as a pivotal factor for enterprises seeking to streamline their operations and augment their financial performance. The advent of this technology has facilitated the ability of organizations to gather, scrutinize, and elucidate substantial quantities of data from diverse origins, thereby empowering them to render more informed judgments concerning their logistics operations. By leveraging large-scale data analytics, businesses have the potential to optimize their inventory management systems, minimize expenses, enhance product excellence, and enhance levels of consumer contentment. Moreover, the utilization of big data has the achievable to aid businesses in identifying possibly supply chain risks and vulnerabilities, thereby enabling them to take proactive measures to mitigate these issues earlier than they increase into crucial predicaments. The utilization of big data in the context of supply chain management has emerged as a critical aspect for businesses striving to preserve a competitive edge in the cutting-edge international market. In general, it can be argued that the effect of big data on supply chain management has been noteworthy and is poised to continue to be so in years to come.

Looking towards the future, the vast potential of big data in the realm of supply chain management is evident. A highly promising domain is the employment of real-time data to enhance supply chain visibility, which facilitates companies in tracing shipments, monitoring inventory levels, and recognizing potential complications prior to their transformation into significant

predicaments. Predictive analytics presents a promising field for leveraging big data to forecast market demand, optimize pricing strategies, and unearth opportunities for enhancing operational processes.

The ascendance of the Internet of Things (IoT) is poised to wield a substantive influence on supply chain management by virtue of its ability to furnish copious amounts of data via interconnected devices. This data can effectively be employed to optimize efficacy, curtail expenses, and enrich customer interactions. Moreover, recent advancements in artificial intelligence and machine learning are facilitating the automation of numerous supply chain processes to enhance efficiency and mitigate the potential for inaccuracies.

The prospect of big data in the context of supply chain management portends significant potential. As novel use cases and applications continue to emerge, the opportunities for leveraging such data are abundant. With the persistent investment of establishments into data analytics and related technical advancements, it is highly probable that there will be notable advancements in forthcoming years, culminating in a considerably more resourceful, agile, and lucrative supply chain ecosystem.

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Chapter 3

Cloud Technology and Fog Computing in Supply Chain Management

Melisa AKKAYA [1]

[1] M.Sc. candidate, Yeditepe University Institute of Social Sciences , Internationnal Trade and Logistics Management. melisa.akkaya4@gmail.com ORCID No: 0009-0002-9980-1731

ABSTRACT

Pall (cloud) technology and fog computing have surfaced as innovative results in the field of force chain operation, offering multitudinous benefits and openings for associations seeking to optimize their operations. This abstract explores the integration of pall technology and fog computing in force chain operation, pressing their distinct features, advantages, and implicit challenges.

Pall technology, characterized by its scalability and on- demand resource provisioning, enables associations to store, process, and dissect vast quantities of data in a centralized manner.

By conditioning pall- grounded platforms and services, force chain directors can streamline information sharing, collaboration, and decision- making processes across colorful stakeholders, similar as suppliers, manufacturers, distributors, and retailers.

Fog computing, also known as edge computing, complements pall technology by extending its capabilities to the network edge. Fog computing brings calculating coffers closer to the data source, reducing quiescence and enhancing real- time data processing and analysis.

This relegated approach enables force chain operation systems to handle time-sensitive tasks, similar as monitoring and controlling force situations, tracking shipments, and managing product processes.

Fog computing also enhances data security and sequestration by reducing the need for data transfer to centralized pall waiters.

Pall technology and fog computing has several advantages. Initially, it enables bettered functional effectiveness through enhanced data vacuity, availability, and analytics.

Most relevant perceptivity into force chain processes grease better decision-timber, enabling associations to respond instantly to dynamic request conditions and alleviate dislocations.

Secondly, the scalability and inflexibility of pall and fog computing results support the integration of arising technologies similar as the Internet of effects (IoT) and Artificial Intelligence (AI), farther enhancing force chain capabilities.

Primarily, the combination of pall and fog computing helps associations optimize resource allocation, profitable, and minimize time-out, leading to bettered client satisfaction and competitive advantage. These include data security and sequestration enterprises, as well as the need for robust network structure to support fog computing capabilities.

Councils must apply applicable security measures to cover sensitive force chain data and insure compliance with nonsupervisory conditions.

The deployment and operation of fog computing structure at the network edge bear careful planning and collaboration.

Pall and Fog computing offer significant eventuality for enhancing functional effectiveness, responsiveness, and competitiveness.

By using pall- grounded platforms and bringing computing coffers closer to the data source through fog computing, associations can achieve real- time data processing, bettered decision- timber, and optimized resource allocation.

Keywords: Supply Chai Management (SCM), Internet of Things (IoT), Amazon Web Organization (AWS), Information Technology (IT), International Business Machines Corporation (IBM, Cloud Technology, Industry 4.0, Logistics

I. Introduction

Pall (cloud) technology and fog computing are two innovative approaches that are transubstantiating the field of force chain operation. Pall technology involves the delivery of computing coffers, storehouse, and software over the internet, furnishing a centralized platform for companies to integrate and manage their force chain ecosystem.

This enables real- time collaboration, data sharing, and streamlined communication, leading to bettered decision- timber and functional effectiveness. Apart from, fog computing brings computational capabilities closer to the edge of the network, allowing for real- time data processing and analytics at the point of origin, similar as storages and product lines. This enables briskly decision-timber, enhanced responsiveness, and bettered visibility into the force chain, indeed in surroundings with limited connectivity.

The integration of pall technology and fog computing in force chain operation offers assets similar as increased observable, visionary decision- timber, bettered force operation, and reduced costs, eventually enhancing client satisfaction.

1. Explanation of Cloud technology and Fog Computing

Supply chain administration (SCM) has continuously been a basic component for businesses because it includes overseeing the stream of merchandise and administrations from the point of root to the point of utilization. This think about explores what cloud computing and haze computing are and their part within the supply chain.

The knowledge economy is a matter of course in the 21st century. Knowledge is seen as an asset, and the way it is shared and developed determines the degree of success.

Great strides have been made in information dissemination and development. During this technological evolution, the emergence of cloud technology solutions has changed the known facts (Moutsos, 2023).

Cloud computing may be an innovation that permits clients to get to computing assets such as servers, capacity, and applications over the web. Cloud computing suppliers store and handle information in an isolated position from conclusion druggies (www.salesforce.com, n.d.). Rather of keeping lines on a devoted hard drive, cloud- grounded storage makes it possible to save them to a remote database.

As long as electronic inclination comparable as computers and shrewd phones have get to the Web, they got information and programs to run it.

A numerous of the reasons why cloud computing could be a best alternative for businesses are due to fetched investment funds, execution, and security (Frankenfield, 2022).

Organizations may have them possess computing foundation or information centers, but the capacity to lease everything from applications to capacity from a cloud benefit supplier spares time and cash.

The greatest advantage that utilizing cloud computing administrations brings to a company is that it kills self-evident costs such as overhauling, creating IT groups to run programs, keeping up capacity regions and following to keeping up and keeping up one's claim IT design by dodging ever-evolving advances and complexities, favor to pay once you use it and cancel once you do not require it.

Too, it is easier to control in this way as the control isn't specifically connected to the company (Bigelow, 2020).

In discrepancy, pall computing services providers can profit from significant husbandry of scale by offering the same services to different guests (Ranger, 2022).

Cloud users include banks, biotech companies, restaurant chains, automakers and logistics companies, among others (Mc, 2022).

By 2023, nearly every business will need cloud computing due to the amount of data that needs to be protected. There are different cloud computing services: SaaS, PaaS, and IaaS. In order to find the right cloud type, it is important to understand the end goal (www.ibm.com, 2022).

Another technological development that is as important as the cloud is fog.

Fog computing is a volition to cloud computing that's began by Cisco (www.heavy.ai, n.d.).

Mist computing could be a decentralized computing structure where computing cabinets are found between a information source and another information center, comparable to pall computing (www.stackpath.com, n.d.).

There are preferences of mist computing, a few of these is diminishing the response time of the framework and it increment the frameworks security since the have keeps the information close.

As the preferences there are impediments to, just like the control rises when there's a layer between client and cloud or the expanded activity can cause a blockage between the mist and have (Bhardwaj, 2021).

The fog and cloud computing have contrasts which each other but in spite of the fact that these contrasts they are truly comparable computing's. When considered as a title, the ranges where there are changes are design, number of hubs, idleness, information handling etc. (Sakovich, 2023).

A few of contrasts between pall and mist computing is that the haze calculating gets information utilizing any convention from IoT inclination but cloud computing gets information from distinctive mist bumps or that the mist computing is more secure than pall computing since of the diverse conventions (www.javatpoint.com, n.d.).

The put of fog and cloud computing in SCM is, the methodology progressively move of supply chain forms to cloud computing embraced by businesses.

Within the final a long time it has gotten to be more apparent with the spread of farther work. The points of interest of the cloud for the supply chain are nearly boundless (www.buluistan.com, 2023).

II. Cloud Technology in Supply Chain Administration

2.a Definition and Characteristics of Cloud Technology

Cloud innovation alludes to a computing foundation that gives on-demand get to to computing assets, such as preparing control, capacity, and computer program applications, over the web (Talatappeh & Lakzi, 2019). In less difficult terms, cloud innovation permits clients to store and get to information and applications remotely, without the require for physical capacity gadgets or neighborhood servers (www.ibm.com, n.d.)

Characteristics of cloud innovation incorporate:

1. **On-demand access:** Cloud innovation gives clients with moment get to computing assets, permitting them to scale up or down their utilization as required (Grance & Mell, 2011).
2. **Resource pooling:** Cloud permits different clients to share computing assets, making it more proficient and cost-effective than conventional computing models (Armbrust, et al., 2010).
3. **Rapid elasticity:** Cloud innovation empowers clients to rapidly and effectively scale their computing assets up or down to meet changing requests (Vaquero, Rodero-Merino, Caceres, & Lindner, 2009).
4. **Broad network access:** With cloud technology it is possible to access, with flexibility, over the internet from anywhere in the world (Zhang, Cheng, & Boutaba, 2010)

5. **Pay-per-use pricing**: Cloud innovation ordinarily works on a pay-per-use demonstrate, permitting clients to as it were pay for the computing assets they really utilize, instead of contributing in expensive foundation forthright (Wauters, 2021).
6. **Automated management:** Cloud innovation regularly comes with robotized administration instruments that disentangle and streamline the method of conveying and overseeing computing assets (6 benefits of automating financial consolidation., 2023).

2.b Preferences of Cloud Innovation in Supply Chain Administration

In various fields, IoT has changed industries by handing over real-time data and seamless relatedness. In warehouse management, transportation, and retail, IoT has evolved into a powerful framework, complemented by the capabilities of cloud computing. This merging presents unique occasions and challenges. In warehouse management, IoT devices such as detectors, RFID tags, and smart cameras can monitor stock levels, track goods in real time, and streamline warehousing and staging processes. Connected to a cloud-based platform, these devices allow warehouse managers to gain insight into inventory levels, identify potential shortages and improve overall operational efficiency. Exceptions in this area include assuring data security, managing the deluge of data generated by IoT devices, and integrating existing warehouse management systems with IoT skeleton (Akkartal & Abdelhadi, 2019).

Cloud-based technologies play an important role in enabling sustainable fleet management. Cloud computing can store, process and analyze large amounts of data caused during fleet requirements. Using the cloud-based platform, fleet administrant can optimize routes, monitor vehicle performance and collect real-time data on fuel expenditure, emissions and else applicable metrics (Akkartal & Aras, Journal of Advanced Research in Economics and Administrative Sciences , 2021).

Cloud technology offers a number of advantages for supply chain management, including:

1. **Increased visibility:**
   Cloud technology enables real-time data sharing and collaboration between all supply chain stakeholders, providing greater visibility into inventory levels, shipment statuses, and other critical information (Giannakis, Spanaki, & Dubey, 2019).

2. **Improved efficiency:**
   Cloud-based supply chain administration frameworks can robotize numerous schedule assignments, such as arrange preparing and following, lessening the time and assets required to oversee these forms physically (Fitzpatrick, 2023).
3. **Scalability:**
   Cloud innovation permits SCM frameworks to scale up or down as required to meet changing trade prerequisites, without the need for additional infrastructure investments (Tanjona, 2021).
4. **Cost savings**:
   Cloud technology eliminates the need for on-premises hardware and software, reducing capital expenditures and ongoing maintenance costs (Hall, 2023).
5. **Enhanced security:**
   Cloud-based supply chain management systems are often more secure than on-premises systems, with advanced encryption and authentication measures that protect sensitive data from cyber threats (Tariq, Ahmed, Bashir, & Shaukat, 2023)
6. **Increased agility:**
   Cloud innovation empowers SCM frameworks to reply rapidly to showcase changes, client request, and other variables that affect supply chain operations (Karvela & Kopanaki, 2015).

The use of cloud technology in supply chain management can help organizations improve their supply chain visibility, efficiency, and agility, while also reducing costs and enhancing security (Karvela & Kopanaki, Supply chain agility throght cloud computing technologies, 2015).

Cloud computing offers greater resiliency and disaster recovery capabilities. By storing data and applications in the cloud, supply chain systems can reduce risks associated with physical infrastructure failures or natural disasters. Cloud-based retreat and prolixity assesses secure business persistence and minimize supply chain derangement (Akkartal, Tedarik Zinciri Bilgi Sistemleri ve Teknolojileri, 2018).

The consequence of business intellectuality in organizations for data-driven governing and determined odds. It identifies that cloud computing attempts compelling benefits to business intelligence (BI), such as scalability, cost-effectiveness, and accessibility. By using cloud computing for BI, companies can benefit from increased processing power and storage capacity. Cloud-based BI solutions can process and analyze large volumes of data, enabling real-time

reporting, predictive analytics, and data visualization. Additionally, cloud computing contributes the resilience to scale assets up or down according to business needs, amend conduct and amount ability (Akkartal, Aslan, & Demirdag, Collaboration of Business Intelligence and Cloud Computing and Selecting the Best Cloud Business Intelligence Solution, 2021).

Cloud computing supports association and information allocation in dispersion through supply chain allies. The cloud-based platform enables companies to securely share data, ideas and awareness, facilitating collaborative and contemporary work. Cloud-based collaboration appliances further enable real-time communication and virtual synergy regardless of geological location (Akkartal, Akkartal, & Yildirim, 2019).

2.c Challenges and Risks Associated with Cloud Technology in Supply Chain Management

Mist computing has developed as a promising arrangement to address the challenges of handling and analyzing huge sums of information produced by Web of Things (IoT) gadgets at the edge of the organize.

In the context of supply chain management, fog computing can provide real-time data processing, analytics, and storage capabilities to enable greater efficiency, visibility, and responsiveness in supply chain operations (Das & Inuwa, 2023).

Be that as it may, the usage of mist computing in supply chain administration too presents a few challenges and dangers that must be considered.

One major challenge is security dangers, as the dissemination of information preparing and capacity over a arrange of gadgets increments the hazard security breaches and unauthorized get to delicate data. Executing vigorous security conventions and measures, such as encryption and verification, is vital to moderate the chance of information breaches (Botta, Donato, Persico, & Pescape, 2016).

Another challenge is the integration of information from numerous sources, which can be challenging due to the assortment of information designs and conventions utilized by distinctive gadgets. Creating a standardized information integration system is fundamental to guarantee the productive and successful utilize of haze computing in supply chain administration (Mikavica & Ljubisavljević, 2019)

Asset limitations are moreover a noteworthy challenge, as edge gadgets in a mist computing arrange regularly have restricted preparing control, capacity capacity, and battery life. Guaranteeing the ideal utilize of assets and minimizing

the effect of asset imperatives is pivotal to realizing the complete potential of mist computing in supply chain administration. (Inuwa & Das, 2023).

The complexity of actualizing mist computing in supply chain administration is additionally a challenge, because it requires critical ability, assets, and venture to guarantee the smooth integration and administration of the organize.

Additionally, the lack of interoperability standards and protocols for fog computing can make it difficult to integrate fog devices with existing supply chain systems, making the development of standardized protocols and open standards essential (Hu, Zhang, Zhang, & Zhou, 2019).

III. Fog Computing in Supply Chain Management

3.a Definition and Characteristics of Fog Computing

Haze computing is a developing computing worldview that points to bring the benefits of cloud computing closer to the end-users and gadgets at the edge of the organize. It is an expansion of the cloud computing show that takes advantage of the dispersed computing assets accessible at the organize edge to supply real-time information handling and capacity capabilities (Posey, 2023).

Haze computing is characterized as a decentralized computing foundation that empowers information preparing and analytics to be performed at the edge of the organize, closer to where the information is created and devoured.

The term "fog" is utilized to talk to the cloud's extension to the edge of the organize, where it gets to be denser and closer to the ground, or maybe like a mist (Yousefpour, 2019).

Fog computing is characterized by several key features that distinguish it from cloud computing. To begin with, mist computing gives low-latency, real-time information handling and analytics capabilities, making it appropriate for applications that require prompt reaction times. Moment, haze computing leverages the dispersed computing assets accessible at the edge of the arrange to decrease the workload on the central cloud foundation and move forward versatility.

Third, mist computing gives a better degree of protection and security, as delicate information can be prepared and put away locally, lessening the chance of information breaches and unauthorized get to (Caiza, 2020).

Fog computing is also designed to operate in heterogeneous environments, where devices and networks have varying capabilities and characteristics. Fog computing can adapt to these variations and provide a seamless computing experience, regardless of the device or network type (Yousefpour, Kadiyala, Jalali, & Nguyen, 2018).

Fog computing inflate the possibilities of cloud computing by bringing computing resources closer to where data is caused and consumed. This immediacy to severity devices speeds up processing, deplete latency, and improves real-time relations. By integrating fog computing into gamified learning environments, students can access real-time data, simulations, and interactive content directly from edge devices. This can improve the realism and responsiveness of gaming activities and provide students with a more mesmeric and pragmatic learning involvement (Akkartal, Akkartal, & Barooti, Gamification Methods for Teaching Logistics and Supply Chain Management, 2019).

3.b Advantages of Fog Computing in Supply Chain Management

Haze computing could be a dispersed computing demonstrate that brings computation, capacity, and organize assets closer to the edge of the organize.

It contains a few central focuses when associated to supply chain organization.

1. **Reduced Latency:**
   One of the major preferences of haze computing in supply chain administration
   is the reduction in latency.
   By processing data closer to the edge, haze computing can decrease the time it takes for information to be transmitted to the cloud and back.
   This can lead to faster decision-making and improved responsiveness (Haneef & Venkataraman, 2021).

2. **Improved Data Security:**
   Haze (Fog) computing can too progress information security in supply chain administration.
   By keeping information closer to the edge, mist computing decreases the hazard of information breaches and cyber-attacks that can happen amid information transmission to the cloud (Haneef & Venkataraman, 2021).

3. **Increased Scalability:**
   Haze computing can too increment versatility in supply chain administration. By scattering computing resources over the edge of the organize, fog computing can handle colossal entireties of data without over-burdening the cloud (Jumani, et al., 2023).

Fog computing has a few preferences when connected to supply chain administration, counting diminished inactivity, made strides information security, and expanded versatility.

By leveraging mist (fog) computing, supply chain supervisors can progress the by and large execution of their supply chain and pick up a competitive advantage in their industry (Javadi, Rezapour, Asghari, & Ghanbari, 2021).

3.c Challenges and Risks Associated with Fog Computing in Supply Chain Management

Whereas haze computing has a few preferences when connected to supply chain administration, there are too a few challenges and dangers related with its usage. A few of these challenges and dangers are:

1. **Security Risks:**
   One of the essential concerns related with mist computing in supply chain administration is security. Since mist computing includes conveying computing assets over the edge of the arrange, it can increment the assault surface for cybercriminals, making it more challenging to secure the framework (Ometov, Molua, Komarov, & Nurmi, 2022)

2. **Interoperability Challenges:**
   Another challenge associated with fog computing in supply chain management is interoperability. Because fog computing involves multiple devices and platforms, it can be challenging to ensure that they can all communicate and work together seamlessly (Bittencourt, Immich, Sakellariou, & Fonseca, 2018).
3. **Complexity:**
   Fog computing in supply chain management can also be complex and challenging to implement. Because it involves multiple devices and platforms, as well as complex data processing and analysis, it can require significant expertise and resources to set up and maintain (Kochan, Paksoy, & Ali, 2021).

   Fog computing in supply chain management has several challenges and risks associated with its implementation, including security risks, interoperability challenges, and complexity.

   While these challenges can be significant, they can be overcome with the proper planning and implementation (Inuwa & Das, 2023).

IV. Cloud Technology and Fog Computing Applications in Supply Chain Management

4.a Cloud-based Supply Chain Management Applications

Cloud-based supply chain organization applications have revolutionized the way organizations direct their supply chain operations. These applications allow companies to induce to and manage their supply chain data and shapes from wherever inside the world, enabling real-time decision-making and making strides operational capability

(Raj & Sharma, 2015).

One of the most benefits of cloud-based supply chain administration applications is their adaptability and adaptability. Organizations can effortlessly scale their utilization up or down depending on their commerce needs without the require for critical speculations in equipment and program foundation. Besides, cloud-based applications can be gotten to from anyplace, making them perfect for organizations with numerous areas or inaccessible laborers (Haneef & Venkataraman, 2021).

Cloud-based supply chain administration applications moreover empower way better collaboration and communication among all partners within the supply chain.

By giving a centralized stage for information sharing and communication, these applications can move forward the effectiveness of supply chain operations and decrease the probability of blunders and delays (Giannakis, Spanaki, & Dubey, A cloud-based supply chain management system, 2019).

Another advantage of cloud-based supply chain administration application is their cost-effectiveness. These applications are conveyed as a benefit, which implies organizations can maintain a strategic distance from the forthright costs related with conventional program establishments. Instep, they pay a membership expense that regularly incorporates progressing bolster and upkeep

(Ranger, What is cloud computing? , 2022).

A few of the foremost prevalent cloud-based supply chain administration applications incorporate SAP Ariba, Prophet Supply Chain Administration Cloud, and Microsoft Flow Supply Chain Administration. These applications offer a extend of highlights and capabilities that can offer assistance organizations move forward their supply chain operations (Microsoft vs SAP Ariba, 2023).

4.b Fog Computing-based Supply Chain Management Applications

Haze (Fog) computing may be a promising advancement that has the potential to revolutionize the way supply chain administration applications are created and conveyed.

Not at all like cloud computing, which depends on centralized information centers, mist computing brings computing control closer to the edge of the arrange, empowering quicker preparing and way better information administration (Jumani, et al., 2023).

Haze computing-based supply chain administration applications offer a few benefits, counting real-time information handling, moved forward information security, and upgraded unwavering quality. These applications can handle huge sums of information created by sensors, RFID labels, and other gadgets within the supply chain, giving real-time perceivability into the development of merchandise and stock levels. Moreover, haze computing-based supply chain administration applications can progress information security by keeping touchy data closer to the edge of the arrange, instead of transmitting it to a centralized information center.

This approach reduces the risk of data breaches and ensures that critical data is not compromised (Carbone, Davcev, Mitreski, & Kocarev, 2018).

Another advantage of fog computing-based supply chain management application is their enhanced reliability.

By distributing computing power across the network, these applications can continue to function even if one node fails. This approach ensures that critical supply chain operations continue without interruption, even in the event of a network outage or other disruption (Xu, Zhang, Su, & Zhao, 2023).

A few haze computing-based supply chain administration applications are as of now accessible on the advertise. These applications incorporate IBM Watson IoT, FogHorn Lightning, and Cisco Haze Computing.

Each of these applications offers a extend of highlights and capabilities that can offer assistance organizations progress their supply chain operations (Byabazaire, Taneja, Jalodia, Davy, & Olariu, 2019).

4.c Combined Applications of Cloud Technology and Fog Computing in Supply Chain Management

Supply chain administration could be a complex and basic handle that includes the effective stream of merchandise, administrations, and data from providers to conclusion clients. In later a long time, the coming of cloud innovation and fog computing has brought approximately noteworthy progressions within the field.

This article explores the combined applications of cloud technology and fog computing in supply chain management, highlighting their benefits and providing real-world examples of their implementation (Daya, Hassini , & Bahroun, 2017).

Some key applications of cloud technology in supply chain management include:

A) Data Storage and Accessibility

1.a Cloud-based storage solutions offer secure and scalable storage for large volumes of supply chain data. This includes inventory records, sales data, customer information, and logistics data (Giannakis, Spanaki, & Dubey, A cloud-based supply chain management system, 2019).

2.a Cloud capacity providers like Amazon Web Organizations (AWS), Microsoft Purplish blue, and Google Cloud Organize offer tried and true and cost-effective courses of action for putting absent and getting to data. (Jones, 2021).

B) Collaborative Planning and Execution

Cloud-based collaboration platforms enable real-time communication and collaboration among supply chain stakeholders. These stages encourage data sharing, coordination, and decision-making over diverse divisions and organizations.

Examples include tools like Microsoft Teams, Slack, and Trello, which streamline communication and enhance collaboration in supply chain operations (Anderson, 2023).

C) Data Analytics and Insights

Cloud-based analytics platforms leverage advanced data processing capabilities to extract meaningful insights from supply chain data. These insights can help optimize inventory management, demand forecasting, and overall supply chain performance. Solutions like Tableau, Power BI, and Google Analytics enable businesses to gain actionable intelligence and make data-driven decisions (Kawalek, Arunachalam, & Kumar, 2017).

D) Fog Computing in Supply Chain Management

Mist computing, too known as edge computing, complements cloud innovation by bringing computation and information capacity closer to the edge of the arrange. This permits for real-time information preparing, decreased idleness, and made strides responsiveness in supply chain operations.

Some notable applications of fog computing in supply chain management include (Gandhi & Tank, 2023):

1.d Real-time Monitoring and Control

Mist computing empowers the sending of sensors and IoT gadgets at different focuses within the supply chain, permitting real-time observing of basic parameters such as temperature, stickiness, and area. This helps ensure product quality, prevent spoilage, and optimize logistics operations (Vidyasankar & Musa, 2017).

2.d Edge Analytics and Decision-making

Mist computing empowers decentralized information preparing and analytics at the edge of the arrange. This permits for faster investigation of supply chain information, empowering quicker decision-making and reaction to changing conditions.

For example, fog computing can facilitate predictive maintenance of equipment, reducing downtime and improving overall operational efficiency (Aazam, Zeadally, & harras, 2018).

3.d Localized Data Storage and Security

Haze computing empowers localized information capacity and handling, diminishing the require for broad information exchange to the cloud. This moves forward information security, diminishes arrange transfer speed necessities, and guarantees compliance with information security directions (Inuwa & Das, 2023).

V. Case Studies on Cloud Technology and Fog Computing in Supply Chain Management

5.a Walmart's Use of Cloud-based Supply Chain Management

Walmart, one of the world's biggest retail companies, has broadly utilized cloud-based supply chain administration arrangements to improve its operational productivity and move forward client fulfillment. By receiving cloud innovation, Walmart has picked up real-time perceivability into its supply chain, streamlined forms, and optimized stock administration (Rickerby, 2020).

VI. Conclusion

In conclusion, cloud innovation and mist computing have altogether changed supply chain administration, revolutionizing the way businesses work and collaborate inside the industry. These mechanical headways have brought almost various benefits, empowering organizations to streamline their operations, improve proficiency, and make strides in general supply chain execution.

Cloud advancement, with its flexible and versatile nature, has given supply chain organization with the infers to store, handle, and get to perpetual wholes of data in real-time. By leveraging cloud-based stages and organizations, businesses can centralize their operations, facilitated diverse accomplices, and choose up a all-encompassing see of their supply chain works out. This level of perceivability and straightforwardness licenses for predominant decision-making, extended responsiveness to promote changes, and optimized stock organization. Besides, cloud innovation has encouraged consistent communication and collaboration among supply chain accomplices. By utilizing cloud-based communication apparatuses and

stages, organizations can share data, trade information, and arrange exercises in a more effective and opportune way. This improved network has driven to made strides coordination, decreased lead times, and expanded deftness, empowering supply chains to adjust rapidly to disturbances and changes in client requests. In expansion to cloud innovation, mist computing has risen as a promising arrangement in supply chain administration.

By decentralizing computing resources and bringing them closer to the edge of the network, fog computing addresses the limitations of traditional cloud computing, such as latency and bandwidth constraints.

Haze computing empowers real-time information preparing and investigation at the edge gadgets, such as sensors and IoT gadgets, permitting for faster decision-making, diminished arrange activity, and made strides responsiveness. The combination of cloud innovation and haze computing has opened up unused conceivable outcomes for progressed analytics and prescient capabilities in supply chain administration. With get to to enormous sums of information and effective computing assets, organizations can utilize machine learning calculations and data-driven models to pick up important bits of knowledge, foresee request designs, optimize steering and coordination's, and moderate dangers. These cleverly analytics capabilities have the potential to revolutionize supply chain arranging, determining, and optimization. Be that as it may, it is fundamental to recognize that executing cloud innovation and haze computing in supply chain administration comes with challenges. Security and information security concerns, interoperability issues, and the require for gifted IT experts are among the key obstacles that organizations must address. Also, the selection of these innovations requires cautious arranging, venture, and alter administration methodologies to guarantee effective integration into existing supply chain operations.

In conclusion, cloud innovation and mist computing have brought critical progressions to supply chain administration, advertising made strides perceivability, improved collaboration, and progressed analytics capabilities.

Whereas challenges exist, organizations that grasp these innovations and overcome the related obstacles stand to pick up a competitive edge in today's energetic and advancing commerce scene.

The proceeded advancement and selection of cloud innovation and haze computing hold gigantic potential for advance development and optimization in supply chain administration, forming long-standing time of the industry.

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Chapter 4

Artificial Intelligence in Logistic Industry

Mahyae SOHRABI [1]

[1] M.Sc. candidate Yeditepe University, Institute of Social Sciences / International Trade and Logistics Management Dept., mahyae.sohrabi@std.yeditepe.edu.tr

ABSTRACT

In today's world artificial inteligince is one most controversial topics . the purpose of this study is getting to know about the digital word and more specifically the word of artificial inteligence in logistics (AI).

The word of artifical intelligence in logistic industry ,with digitalization can be found better and chaeaper solution.

AI has given important credibility to logistics with thw hwlp of digital world. We owe this moderninity in the world of logistics to Artificial intelligence.

AI opened new possibilities for managing and solving many problrms in both theorical and practical logistics industry's.

They are capable to analyze not only enormous amount of data (big data)

In an extreamly short time but also this processes of analyses are easily improved by machine itself (machin learning). Example of AI application in several logistics company using in warehouse operations ,remoute production , smart tyre and ….

if logistics companies want to achieve higher quality development, they cannot do without new technology,they should to be up date and make long term planning for making the most of benefits of AI .

The first section of this articles is devoted supply chain management in AI , and the rest of this article partical examples of using artificial intelligence in logistics companies are given.

Keyword's: artificial intelligence , logistics, digital, logistics industry, supply chain

1. Introduction

Advanced technologies such as artificial intelligence are rapidly growing and becoming stronger, so that we see traces of these technologies in all industries today.

With Using these technologies, we can teach machines how to act, or sometimes even teach machines to act like humans. By researching and knowing these technologies to some extent, we will make artificial intelligence technology in the field of computer science, which focuses on the design of intelligent computer systems such as systems with linguistics, ability, learning, reasoning and problem solving.

Advanced technologies like artificial intelligence are now a strong and ever-growing platform. From self-driving vehicles to social media, everything is defined by how fast technology can teach - or maybe even overcome - machines to act like humans. This allows us to describe artificial intelligence as the computer science area, which focuses on the design of intelligent computer systems, such as systems with linguistic capability, learning, reasoning, and problem solving (Barr, 1981).

Artificial intelligence has brought a serious change to the world, and logistics is no exception to this rule. Artificial intelligence can play an important role in increasing the efficiency and effectiveness of logistics operations.

In this article, we will describe some methods of using artificial intelligence and we will examine their performance and effectiveness in logistics. In fact, this function and algorithm can be reducing transportation cost, save time and energy and improving human performance. This can lead to improved responsiveness to changes in demand, reduced lead times, and lower costs. AI is having a great impact on supply chain management. Supply chain management logistics firms can benefit from AI's ability to monitor freight forwarding on a massive scale and anticipate shipping needs (Rahimi & Alemetabriz ,2022).

Supply chain management can be a factor for integrating the proper management of the flow of materials and goods, information, liquidity transfer and the ability to respond in different situations. Meanwhile, logistics management also plays an effective role in the supply chain. In a way, he is responsible for designing, implementing, controlling and increasing efficiency in the processes related to stocking goods and production flows.

In this article, we will examine the position of artificial intelligence in the all over the world.

2. Optimization of supply chain management using AI

Optimizing material supply chain management is one of the most widely used key topics in artificial intelligence, here are more details on how to use artificial intelligence to optimize supply chain management:

Demand forecasting: AI algorithms have the ability to analyze data from various sources such as sales history, market trends, social media activity, weather patterns to accurately forecast demand. These analyzes can help companies in matters such as optimizing inventory levels, reducing warehouses, and minimizing waste. The logistics and supply chain industry, which has huge data and rich business scenarios, (zhang, 2019)

2-1-What it needs is technological innovation?

2-1-1-Inventory management: AI can help optimize inventory and ensure that the right products are available at the right time. Also, artificial intelligence algorithms have the ability to predict the demand and automatically order the required products if the inventory level is low. This issue can have two main benefits for the company: it helps to reduce the cost of inventory maintenance and at the same time ensures that the products needed by customers are available to them when they need them.

2-1-2-Supplier management: AI can also help companies identify and evaluate the best suppliers based on factors such as quality, price, delivery time and delivery performance. AI algorithms can analyze supplier data to identify patterns and trends that can help companies make better decisions about which suppliers to work with.

2-1-3-Logistics optimization: Artificial intelligence has the ability to help optimize logistics operations such as transportation planning and scheduling, routing, and route mode selection. Also, AI algorithms can analyze data about factors such as traffic, distance and weather conditions to determine the most suitable and efficient routes and modes of transportation. This issue can help reduce transportation costs and save delivery time.

Utilizing AI algorithms and technology to streamline warehouse operations is known as AI-powered warehouse management. This includes real-time tracking and analytics of warehouse operations as well as inventory optimization through data analysis, AI-powered robots for automated picking and sorting, and predictive maintenance through equipment monitoring in real-time. Businesses may increase productivity, lower labor costs, and improve stock tracking and delivery accuracy by employing AI to manage warehouse operations. Overall, AI-powered warehouse management can lead to higher customer satisfaction, lower operating costs, and better warehouse performance.

2-2-Numerous advantages of AI in the logistics sector can help businesses improve their operations and acquire a competitive edge. Among the main advantages are

Enhanced productivity and efficiency: AI can automate a variety of operations, including demand forecasting, route optimization, and inventory management, which will help the logistics sector become more productive and efficient. Faster deliveries, lower labor expenses, and increased throughput are possible outcomes of this.

2-2-1-Savings: By employing AI to optimize supply chain management, businesses can save money on transportation, excess inventory, and stock outs. Significant cost reductions and increased profitability are possible outcomes of this. Customer satisfaction will increase as a result of faster and more accurate deliveries made possible by logistics companies utilizing AI to streamline operations. Increased consumer loyalty and repeat business may arise from this assist business in determining areas for improvement, pricing optimization, and customer service enhancement. Enhanced safety: By minimizing the danger of accidents and optimizing routes, AI can contribute to enhancing safety in the logistics sector. This can lower insurance costs for businesses and boost their safety record.

3. One of the main advantages of deploying AI-based solutions in logistics is improved customer satisfaction, as these technologies may assist in ensuring accurate and on-time delivery. Companies may better predict client demand and change their inventory levels as a result of employing AI-powered demand forecasting, which lowers the risk of stock outs and delivery delays.

Additionally, logistics organizations can improve their delivery routes and timetables with the use of AI-powered scheduling and route optimization algorithms, resulting in on-time and cost-effective deliveries. This can decrease delivery times and delivery costs, which can increase customer satisfaction.

Additionally, real-time visibility into the delivery process can be provided via AI-powered tracking and monitoring systems, allowing consumers to track their shipments and receive notifications about any delays or potential problems. Customers' trust can be increased as a result, and their overall happiness with the delivery process can be improved.

While applying AI to the logistics sector has many advantages, there are also a number of potential drawbacks for businesses. Here are a few illustrations:

3-1-Data availability and quality: For effective training and operation, AI systems need a lot of high-quality data. However, given the fragmented structure

of the sector and the absence of standardized data formats, logistics organizations may find it difficult to acquire and gather the required data.

3-1-2-Implementation costs: Especially for smaller logistics organizations with fewer resources, implementing AI-powered solutions can be expensive. Adoption can be significantly hampered by the expense of purchasing, maintaining, and educating staff on the required gear and software. Employee resistance to change may arise from their reluctance to adopt new technology or alter their established working practices. AI-powered solutions may necessitate considerable modifications to current procedures and workflows.

Integrating AI-powered solutions with current IT infrastructure and logistics management systems can be a challenging and time-consuming procedure. It can be difficult to ensure compatibility and seamless integration, especially for businesses with older systems.

3-2-2-Compliance with laws and regulations: AI-powered solutions may be subject to a variety of laws and regulations, including those governing data privacy and the usage of AI in specific industries. It can be difficult to ensure compliance with these criteria, especially when regulations continue to change.

4. AI warehouse management

Think about going back in time to a sizable warehouse in the 1980s or 1990s. If you could, it would highlight the technical advancements made in modern warehouses. Think about what a warehouse could look like in 2050 or later. Probably extremely dissimilar from the present.

Some warehouses may give you odd stares if you mention AI. However, a lot of staff members and even supervisors aren't even aware they're using AI solutions. Even if they aren't, it's likely that their rivals are. The eight ways AI is changing warehouse management are listed below.

4-1 Productivity

Boost the effectiveness of pick-and-pack operations.

Because ML enables managers to capitalize on the effectiveness of the most productive pickers to produce a fully integrated system-directed solution, processes are transformed and simplified. The interface for operating rules to be used in the smart warehouse and a suggested SKU strategy based on past and future sales data are already included in slotting software. While humans still modify slotting tactics based on their own expertise and experience, this practice will eventually give way to ML algorithms.

ML:(focuses on the development of algorithms and statistical models that enable computer systems to learn and improve from data without being explicitly programmed.)

SKU :(SKU stands for Stock Keeping Unit. It is a unique alphanumeric code or number assigned to a specific product or item in inventory management. SKU strategy refers to the approach and methodology used to create and manage SKU codes for products in a business.)

4-2 Communication

Artificial intelligence (AI) and machine learning algorithms allow automated systems to interact at a rate that is several times faster than that of human operators.

Many warehouse-related tasks are already automated, but by combining IoT-enabled devices into these operations, speed and accuracy will be greatly increased. All components of your system can engage in a discussion that includes system monitoring and control thanks to wireless cloud data transfers.

Deep learning techniques also give computers the ability to continuously study the data streams produced by these components, enabling them to make improvements and adjustments in an integrated WMS (Warehouse Management System) in real-time.

4-3 Wages

Payroll costs will be cut, initially being compensated by the necessary technical expenditure.

The labor expenses aspect of how AI will change warehouse management is the most disputed. At this point in its development, robot aid barely affects how things are done now. Though 30% of UK warehousing jobs will be totally automated by 2030, AI has the ability — and will have the potential — to increase machine handling capabilities.

The most likely industries for automation are those that involve data gathering, processing, and predictable physical operations. Established e-commerce companies assert that rising automation would increase the overall scale of their business operations and hence create jobs, but this will only become clear over time.

4-4 Warehouse Logistics

Processing times and operator error reduction can boost productivity and overall effectiveness.

Using AI to optimize logistics will change warehouse management as well. Think about figuring out how many pallets need to be moved each day, how much equipment is needed to handle that movement, and how much labor is necessary to complete that movement. In the past, these estimates were based on the operator's expertise and SKUs (stock-keeping units). ML algorithms now make it possible to forecast and manage stock movement in great detail to improve material handling.

4-5 Robots

In comparison to human workers, robots can pick up and re-distribute things in a fraction of the time.

ML algorithms can help warehousing bots decide the most effective picking and slotting routes as well as the optimum packing based on the size, number, weight, and kind of the products. Now, some machines can pack their goods while utilizing AI to maximize available materials and storage.

4-6 Visibility

For the first time, end-to-end insight across numerous supply chains is offered by fusing machine learning with cutting-edge analytics, Io T sensors, and real-time monitoring.

These days, many supply chains need a whole new operating system or architecture built on real-time data that has been enhanced with patterns and insights that were previously invisible to analytics tools. Future supply chain platforms will be essential for incorporating machine learning, which will revolutionize all facets of supply chain management.

4-7 Data

In order to improve all facets of supply chain management, cooperation, logistics, and warehouse management, machine learning is being applied in Logistics Control Tower operations. Visual pattern recognition is a skill that machine learning is particularly good at, which opens up a large range of possible applications for inspecting and maintaining physical assets throughout the entire supply chain network.

By developing and interpreting algorithms that swiftly pinpoint the most important aspects of a supply network's success while continuously learning in the process, AI and ML enable the detection of patterns in data from the supply chain. Finding novel patterns in supply chain data is a practice that has the power to completely change any firm.

4-8 Inventory

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5. Benefits of AI in logistics industry

The logistics sector has undergone a revolution thanks to AI, which has transformed traditional processes and brought several benefits. Here are some key advantages of AI in the logistics industry.

5-1. Cost reduction

The term "cost reduction" in AI refers to an organization's capacity to reduce costs and make savings across a range of operational areas by utilizing artificial intelligence technologies and applications. AI can optimize processes, automate operations, and make wise decisions that lower costs and boost financial performance when used efficiently.

5-2 .Increase competitiveness

The potential of AI technology and applications to offer benefits that enable logistics organizations to outperform their rivals is referred to as increasing competitiveness in the logistics industry through the use of AI. When properly applied, AI can provide distinctive skills and advancements that strengthen a business's position in the market, operational effectiveness, and client happiness.

5-3 .Increase customer service level

Artificial intelligence (AI) applications and technology are being used to raise customer service standards by improving the effectiveness, quality, and experience of customer service interactions. By offering individualized support, timely responses, and correct information to fulfill customers' requirements and expectations, AI may significantly improve customer service.

One of the most disruptive technologies for Contemporary operations and supply chain management (OSCM) is artificial intelligence (AI) (Fosso Wamba et al. 2021; Dubey et al. 2020; Grover, Kar, and Dwivedi 2020

AI which is being used to work on a vast array of issues, including product recommendations and customization, dynamic pricing, real-time production tracking, prevention of order shipment delays and inventory shortages, Customer feedback collection for product development, and supplier monitoring for procurement costs reduction. (Syam and Sharma 2018; Dong et al. 2021)

Table1. Some examples of industry experiences of AI

Company	Type of AI	Example of main benefits
Amazon	Robots	Productivity improvement and errors minimization
DHL	IDEA algorithm	Order-picking processes improvement, costs minimisation, and e-fulfilment optimization
General Motors	Computer vision	Predictive maintenance and downtime minimisation
Goodyear	AI sensors with IoT	Monitoring and control of the tire changes and self-repair case of damag
Nestle	Augmented reality (AI)	Operations efficiency increase, quick response, CO minimisation
Netflix	Machine Learning	Resources and production process optimization, and customer product prediction
Atomwise	Deep convolutional, Neural network	Drug discovery process optimization

6.Challenges in implementing AI in logistics industry

While applying AI in the logistics sector has many advantages, there are also a number of difficulties and challenge that must be overcome. Here I discuses about some most important challenge. The role of AI to drive better and deeper

customer experiences within digital processes is widely recognized today (cf. Martorelli and Stroud 2017),

Data Availability and Quality: For effective training and operation, AI primarily relies on high-quality data. However, complex and diverse data from numerous sources is frequently dealt with in the logistics sector. Data integration, cleansing, and preprocessing processes are necessary to ensure data quality, consistency, and accessibility.

Data Security and Privacy: Sensitive data, including customer information, shipment information, and trade secrets, is used in logistics operations. When using AI, ensuring cyber security and data privacy are essential. To protect data from breaches, unauthorized access, and misuse, businesses need to implement strict security policies.

Costs of Implementation: Hardware, software, and the hiring of qualified personnel can all be expensive upfront when implementing AI systems and infrastructure. For smaller logistics organizations with fewer resources, the expenditure needed to create or acquire AI solutions may present difficulties.

7.Case studies of AI in logistics industry

In this article, a number of large companies that use artificial intelligence were mentioned.(table 1)

In this article, I will explain in more detail about DHL.

The more we can use robots to complete repetitive or distant tasks in highly predictable, structured environments, the more we free up our employees to leverage their unique human capabilities.

(Tim Tetzlaff, Global Head of Accelerated Digitalization, DHL Supply Chain)

Automation and artificial intelligence in logistics and supply chains are unquestionably the keys to the success and sustainability of e-commerce as DHL develops smarter warehouses. And that e-commerce fulfillment solutions and logistics automation will bring forth the subsequent wave of efficiency.

In warehouses, pallet-wrapping machines are a common sight. Forklifts are often used to transport pallets filled with cartons to this equipment, which is typically stationary. The pallets are wrapped before being forklifted to the following staging place. Pallet-wrapping robots are already accelerating this operation. A wrapping robot that resembles a lawnmower is simply driven from pallet to pallet, stopping at each load along the route to wrap it.

The subsequent wave of artificial intelligence (AI) in logistics and supply chains, which significantly improves e-commerce efficiency, will also include assisted picking robots (AP robots). AP robots are autonomous carts that show visuals of the items to be picked up and figure out the best routes to take.

They go far between different areas of a warehouse, obtaining products from human workers who stay put and perform the specialized task of piece picking. After filling their order baskets, the robots independently transport them to the packing station. Another individual completes the shipment process there.

DHL AP robots have so far resulted in productivity gains of 30% to 180%. For usage in warehouses around the world through the end of 2022, they just hired 2,000 AP robots from Locus Robotics.

CONCLUSION

In conclusion process optimization, increased productivity, cost savings, and improved customer satisfaction, AI has completely changed the logistics sector. A competitive edge in a market that is becoming more complicated and dynamic can be achieved by logistics companies by utilizing AI technologies. By adopting AI-driven solutions, logistics companies may better meet customer requests, manage resources, and produce better operational results. AI has completely changed the logistics sector by increasing productivity, enabling real-time tracking and visibility, optimizing demand forecasting and inventory management, automating warehouses, optimizing last-mile delivery, enhancing risk management, and improving the customer experience. Further optimization, cost savings, and innovation in logistics operations could result from its continuous integration and development.

Artificial intelligence, a crucial technological resource in the twenty-first century, may offer supply chain logistics technical support that incorporates big data, cloud computing, and the Internet of things. A significant factor behind the logistics sector's change is artificial intelligence. In order for supply chain logistics companies to succeed, they must embrace the current trend of intelligent development in all spheres of life, vigorously promote the transformation of logistics infrastructure and production tools to intelligent, realize the construction of supply chain logistics operation processes in the direction of intelligence, and simultaneously realize supply chain resource sharing.

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Chapter 5

Sectoral Use And Applications Of Augmented Reality

Aysun SANATÇI [1]

[1] Ph.D. candidate, Yeditepe University Institute of Social Sciences / International Trade and Logistics Management aysun@mobiliproject.com OrcID: 0000-0001-5616-3018

ABSTRACT

This study provides a general overview of the concept of augmented Reality (AR) and its accepted definition, as well as the characteristics of augmented Reality technology. Augmented Reality Technology is described as an environment where real and virtual images are perceived simultaneously. The text highlights various sectors where augmented Reality is being utilized, including industrial design, tourism, healthcare, art and museums, gaming, education, medicine, engineering, advertising, architecture, and construction.

The subject is discussed in more detail by giving examples of the use and application of augmented Reality technology not only in the sectoral sense, but also in different areas within the organizational structure. In the organizational structure, how it is applied in departments such as human resources, project management, sales and marketing, product development, supply chain management is also stated.

As a result, a perspective on the application areas of augmented Reality technology within the sectoral and organizational structure was presented and the conveniences it offered to people in social life were examined.

Keywords: Augmented Reality, Industry4.0, Supply Chain Management, Distruptive Technology

1. Introductıon

This study focuses on augmented Reality (AR), which has gained significant attention among information technologies in recent years, and explores its integration into our daily lives and various sectors. Augmented Reality refers to an environment where computer-generated data and images can be added to real-world visuals, allowing the simultaneous perception of real and virtual images. This new medium enables the virtual perception of objects that are challenging to physically place in the real world.

Today, augmented Reality is utilized in a wide range of sectors, including industrial design, production control, tourism, shopping, healthcare, real estate, art and museums, gaming, video, maintenance and repair, as well as education, medicine, engineering, advertising, architecture and construction, e-commerce, and the furniture industry.

When looking at the application areas of augmented Reality technology, it is used in human resources, project management, motivation, and team-building activities within organizational structures. In customer management departments, it is employed in sales and marketing, installation and training, service and maintenance activities. It is also applied in product development departments for design, review, and ergonomic studies. In supply chain departments, it is used for quality control, remote support, and procedural training. Additionally, in production management departments, it is utilized for assembly line design and training.

The use of augmented Reality technology provides numerous benefits in various sectors and application areas. It enhances productivity, improves efficiency, and enhances the overall user experience. It facilitates better visualization, simplifies complex processes, and offers innovative solutions. Augmented Reality has the potential to transform how we interact with our surroundings and revolutionize industries.

The aim of this study is to provide a general overview of the concept of augmented Reality in terms of sectors and application areas, explore the latest developments, and examine the conveniences it offers in our social lives.

2. Augmented Reality

Augmented Reality is a technological concept created by adding computer-generated images and/or sounds to the real world environment. This technology emerges with the addition of virtual objects to the real world environment and also offers users an interactive experience between the virtual and real world. For example, a furniture store can use augmented Reality to show what furniture will look like in a user's home. (Azuma R. , 1997)

Augmented Reality technology is used in many different industries such as games, education, health, tourism, construction, art and retail. The use of this technology provides users with more realistic and interactive experiences, while also creating new opportunities in many industries. (MILGRAM, 1994)

Augmented Reality (AR) is a technology that combines the real world with virtual objects. AR provides users with a richer experience by adding virtual elements such as computer-based graphics, sound, video, and haptic sensations in a real-world environment. (Billinghurst, 2002)

AR is often performed through portable devices such as smartphones, tablets or glasses. These devices have features such as cameras, sensors and processors that can detect the real world and place virtual objects on it, allowing the user to interact with them. (Kipper, 2012)

For example, when AR is used to sell furniture, users can place furniture virtually through their mobile devices in the physical environment they are in a furniture store. The camera detects the position of the furniture in the real world and displays it as virtual objects appearing on the screen. Users can view the furniture from different angles, measure its dimensions and experience how it will look in real time. (Thomas, 1999)

2.1 Sectoral Usage And Examples Of Ugmented Reality

Augmented Reality technology has started to be used in many sectors around the world. Its use is increasing day by day, especially in education, medicine, architecture, interior design, construction, engineering, game industry, advertising, tourism, e-commerce, art, entertainment and furniture sectors.

2.1.1 Use Of Augmented Reality Technology In Educatıon

Augmented Reality in Education is used to make students' learning experience more interactive. For example, it is possible to experiment in virtual laboratory environments or visit historical places virtually. (Vujaklija)

According to the results obtained, augmented Reality technology is seen as a very useful tool in the field of education. By providing an interactive environment in the learning process of students, it can enrich their learning experiences and make them more effective. Below are some examples of how augmented Reality is applied in the field of education. (Kerdic, 2020)

- Virtual Labs: By using augmented Reality, virtual labs can be offered to students instead of real labs that have security risks or are expensive. Students can thus experiment without risks and at less cost.

- Discovery of Historic Places: Augmented Reality can make history lessons more enjoyable by giving students the opportunity to visit and explore historical places. Students can have interactive learning experiences by exploring historical places with augmented Reality.
- Language Learning: Augmented Reality technology can assist students in the language learning process. For example, using augmented Reality, students can be shown the word and sentence structures of a language, thus enabling more effective learning. (Mendiola, 2021)
- Visual Learning: Augmented Reality allows students to use visual learning methods. In this way, students learn with concrete examples and visual elements. (Akkartal, 2021)
- Vocational Education: Augmented Reality technology can also be used in the field of vocational training. For example, with augmented Reality, interactive learning materials can be presented to students showing the repair processes. (Yuen, 2017)
- Reading Book Experience: Augmented Reality can enrich students' book reading experiences. For example, by using augmented Reality, students can be offered the opportunity to animate the characters in the books.
- Teacher Education: Augmented Reality can make teachers' training more effective. For example, teachers can be trained on classroom management using augmented Reality. (Dunleavy, 2009)

In addition to the examples mentioned above, augmented Reality technology is also used in museums and exhibitions. In this way, students can examine the artifacts in museums more closely and learn more about these artifacts. In addition, augmented Reality technology can enhance students' imaginations without affecting their physical environment. (Bacca, 2014)

Another important application area of augmented Reality in the field of education is that it helps students learn more effectively in distance education processes. Students can make their learning more effective by having interactive learning experiences even during the distance education process. (Wu, 2013)

In conclusion, augmented Reality technology is a very useful tool in the field of education and can help students learn more effectively by enriching their learning processes.

2.1.2 Use Of Augmented Reality Technology In Medıcıne

Augmented Reality technology is also used in many different fields in the medical field.

- Surgical Education: Augmented Reality technology is a useful tool for simulations used in the surgical training process. Students can perform

surgical procedures in a virtual environment using augmented Reality, thus having an experience similar to a real operating room environment. (Bhattacharya, 2016)

- Anesthesia: Augmented Reality technology can also be used in anesthesia procedures. Anesthesiologists can monitor patient data such as heart rate, blood pressure and respiratory rate using augmented Reality glasses. (Khor, 2019)
- Hospital Management: Augmented Reality technology is also used in the field of hospital management. Using augmented Reality, hospital staff can track the location of objects in the hospital and the health status of patients. (Vankipuram, 2016)
- Rehabilitation: Augmented Reality technology is also used in physical therapy and rehabilitation processes. For example, paralyzed patients can learn to walk again using augmented Reality. (Lee, 2018)
- Diagnosis and Treatment: Augmented Reality technology can also be used in diagnosis and treatment processes. For example, doctors can use augmented Reality to view patient data so they can make more accurate diagnoses. (Azuma R. B., 2001)

Augmented Reality technology is a very useful tool in the medical field and can be used in many different fields. This way, both medical students and medical professionals can learn and work more effectively.

2.1.3 Use Of Augmented Reality Technology In Engineerıng

Augmented Reality (AR) in engineering can be used in many different areas, including design, manufacturing, maintenance and repair. When we look at the usage areas;

- Design: Augmented Reality allows three-dimensional viewing of CAD (Computer Aided Design) models used in the engineering design process. In this way, engineers can have a better grasp of the actual dimensions of the product and detect design errors. (R. Ahmad, 2017)Production: Augmented Reality can also be used in the production process. For example, a worker on a car production line can use augmented Reality to better see what parts need to go where and complete the assembly process faster. (N. Kumar, 2017)
- Maintenance and Repair: Augmented Reality can also be used in the process of maintenance and repair of machines. Using augmented Reality,

a worker can better understand the locations of parts inside a machine and how they work, and solve problems more quickly. (Ghodsi, 2013)

- Education: Augmented Reality can also be used in engineering education. For example, by using augmented Reality, students can better understand how complex machines work and thus get a better engineering education. (N. Ismail, 2018)Project Management: Augmented Reality can also be used in the project management process. Using augmented Reality, a construction project manager can track the progress of the construction project, thus managing the project more effectively. (Sawant, 2018)

Augmented Reality technology can be used in many different fields in the field of engineering. In this way, both engineers and students can work more effectively.

2.1.4 Use Of Augmented Reality Technology In The Game Industry

- In the gaming industry, augmented Reality adds new dimensions to gaming experiences, helping games become more realistic and interactive. (Akkartal G. R., 2019).
- Below are the usage areas of augmented Reality in the gaming industry:
- Pokemon Go: Pokemon Go is one of the most popular applications of augmented Reality technology. This game allows players to navigate and catch virtual Pokemon in the real world. (J. Han, 2019)
- Minecraft Earth: Minecraft Earth is an augmented Reality version of Minecraft. Players can create virtual structures by placing Minecraft blocks on top of the real world. (J. S. Wu, 2018)
- Ingress: Ingress is a science fiction game that combines augmented Reality and ground-based gameplay elements. Players compete with each other to conquer strategically placed virtual portals around real-world locations. (S. Bachmann, 2016)Wizards Unite: Wizards Unite is an augmented Reality game set in the Harry Potter universe. Players hunt virtual creatures and collect magical objects using their sorcery abilities." (R. Bernardo, 2015)

2.1.5 Use Of Augmented Reality Technology In The Advertising Industry

Augmented Reality has become more and more popular in the advertising space. Augmented Reality technology can be used in the advertising industry in different ways. When we look at the uses of augmented Reality technology in the advertising industry,

- Virtual Experiences: Augmented Reality technology can be used to create virtual experiences that allow consumers to virtually try and test products.

This can make consumers show more interest in the products and make a purchasing decision. (Elliot, 2018)

- Interactive Advertisements: Augmented Reality allows consumers to interact with interactive ads. These ads can increase brand loyalty by offering consumers more information about products. (Chakrabarti, 2018)
- Brand Awareness: Augmented Reality can help brands create more awareness among their target audience. For example, it can increase brand awareness by showing a brand's logo to consumers with an augmented Reality application. (Dhingra, 2017)
- Monitoring and Analysis: Augmented Reality advertising can create more effective advertising campaigns by collecting and analyzing data about consumers' interactions. (Smith, 2017)

2.1.6 Use Of Augmented Reality Technology In Tourısm Industry

Augmented Reality can be used in different ways in the tourism industry. Looking at the examples of the use of augmented Reality in the field of tourism;

- Virtual Tours: Augmented Reality technology offers tourists the opportunity to take virtual tours, allowing them to explore historical and cultural places. This way, tourists can get a better idea of their pre-trip planning. (Hossny, 2018)
- Guides: Augmented Reality apps can guide tourists through their travels. These apps can help tourists explore historical and cultural places. (Amaranggana, 2014)
- Museums and Exhibitions: Augmented Reality technology can enhance the visitor experience in museums and exhibitions. This technology could enable visitors to engage more in artwork and museum exhibits. (Gerhard, 2018)
- Local Culture: Augmented Reality technology can offer tourists the opportunity to learn more about the culture of the region they are traveling to. In this way, tourists can enjoy their travels more by understanding the local culture better. (Du, 2018)

2.1.7Use Of Augmented Reality Technology In The Archıtecture And Constructıon Industry

Augmented Reality (AR) can be used in different ways in the fields of architecture and construction. Considering the uses of augmented Reality in the field of architecture and construction;

- Design and Modeling: Augmented Reality technology allows architects and designers to see and examine their designs more realistically. In this way, it

may be possible to better understand architectural projects and detect design errors. (Al. A. H., 2017)

- Construction Process: Augmented Reality provides a better understanding of the drawings and projects used in the construction process. This technology visually presents the details of the project to the construction teams and provides greater efficiency in the operation of the project. (Al M. S., 2019)
- Visualization: Augmented Reality helps to better explain and present architectural projects to clients. Clients are visualized close to the actual dimensions of the project, providing a better understanding of the design. (Al M. G.-F., 2017)
- Education: Augmented Reality technology can be used in civil engineering and architectural education. This technology assists students in visualizing architectural projects, detecting design errors and realizing projects. (Al. A. S., 2018)

2.1.8Use Of Augmented Reality Technology In E-Commerce

Augmented Reality (AR) technology is used in e-commerce to help customers experience products virtually and make more informed purchasing decisions. For instance;

- Virtual Rehearsal: Virtual rehearsal of clothing items allows customers to experience the fit and how the item will look. For example, Ikea's Place app allows customers to experience furniture products virtually in their homes. (www.forbes.com,)
- Product Details: AR technology allows for more detailed inspection of products. For example, the Sephora Virtual Artist app allows customers to virtually try different makeup products by scanning their faces. (www.forbes.com,)
- Business Visualization: AR technology allows customers to virtually experience businesses' physical locations. For example, Google Maps AR navigation provides real-time directions to users and helps them reach their destination more quickly. (www. Realitytechnologies.com,)
- Customization: AR technology allows customers to customize products. For example, the NikeID app allows customers to customize shoes. (www.digitalmediahub.com.sg,)

Alongside such examples, AR technology can also be used to increase interactions on e-commerce sites and make customers feel more connected to brands.

2.1.9 Use Of Augmented Reality Technology In Art And Entertaınment

In arts and entertainment, augmented Reality can be used to deliver interactive experiences and change the way artworks look, sound, and even smell. Considering their use in this field;

- Virtual Museums: Augmented Reality offers users many extra features when visiting real world museums. For example, they can add descriptions that they can read or take virtual tours to learn more about the artifacts. (Milgram, 1994)
- Virtual Scene: Augmented Reality can be used in concerts, musicals and theater plays by artists, allowing to change stage designs in real time. Thus, different backgrounds can be created depending on the budget of the performance, the stage and even the game being played.
- Augmented Reality Games: Augmented Reality games allow players to play interactive games in virtual worlds based on the real world. For example, in games like Pokemon Go, players can catch virtual Pokemon as they roam the streets of the real world, thanks to the augmented Reality features on their mobile phones. de (Souza, 2016)
- Augmented Reality Artworks: Artists can create murals, sculptures and other works of art using augmented Reality technology. These works give viewers the opportunity to experience the works in a more interactive way. (Fink, 2019)
- Virtual Reality is another technology that allows users to have fun in virtual worlds. When used with augmented Reality, it provides a more realistic experience.

2.1.10 Use Of Augmented Reality Technology In The Furniture Industry

The furniture industry has also started to offer a better experience to its customers by using augmented Reality technology. When we look at the usage areas of augmented Reality in the furniture sector;

- Virtual Store Experience: Furniture stores now offer their customers a virtual store experience using augmented Reality technology. This allows customers to virtually view the furniture and understand how it will look before purchasing.
- Augmented Reality Catalogs: Furniture companies now offer interactive catalogs to their customers using augmented Reality technology. Thanks to these catalogs, customers can see a virtual image of the furniture and better understand the features of the furniture (P. Kiani, 2019)
- Customized Furniture Experience: Augmented Reality technology is also used to enhance customers' furniture customization experience. Thanks to the

augmented Reality technology, customers can view different colors, materials and sizes of the furniture and thus create a custom design for them. (T. Le, 2021)

- Assembly Instructions: Thanks to augmented Reality technology, furniture companies provide assembly instructions to customers, giving them a better understanding of how to assemble furniture.

3. CONCLUSION

In this study, the latest developments in augmented Reality (AR) and sector-specific applications have been examined. Generally, when looking at the sectors and application areas, the concept of augmented Reality has been increasingly utilized in various sectors, including education, medicine, gaming, entertainment, e-commerce, architecture, construction, and the furniture industry. In terms of application areas, it is implemented in organizational structures, as well as sales, marketing, and product development. This application has contributed to minimizing costs through advantages such as affordability, speed, experiential learning, interactive communication, remote education, freedom of choice, detailed inspection, customization, reduced risk of errors, quality control, and ergonomics.

Augmented Reality applications have not only improved people's quality of life but also had positive effects on their lifestyles in areas they previously couldn't benefit from. In the fields of medicine and education, AR applications directly impact human lives by saving lives and enhancing quality of life. Additionally, doctors and medical professionals can enhance their competence through the implementation of this technology in the field of education. In the entertainment, travel, advertising, sales, marketing, construction, and architectural sectors, in short, in commercial domains, the use of AR technology has contributed to an increase in capital, employment, and technological advancements, thereby positively impacting societal and national development.

When examining the research findings and literature reviews conducted in this study, it is observed that there is limited research available on augmented Reality technology. This study provides a general overview of sector-specific applications and serves as a guide for future research. However, it is believed that future studies should be more specific, focusing on certain sectors and conducting more in-depth investigations, which would contribute to the literature.

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Chapter 6

IoT in supply chain management

Aya GAMAL [1]

[1] M.Sc. candidate. Yeditepe University Institute of Social Sciences , Internationnal Trade and Logistics Management. aya.gamal@std.yeditepe.edu.tr ORCID No: 0009 – 0009 – 8570 – 4392

ABSTRACT

Supply chain management is an important process for businesses because it includes the coordination of a network of actions, people, entities, information, and resources targeted at creating and delivering a specific product to the end buyer. Companies may minimize costs, stay competitive, and assure a speedier production cycle by building optimal supply networks. This article's objective is to examine the advantages and challenges of implementing IoT in the supply chain while showcasing its potential. The Internet of Things allows for data collection and sharing in real time from a variety of connected objects, such as sensors, RFID tags and smart devices. By enabling proactive inventory management, optimization of distribution routes, and early detection of potential issues, data can increase visibility into product movements and conditions throughout the distribution chain. The Internet of Things (IoT), which enables the collecting and exchange of data from linked things like sensors, RFID tags, and smart devices, gives the supply chain instant visibility into each of its components. Product monitoring enables businesses to guarantee on-time delivery while facilitating the identification and prevention of possible problems. IoT adoption in the supply chain raises issues with data security, volume management, and integration with current systems; however, by taking a strategic approach and working closely with suppliers and partners, these issues may be solved and the full potential of IoT can be realized. We can conclude that IoT has great promise for enhancing the visibility and efficiency of the supply chain and it is the main and strong advantage of implementing loT in supply chain management.

Keywords: loT, internet of things, RFID, logistics, supply chain management, logistics industry, supply chain

I. Introduction:

Academic research as well as commercial operations have started to pay attention to the idea of disruptive technology. Disruptive technology upends a sector or makes it possible for a business model to birth a brand-new one. Several scientific fields, including computer science, management science, and information systems, have made disruptive innovations the emphasis of their research. Disruptive technologies present a few difficulties, as uncertainty, expense, and complexity. But there is also a positive side which is that it dominates industries with fresh, innovative features that are different from existing technology. (Li, 2018) Purchasing resources, converting those supplies, then producing finished goods as well as semi products, delivery to clients are all performed by a supply chain, which is an interconnected series of facilities and delivery options. Although the difficulty of the linkages varies widely from industry to industry and firm to firm, both production and enterprises use supply networks. (R. B. Dhumale, 2017) Supply chain management focuses on transporting any product to client provided that it will reach the accurate client in the fixed time and the aggregate number agreed about without forgetting to transport the services at the exact place with a convenable price. (Mohamed, 2018) Numerous crucial operations are included in SCM. Primary resources, manufacturers, and companies are utilized as a foundation, and a process is used to control customers. (Weng Chun Tan, 2021) SCM consists of many essential tasks. A procedure is employed to govern buyers while using raw source, suppliers, and businesses as a basis. (Hassini, 2017)There is a need for better chain networks. In logistics field, Lot is being applying by developing an intelligent and safe supply chain management technology in order to produce a sizable of future networks to integrate statistics, knowledge, items, physical devices, and all operational processes. (Mohamed, 2018) Online world is evolving, IoT will be a next step in that progression. It has made significant strides in its capacity to collect, examine, and disseminate data that we can use to arrange data, skills, and eventually knowledge and understanding. (R. B. Dhumale, 2017) If we identify the internet of things as it corresponds to supply chain management, we can describe it as a collection of real-world items that are digitally interconnected for the purposes of detecting, able to monitor, and interplay both within and between a company and its SC concreting flexibility, accessibility, information exchange, and monitoring to facilitate the planning, controlling, and cooperation of the operations of the supply chain. (Mohamed, 2018) The idea that Lot intends to improve the current transmission methods. Through improving decision-making rapidity and precision, lowering hazard, and boosting output and effectiveness, the Internet of Things will boost both. Future

will be faster as well as the Web will be more expansive, therefore the distribution network must additionally employ the Internet of Things in order to help the society demands. (Mohsen Gerami, 2020) The setup of extensive networks is the primary and fundamental objective of loT through the integration of several wearable sensors, including RFID, the Global Positioning System, or (GPS), and networks to enable worldwide exchange of information. (Weng Chun Tan, 2021) IoT could not only reduce Technology might lower operationally costs while additionally delivering greater creativity, flexible, along with targeted assistance to clients. (Li, 2018) IoT concept, key drivers of technology are presented as key features in internet of things used in managing the supply network. (Hassini, 2017) Web of things is now technical invention which connects gadgets but also materials throughout the Web. (Miah, 2018) One of the cutting-edge innovations in managing supply chains has been named as radio frequency identification (RFID). In order to gather, determine, improve, as well as optimize logistical procedures in a variety of changing circumstances, RFID-IoT is essential. (Weng Chun Tan, 2021) To address diverse SCM difficulties, IoT offers new levels of transparency in the supply chain, speed, and flexibility. (Akkartal G. R., 2019) Additionally, monitoring of the supply line processes remotely will be approved by IoT, improve communication with collaborators, and offer more precise data for enhanced decision. (Hassini, 2017) In current world, innovation is equated with development and modernity in every aspect, first from society to the economical, via the education sector. (Witkowski*, 2017) The term "intelligent supply network" refers to a contemporary, integrated world that advances distribution networks from being implemented in small, localized areas by a particular enterprise to being widely and methodically applied. (Mohamed, 2018) Information technology (IT) advancements have been crucial in improving the organizing, executing, and monitoring of the movements with preservation of merchandise, facilities, information must be transferred via the stage of production to the place of usage with the aim of boosting client satisfaction. (Abderahman Rejeba, 2020) Due to the widespread use of Internet technology, e-commerce networks are becoming more and more crucial to trade in marketplaces. E-commerce emergence in network supply chains against backdrop regarding «Internet Plus" transforms ways that conventional businesses are run while also creating new methods for managing conventional supply chains. (Wu, 2021) (Akkartal E. M., 2010)

II. IoT in Supply Chain Management:

1. How IoT can be used in supply chain management:

The sourcing of industrial inputs and consumer goods from different regions of the world has risen because of the liberalization and globalization of international commerce. Because of this, manufacturers and distributors are now more dependent on one another in global supply chains. As stated by Beamon B. (1998), a Supply Chain is "*a structured manufacturing process wherein raw materials are transformed into finished goods, then delivered to end customers*".

The term "supply chain management" (SCM) describes a network of connected facilities and distribution choices that perform the tasks of procuring raw materials and products, converting them into intermediate and completed items, and delivering the finished commodities to the final customer. The coordination and integration of numerous operations that take place throughout a network of facilities are part of supply chain management (SCM). This network includes the acquisition of raw materials, their processing into intermediate products and finally completed commodities, as well as the distribution of these goods to clients. To maximize client value, traders, consumers, and other key stakeholders in the supply chain must all work together in harmony to align and coordinate key business operations. (Janvier-James, 2012)

The Internet of Things (IoT) is a network of physical objects that are connected to computer systems often by Wi-Fi or data networks in order to monitor, record, send, and exchange data. These gadgets employ sensors to detect a variety of environmental parameters, such as their position, temperature, humidity, light levels, motions, handling, and speed. Internet of Things (IoT) technologies can be applied in different areas of industry, such as smart factories, logistics management, energy systems, supply chain management, packaging optimization, among others. These applications cover all processes. According to a study by Metallo (2018), the use of IoT could replace the traditional product orientation and allow companies to interact with each other, with the environment and to share data to continuously update their products. This technology will also facilitate integration with other partners to customize products, derive mutual benefits, and provide real-time and predictive insights to meet future needs. IoT devices come in a variety of forms, including RFID chips, smart gadgets, and mobile sensors. IoT devices are a useful resource in the supply chain sector for tracking and confirming goods and shipments using GPS and other technologies. Additionally, they may keep an eye on how items are being stored, enhancing quality control across the whole supply chain. (DERAL, 2020)

2. Examples of IoT devices used in supply chain management:

The Internet of Things (IoT) is used in supply chain management to link a variety of sensors, location tracking tools, RFID tags, environmental monitoring systems, surveillance cameras, robotics, drones, and other objects. At each level of the supply chain, these sensors measure the temperature, humidity, light, movement, and handling of the items to increase the effectiveness and caliber of the chain's administration. (Özkanlısoy Ö. &., 2021)

- RFID technology: Radio Frequency Identification a contactless automated identifying technology with the potential to transform many applications, most notably supply chain management, RFID has acquired tremendous momentum in recent years. Beyond the constraints of conventional barcodes, it provides real-time visibility of commodities across the supply chain. RFID helps businesses to achieve real-time monitoring, improve logistics management efficiency, and increase supply chain transparency when used in conjunction with the Internet of Things (IoT). Organizations can foresee trends, proactively adapt to market developments, and increase their overall agility through data analysis at each level of the supply chain. IoT integration enables seamless integration throughout the whole supply chain and boosts supply chain management, resource utilization, real-time monitoring, and information transparency. Enterprises can efficiently prevent counterfeiting by combining RFID and IoT, which improves supply chain management and product visibility. Business potentials are greatly expanded as a result of this integration, and projections indicate considerable financial expenditures in RFID technology. (Sun, 2012)
- Smart plug: The Smart Plug system was created to address the issue of energy conservation by giving consumers more information about the energy use of connected devices. With this solution, customers will be able to operate outlets from their smartphones, enabling them to turn gadgets on and off and establish operational times. A master outlet and a few slave outlets make up the system setup, and the master outlet manages connections between the slave outlets and has Wi-Fi connectivity. ZigBee connectivity will be used by slave outlets to receive instructions from the master and provide power measurements. Modern smart grids will be able to use efficiency thanks to the data obtained by the Smart Plug system, which will also enable future study into energy use. (Musleh, Debouza, & Farook, 2017)
- EV load: The goal of EV charging load balancing is to make sure that every electric vehicle can be charged effectively throughout the day. In order to fulfill peak consumer demand, it also permits charging service providers

to use grid power during off-peak hours and store it on-site without having to pay the utility company excessive peak-hour prices. The overall number of electric automobiles (EVs) will significantly rise soon, which will result in a corresponding rise in the amount of power needed to charge them. The networks used for producing and distributing power may be under a lot of stress because of the rise in energy needed to charge these electric vehicles. There is a growing need for public recharging stations as more EVs join the marketplace. (Shivam Singh, 2022) An EV may be swiftly recharged in less than five minutes at a fast-refueling station, although the batteries' lifespan may be severely shortened by this type of charging. In contrast, it takes more time to recharge an EV at a sluggish filling station. Vehicles must wait from two to eight hours for their battery packs to completely charge at sluggish the first Level or the second Level recharge facilities. Entirely recharging the battery requires between twenty and forty minutes at Level three recharging stations. Battery switching is a term for such a technique. The entire process could just take ten minutes or less, which is far quicker than even some fast-charging facilities and comparable to traditional automobiles. (Angel Alejandro Juan, 2016)

- Power and energy meter: The use of electrical household appliances has significantly increased in recent years, driving up electricity demand and consumption. It is crucial to have a method for monitoring, measuring, and managing electricity consumption as energy resources become scarcer. Conventional energy monitors, on the other hand, do not provide information on energy usage at the individual device level, making it challenging for consumers to monitor or record individual device energy usage. In order to solve this issue, intelligent energy monitors that are IoT-compatible have been developed, allowing consumers access to data on each device's energy use. These facts help to raise awareness and encourage energy conservation that is conscious. IoT systems that are compatible with energy provide crucial information. (Shishir Muralidhara, 2020)
- Bluetooth beacon: Because of the increasing usage of Bluetooth-enabled devices, wireless low-power devices, notably Bluetooth low energy (BLE) beacons, are a viable option for numerous IoT applications. However, interdisciplinary research is required to ensure seamless integration of BLE beacons into the IoT ecosystem. The Internet of Things has created new difficulties and possibilities that must be addressed. The advancement of wireless technology and mobile computing has transformed wireless communication between devices, reducing the challenges associated with

traditional cable connection and enabling dynamic data transmission over the air. RFID, ZigBee, 6LoPan, and BLE technologies have all played an important part in this evolution. (Jeon, She, Soonsawad, & Ng, 2018)

- LoRaWAN sensor: The expansion of the Internet of Things (IoT) requires more interconnected sensor nodes, which requires a scalable network infrastructure. Since many wireless sensing devices have a limited power capacity, power saving techniques have become an important area of research. Besides power efficiency, considerations such as latency, range coverage, and bandwidth are also critical in IoT. The LoRaWAN protocol, which uses LoRa technology to allow end devices to communicate with gateways in a single hop, is a promising solution for the IoT. Although other proprietary LPWAN technologies are already widely adopted. Nevertheless, challenges remain to maintain communication efficiency while reducing power consumption, and heterogeneity in IoT must also be addressed at the radio or gateway level. (Silva, Rodrigues, Alberti, Solic, & Aquino, 2017)
- GPS trackers: Twenty-four satellites make up the Global Positioning System (GPS), which orbits the planet in six different directions. GPS tracking systems deployed in cars, assets, or wearables continually receive navigation data transmitted by these satellites on two L-band frequencies. Each satellite's range information is gathered by five monitoring stations and four ground antennas and sent to a master control station for network coordination and correction information. The gadget offers real-time information about its precise position and motions via GPS tracking, enabling real-time tracking. With the most recent advancements in GPS technology, GPS devices may now be used as sensors, trip routes, and activity monitors at the local or regional level. (R. Bajaj, 2002) (Stefan Van der Spek, 2009)
- Smart pallets: The Smart Pallet is outfitted with a device that incorporates sensors to collect relevant data, such as location, shocks, tilts, and ambient temperature. The acquired data is subsequently sent to the Smart Pallet platform through an IoT network. The data coverage in the supply chain is increased by using Smart IoT Pallets. In contrast to passive technologies such as barcoding and RFID, IoT actively sends events. This technology adds to resilience by allowing for faster detection of exceptions, processing and displaying events in context, exchanging information with supply chain partners and other parties, and improving individual and organizational preparedness and reaction. (J.P.S. PIEST, 2020)

3. IoT In Inventory Management :

The old Inventory Management methodology has grown ineffective to fulfill the demands of modern organizations and different product lines. An IoT-based intelligent Inventory Management System has developed as a solution that offers substantial advantages over previous techniques. Inventory management is critical in every production setting for reducing costs and enhancing customer service, and firms expanding abroad with different components and warehouses require good inventory management. The introduction of IoT technology has transformed the retail business by establishing a smart environment for informed manufacturing, allowing for more visibility and control of production processes, as well as task automation. Inventory management in supply chain management attempts to decrease inventory costs by applying proper regulations and considering various elements to maximize customer service levels. Customers are now playing an increasingly important role in determining demand, and production plans must be altered accordingly. Businesses must assess data to plan production and optimize choices to compete. Inventory replenishment rules, reviews, and ordering amounts should be adjusted to account for changing demand. With Industry 4.0 technologies, notably IoT, inventory management may be more sensitive to altering inventory operations owing to changes in demand. The influence of IoT on inventory management necessitates a rethinking of inventory replenishment procedures as well as the development of new concepts for responding to Industry 4.0 technology. Traditional inventory replenishment methods are incapable of dealing with IoT devices, therefore upgrading a supply chain to an integrated supply chain 4.0 is advantageous. (Guha, 2019) (Yasaman Mashayekhy, 2022) ((Smitha) & Aslekar, 2022)

III. Benefits of IoT in Supply Chain Management:

A supply chain manager stated that *"The influence of the Internet of Things is crazy, ».*

This perspective is consistent with the expanding amount of academic research on the Internet of Things (IoT). The Internet of Things (IoT) is defined as a worldwide intelligent platform enabled by the Internet that consists of objects with unique addresses and capabilities for sensing, networking, and actuation, allowing for the interchange of information between humans, machines, and things in various situations. (Shee S. J., 2021) The movement of raw materials, semi-finished products, and finished products from suppliers to consumers, is known as supply chain management. Logistics management is also included in this process. The use of IoT technologies, such as RFID, sensors, and data visualization, can help increase inventory tracking accuracy and enable easy

monitoring of products throughout the supply chain, facilitating real-time decision-making. The benefits of IoT extend to all logistics activities, including warehousing, shipping, and last-mile delivery. Furthermore, IoT devices can be used to enhance store operations, such as controlling lighting and temperature, and administrators can use IoT technology to modify prices in real-time for products based on demand. When examining the literature, it is found that Internet of Things technology holds promise and benefits for businesses across all industries. However, its primarily focuses on the promises and benefits of the Internet of Things in retail. These operational benefits include monitoring the freshness of perishable products through intelligent tracking and packaging that monitors shelf life, changing price tags in real time, using autonomous smart robots for inventory management and handling of hazardous materials, optimizing the supply chain and logistics with RFID solutions, and improving the customer shopping experience through proximity-based direct marketing solutions. Additionally, the Internet of Things can automate processes, increase efficiency, and reduce costs, increase sales, provide competitive advantage, and improve customer satisfaction and loyalty. The IoT provides a personalized and enhanced shopping experience for customers, using Bluetooth-Beacon technology that allows sales representatives to gather information about previous purchases and customer preferences. Customers also receive personalized coupons upon entering the store. IoT-connected digital signs provide real-time personalized information about selected stores, cities, or regions. Customers can use their mobile devices to call for help, check inventory, or navigate the aisles more easily with smart cards or touchscreen robots. They can also view products and check reviews on social media by scanning barcodes with their smartphone. Smart mirrors allow them to virtually try on clothes, while activity-based products recommend fitness routines. Customers can also make contactless purchases through automated payment methods. Internet of Things technology is considered one of the most important components of Industry 4.0 and digital transformation. The Internet of Things is spreading across all types of devices, which means a new era for all industries. However, in Turkey, IoT applications remain limited due to structural issues, insufficient human resources, and infrastructure costs. It is therefore recommended to examine the effects of this technology using quantitative research methods in future studies. (GÜLŞEN, 2019) The use of the Internet of Things (IoT) has become widespread in supply chain management (SCM) and has various functions such as connecting vendors, offering real-time updates, improving reverse logistics, and collecting product data for operational effectiveness. However, there are still many challenges in adopting and using IoT, such as difficulties in predicting how digitalization will

affect industries and integrating logistics processes across supply chains with different technologies and data services. Security, ethical, privacy, and standardization concerns are also significant barriers, as well as the need to reduce e-waste for environmental sustainability. Many companies are hesitant to invest in IoT due to social, financial, and technical factors. More research is necessary to explore the potential of IoT in SCM and gain practical insights from industry experts. Understanding how smart devices connect all supply chain partners and enhance visibility is essential, and sharing the collected data in a single IoT platform can benefit all supply chain partners. (Shee S. J., 2021) The Internet of Things is an interconnected system of individual terminals (sometimes known as "things") that can interact with one another without the assistance of a human via IP connection. Numerous physical assets, including vehicles, cargo, wind turbines, drilling machinery, and smart meters, are connected to billions of sensors at the edge of these networks. When adequately gathered and processed, the large data produced by these devices may offer supply chain operations unparalleled visibility into current circumstances, enabling problems that need to be corrected to be discovered immediately. The supply chain may achieve new levels of efficiency by swiftly responding to these indications. It is challenging to seize this potential for process improvement, though. In an analytics project, gathering and preparation often take up 80% of the time.

This technology is transforming the way businesses operate, revolutionizing their operational efficiency and enhancing the customer experience. Here are some instances of how the Internet of things is reshaping supply chain management:

- Real-time tracking and monitoring: Through the integration of sensors into products and containers, the loT enables real-time tracking and monitoring of goods and assets across the supply chain. This allows companies to optimize logistics, reduce delivery times, and minimize loss and waste by tracking parameters like location, temperature, humidity, and more.
- Predictive maintenance: The loT facilitates predictive maintenance by continuously monitoring the performance of equipment and machinery in real time. This approach reduces downtime, extends the lifespan of equipment, and improves overall efficiency.
- Inventory optimization: By providing real-time visibility into inventory levels, demand patterns, and supplier performance, the loT helps businesses optimize their inventory. This reduces the risk of stock outs and excess inventory, leading to lower costs and enhanced customer satisfaction.

- Enhanced collaboration with suppliers: The loT enables closer collaboration between suppliers and manufacturers by offering real-time visibility into supplier performance, inventory levels, and production schedules. Through data sharing, companies can optimize supply chain processes, reduce lead times, and improve quality.
- Improved customer experience: Through the loT, businesses can deliver an improved customer experience. Real-time visibility into inventory, delivery times, and performance allows companies to proactively respond to customer requests, reduce delays, and ensure reliable product delivery, resulting in heightened customer satisfaction.

By embracing loT technology, companies can enhance supply chain efficiency, reduce costs, and increase customer satisfaction. Although concerns about data security and standardization persist, the numerous benefits offered by the loT in supply chain management far outweigh the potential risks. Moreover, the loT opens doors to new business models and revenue streams for supply chain companies. For example, some companies are exploring loT-based subscription models where customers pay for access to a product or service instead of owning it. This model provides recurring revenue, improved demand forecasting, and optimized inventory levels.

Another example is loT-based asset sharing models, where companies share resources and assets to enhance efficiency and reduce costs. This model is particularly relevant in sectors like logistics, where companies can share trucks, warehouses, and other resources to optimize operations. The loT also empowers businesses to leverage data analytics and artificial intelligence (AI) for deep insights into their supply chain operations. By analyzing the vast amounts of data collected from sensors and devices, businesses can identify patterns, trends, and anomalies, enabling data-driven decision-making. AI-powered tools like predictive analytics and machine learning further aid in anticipating demand, optimizing inventory levels, and improving logistics operations. Additionally, by using sensors and devices to monitor equipment and machinery conditions and performance, businesses can identify potential issues before they occur and take preventive action to avoid downtime and disruptions. For instance, loT-powered sensors can monitor energy consumption, allowing companies to identify inefficiencies and reduce their environmental footprint. Tracking devices powered by the loT can also monitor waste and emissions throughout the supply chain, enabling waste reduction and offset opportunities. Some companies are also exploring the use of supply chain technology and smart contracts to facilitate secure and transparent transactions within the supply chain. In terms of the supply

chain industry, Bitcoin can be employed to facilitate cross-border transactions, reduce transaction costs, and increase transparency. Adopting Bitcoin allows companies to bypass intermediaries like banks, reducing costs and speeding up processes. The underlying blockchain technology of Bitcoin further establishes a secure and transparent network for the supply chain, enabling participants to monitor the flow of raw materials and validate their legitimacy. This helps companies mitigate the risk of fraud and counterfeiting while improving overall supply chain efficiency.

In conclusion, the loT is not just a technology; it is a significant game-changer for the supply. (Santagate, 2015)

IV. Challenges of Implementing IoT in Supply Chain Management:

1. Major Challenges of internet of things:

The Internet of Things vision presents several technical and practical difficulties. Security and privacy are endangered in a connected world where data is sent to dispersed cloud computing. It is essential to preserve the values of secrecy and data security and to provide privacy protection in new sectors. The need for efficient IoT governance cannot be overstated. The initial idea of an RFID-based worldwide network of connecting devices has been further broadened to include the idea of heterogeneous items interacting with their actual environment. Various techniques are used to facilitate communication between these devices. (Özkanlısoy Ö. A., 2020)

The abundance of devices linked to the internet and actively sharing data is a major component of IoT. Scalable apps can help to solve the problem of storing and analyzing enormous amounts of data, but they can do more than that. It is crucial to establish perfect trust in IoT to make sure that the data transferred has no negative consequences on people or society.

Here are some main challenging domains of loT:

- Privacy and Security: The IoT presents substantial privacy and data security problems. The credentials and access privileges for each piece of information must be identified. Businesses must be fully prepared due to the new security environment created by the exponential increase of connected devices. However, this also opens fresh possibilities for providers who specialize in security in the field of operational technology.
- Standardization and Interoperability: A significant challenge is ensuring the flawless operation of the varied technology platform. The growth of disruptive devices inside the Internet ecosystem will be slowed down by the adoption of relevant standards, reference models, and best practices.

- Big Data: Managing enormous amounts of data presents a variety of difficulties. How can the data flow from billions of "actors" be properly managed? How do we ensure that the data remains relevant and useful? What challenges are involved in processing, analyzing, and exploring the data produced by these devices? Where will it all be stored? (Tadejko, 2015)
- Cost: Internet of Things has gained popularity for a long time. However, because of its higher unit cost, restrictions on item-level scope, and expenses associated with its integration with the organization's current software systems as well as contacts with suppliers and consumers, RFID technology, which serves as the foundation of the IoT, has not been able to gain power in the market. (Shee S. J., 2021)

2. Challenges Associated with Deploying IoT in Supply Chain Management:

IoT has historical origins in logistics. Since many years ago, tracking objects with the aid of technology has been possible thanks to various information and communication technologies. Consequently, the advances brought about by IoT in the logistics industry may be seen as a progression from earlier innovations. Logistics' primary goals are to ensure the accurate movement of commodities, considering factors including quantity, quality, timing, location, and cost. (Mohsen Gerami, 2020) IoT-based methods can offer the industrial execution system a real-time solution for data optimization across several manufacturing process levels. It is possible to track and record real-time information about a variety of production aspects, including operators, equipment, pallets, commodities, and more, using key components of transportation and logistics systems. Now it is feasible to dynamically improve the production process in novel ways by utilizing real-time data from IoT devices. This dynamic optimization's goal is to quickly assess and modify production control settings based on data provided by IoT devices. (Tadejko, 2015) The retail business and its supply chains may take use of the IoT's numerous benefits, but there are obstacles to its widespread adoption. (Shee S. J., 2021) The initial and main barrier is hence the expenditure required for the adoption of Industry 4.0 technology. Significant capital expenses and usually unclear cost-effectiveness studies are significant barriers for new Industrial Internet applications. Acquiring the necessary knowledge to satisfy the demands of the digital world is equally crucial. Additionally, it is crucial to create enforceable standards and take care of cybersecurity chores. It is without a doubt necessary for corporations, unions, organizations, and policymakers to work together to advance this fourth industrial

revolution. (Mohsen Gerami, 2020) The second main challenge is figuring out how to create a framework for gathering and integrating real-time data while also establishing a reference architecture for the IoT-based manufacturing execution system. Nevertheless, there are also other obstacles preventing the full use of the acquired data, despite enterprises' desire to use IoT-driven industrial processes. These difficulties are mostly caused by the lack of standardized, effective data security and management services that provide the required level of sensitive data protection. Since the guarantees offered by the existing approach won't be sufficient to fulfill the requirements of sensor based IoT networks, the next problem is related to standard IP networks and the degree of quality of service (QoS). Now, most machine-to-machine systems and IoT solutions require implementation at the transport layer, combining unique application protocols connected to the network layer. This situation becomes critical when dealing with certain applications like linked cars and telemedicine, where latency and assured delivery are vital. As a result, rather than only acting as a network transport medium, this kind of solution must incorporate the thorough, multi-layered design of the complete system. The creation of a specialized architecture that permits the seamless integration of billions of intelligent objects is another scientific and technological challenge in the design of IoT systems. Wi-Fi and GSM 3rd Generation/Long-term Evolution networks are examples of modern wireless technologies that are only used as means of transportation. Wireless technology will be used by smart devices and RFID sensors to create an intelligent network, but to simplify logistics management, it is crucial to develop standards for Internet-Enabled products inside the IoT architecture. It's been common knowledge that logistics are a key component of emergency response operations. To properly manage life-saving machinery, vehicles, on-site staff, as well as the processing of food, medication, and other consumer items, technology is essential. As is evident the scientific and technological issues connected with building IoT solutions for transportation and logistics necessitate the use of a wide range of systems and skills. These challenges include establishing connectivity among several smart things inside a network, integrating these items with external networks, and effectively managing data storage, exploration, and sharing. (Tadejko, 2015) A further barrier is the under-qualification of personnel, which has changed the needs for workers at every level of the value chain. There will be a growing need for workers with knowledge in data science and information technology as the IoT and digitalization continue to expand. The basis for the necessary education should be laid by policymakers, and early technology excitement should be encouraged. IoT provides the supply chain with an unparalleled level of transparency, enabling the early detection of problems

that need to be fixed on both the internal and external levels. Consequently, via effective internal operations and improved cooperation with suppliers and consumers, firms are better able to react quickly to changes. The entire promise of the IoT, however, has not yet been completely realized by existing technologies and applications. We do not have now the complete coverage needed for the whole supply chain; instead, we only have discrete, fragmented applications. (Abdelhadi, 2019)

The following shortcomings are shown by current research on IoT applications in supply chain management:

- The absence of strong frameworks that offer a roadmap and clear instructions for using IoT in the context of supply chains. Given the different IoT adoption levels across supply chain partners, these frameworks would help businesses choose the best method and deployment stage for their IoT deployments. Additionally, these frameworks would help with changing management techniques used by businesses and the whole supply chain.
- Poorly developed models for dealing with supply chain problems in an IoT setting. Managing smart supply chains requires new tools and models that consider the distinctive features of this evolving environment, including the amount of huge data created by sensors and connected devices. Managing smart supply chains varies from managing traditional supply networks. The use of IoT will have an influence on several areas, including maintenance, inventory management, quality assurance, and maintenance planning.
- The successful integration of IoT in SCM faces several obstacles, both technological and administrative in nature. Greater privacy and security problems are brought about by a connected society. This worry is especially important in the context of the supply chain, where information exchange has historically presented major difficulties. (Mohsen Gerami, 2020)

V. Case study: Example of a company using loT in supply chain management:

A Third-Party Company's Real-time Logistics System Leveraging IoT Technology:

The increasing demand for third-party logistics (3PL) services in the e-commerce industry has posed challenges in warehouse management. To address these challenges, a study introduces a IoT system that supports wearable devices and wireless technologies. This system has been successfully implemented in an

auto parts 3PL company, resulting in improved operational efficiency, visibility, and traceability. Other 3PL companies can replicate or customize this model to enhance their own warehouse management practices. In our case study, the industry leader in third-party logistics services is HOZDO Visual Logistics Ltd., which has its corporate office in Guangzhou, China. HOZDO, which focuses on automotive logistics, is renowned for its superior customer service and cutting-edge technology. Their main goal is to maximize customer satisfaction by optimizing the entire supply chain through the integration of dedicated transport partners. HOZDO is dedicated to creating a tailored information system that decreases paper usage, increases operational efficiency, and improves visibility and traceability. The company has a fleet of over two thousand vehicles plus Eighteen warehouses. To accommodate the preferences of their workforce, they put a high priority on a user-friendly system deployment.

1. Setting up the new system: System empowered by IoT technology:

The system empowered by IoT technology is seamlessly connected with RFID devices, QR-code scanners, wireless connectivity, mobile and desktop applications, and cloud services. Through the utilization of these resources, it enables efficient management of large volumes of data and facilitates real-time synchronization of operations.

1.1. Information exchange:

The data transmission is categorized into three stages, which are determined by the hardware and software implemented in the novel system. These stages encompass the acquisition, exchange, and retention of the data.

- Data acquisition: To collect and send data, the new system combines RFID tags with a specially designed Smart Pen. RFID tags have a two-piece construction that makes them firmly fasten to pallets, and the Smart Pen, which has an RFID reader, QR scanner, and Bluetooth module, lets users access information. Physical products are transformed into digital data by attaching a distinct RFID tag to each pallet, allowing for easy registration and simple access inside the system.
- Data interaction or data communication: There are desktop and mobile apps available in the system for different management levels. The desktop tool enables managers to supervise operations, handle information and inventories, and assign tasks. It includes management modules for inventory, vehicles, locations, and accounts, as well as the ability to record transactions, import receipt notes, and produce shipping lists. Although they have little control, warehouses can track and share the status of their

goods. Senior managers have independent power. Operators use the mobile app to receive and complete tasks like putting items on pallets, completing assigned orders, inspecting shipped goods, and assisting with warehouse put-away. It also permits decision-making access to the inventory.

- Data retention: The new system completely utilizes cloud computing by using a cloud server for data transport and processing. The database is housed on the server, and quick access is made possible using client-side storage. Users can instantly upload to and get data from the server without any issues.

1.2. Operational sequence:

- Conventional inbound process: According to this approach, keeping commodities entails going through the receiving slip procedure. The operator enters product information into the mobile app, links it to the pallet with the Smart Pen, and fastens the RFID tag. After then, all the data is uploaded to the cloud server. The operator uploads digital receipt notes to the mobile app if they are already accessible in that format. To effectively optimize placement, the operator chooses the receipt list upon arrival, scans the RFID tag, and records the position.
- Expedited inbound procedure: With a quick input process, the new technology facilitates cross-docking across warehouses. The operator scans the QR code on the receipt list with the Smart Pen, which causes the items to appear on the mobile app. The operator checks the correctness of the RFID tags on the receiving pallets and finds any transportation losses by scanning the tags. The ensuing actions follow the typical reception procedure. This streamlined method, which only requires three steps—"Scan," "Accept," and "Store"—significantly improves operational effectiveness.
- Order selection: The manager in the office uses the desktop software to choose products from the inventory module and build a shipping list. The manager can be reminded of approaching delivery dates by setting an automated alert. The shipment order is confirmed and given to the operator for fulfillment after being verified. For future use, the shipment list is kept in the cloud. The manager's account may be used to do these activities on the mobile app. The operator verifies the shipment orders on the mobile app in the warehouse and uses location data to find the relevant pallets. To confirm the contents of each pallet, the operator scans the RFID label using a Smart Pen. The process continues until all necessary goods are selected.

The prepared shipping items are then sent to the shipping area, while the confirmed shipping list is uploaded to the cloud.

- Dispatch: The operator uses the "Outbound" portion of the mobile application in the dispatch area to submit the dispatch list that has been confirmed. The smartphone software directs the user on how to load the items into the proper vehicles after choosing the pertinent list and available trucks. Using the "Unlink" function of the mobile app, the RFID tag is eliminated and recycled if it is the destination's final location. Then, using the smartphone app, the operator takes pictures of the vehicle, including its license plate, to link them to the loaded cargo. This entire collection of data is sent to the cloud. The driver then transports the cargo to its destination.
- Logistics scheduling: Effectively controlling the shipment dates of stored products is essential in logistics when preparing inventories or orders. For warehouse managers, the mobile app has a dedicated "Ship Date Management" area. They can choose the things to be moved and do product searches utilizing codes. The software provides suggested relocation directions after cloud-based computations and sorting. By scanning the RFID tag, operators remove the products from the pallet, move them to new or used pallets, and then scan fresh tags to create the link. Once all the requirements have been met, the location information is transferred to the cloud and the connected data is updated.

2. Introspection:

Paperless processes have been effectively adopted by the IoT project using desktop and mobile applications. When compared to traditional paper records, the transition to digital procedures improves stability, durability, data transfer speed, and storage capacity. The warehouse may completely run without paper while keeping vital information by properly deploying the technology. In terms of paper usage, this transformation results in significant cost reductions annually.

2.1. Enhance managerial effectiveness:

The real-time data synchronization within the IoT system enhances management efficiency. Through the cloud server and desktop application, managers can effectively monitor and control the process without relying on manual updates or physical presence at the warehouse. Decision-making and implementation can be done promptly from the office. The securely stored data allows managers to assess operational information across different timeframes. This data facilitates the evaluation of worker productivity and warehouse workload, leading to improved resource allocation and utilization. Overall, the

new approach significantly enhances management effectiveness by optimizing resources and labor.

2.2. Minimizing errors:

By introducing automation utilizing gathered data and specified algorithms, the new system lessens reliance on human knowledge and lowers mistakes. By improving procedural control, a more effective operating procedure with fewer mistakes is produced.

2.3. Reduce the employee onboarding time:

The desktop and mobile software offer detailed operational information, eliminating the need for employees to remember every aspect of their jobs. It also standardizes the working method, allowing employees to easily follow the instructions in the mobile app. This streamlined and readily available knowledge reduces training time and facilitates the rapid adaptation of new staff, leading to increased operational productivity for the company. Usability is improved by streamlining processes and introducing rapid execution features. Long-term dependability and smooth transitions are ensured by using wireless transmission technologies. This IoT system has a lot of room for development overall. This section provides a case study of how a third-party logistics provider developed a nationwide warehouse synchronization system for automotive components. The lack of information exchange between warehouses resulted in inefficient and error-prone paper-based processes. To address these issues, an IoT cyber-physical system was implemented, incorporating diverse technologies for data collection and transmission. The system integrated desktop and mobile applications to enhance visibility, traceability, and streamline procedures, leading to increased productivity, particularly for management teams. It examines the system's design, workflow, and provides recommendations for future enhancements based on real-world testing. This project is significant as it creates the essential hardware and software for logistics synchronization, presents a potential solution for similar logistical challenges, and demonstrates the transformative potential of IoT in the logistics industry, motivating other companies to adopt these advanced technologies for future competitiveness. (Wei Wu, 2020)

VI. Future of IoT in Supply Chain Management: Predictions, Emerging Trends, and technologies:

1. Predictions for the future of IoT in supply chain management:

The incorporation of Internet of Things technology has enormous promise for influencing the future of the industry as supply chain management develops further. Future predictions for IoT in supply chain management cover a wide variety of innovations and changes that are expected to fundamentally alter how businesses run and manage their supply networks. In the ever-evolving realm of supply chain management, the future of IoT will be defined by constant innovation and flexibility. To maintain a competitive edge in the dynamic supply chain landscape, organizations must adopt a culture of innovation, agility, and collaboration. The integration of IoT with other emerging technologies will play a pivotal role, allowing organizations to collect real-time data on customer preferences and behaviors. This valuable information can then be leveraged to personalize product offerings, improve delivery options, and enhance overall customer satisfaction and loyalty. These projections underscore the game-changing capability of IoT to completely transform supply chain management and propel operational excellence in the future. (Shehzad Ahmed, 2021) (Akkartal G. A., 2019)

2. Emerging trends and technologies in IoT for Supply Chain Management:

2.1. Enhancing Supply Chain Visibility :

Businesses must attain high supply chain visibility (SCV) in today's complicated supply chains to simplify operations, cut down on errors, and lessen complexity. SCV entails following a product from its creation to its consumption, and the IoT significantly enhances supply chain operations by supplying trustworthy real-time data. Organizations may obtain information transparency and visibility through the deployment of IoT, getting precise insights into operations and product movement. Effective inventory management, component tracking, and inventory control optimization are made possible by the introduction of IoT. Using IoT for DMC has several advantages. It makes it possible to organize the supply chain effectively, encourages stakeholder cooperation, increases traceability and transparency, encourages flexibility in responding to changes, helps performance management, and enhances order management. These benefits enable organizations to achieve operational excellence, reduce costs and improve customer experience within their supply chains. (Shehzad Ahmed, 2021)

2.2. Integration of AI and Machine Learning:

Supply chain management is a broad term that includes the worldwide coordination of production, trading, and logistics across the whole supply chain. It entails efficiently controlling and coordinating the flow of products, funds, and information between suppliers and buyers. SCM systems offer process automation, more informed planning decisions, better flexibility, cost savings, and enhanced data analysis capabilities by integrating intelligent technology. The capacity of AI-based SCM to make autonomous choices, optimizing various parts of the supply chain through optimization, prediction, modeling, and simulation, distinguishes it. Within SCM, the use of big data and machine learning helps to improve forecasting, inventory management, revenue optimization, transportation efficiency, and risk analysis. AI improves decision-making processes by using both internal and external supply chain knowledge and data. To attain the best results, it is critical to combine artificial and human intelligence. AI use in SCM has shown to be quite beneficial, particularly in the manufacturing business. Overall, the function of AI in SCM is an intriguing and vital field of research, with plenty of room for additional investigation and progress. (Hao, 2020) (Aslan, 2021)

2.3. Increased Adoption of Autonomous Technologies:

Through digitization and technology improvements, the logistics sector is evolving and presenting new business prospects, increased efficiency, and creative planning strategies. Future planning and execution will be significantly impacted by important trends like automation and the development of autonomous logistics systems. When it comes to the design and management of logistics systems, automation is essential for achieving objectives like cost savings and increased decision-making freedom within logistics networks. Additionally, firms will be able to enhance demand forecasting, inventory management, and proactive supply chain disruption management thanks to the integration of AI, machine learning algorithms, and IoT data. Forecasts suggest that in the upcoming years, robotic process automation (RPA) will become more widely used and that logistical operations will get closer to being completely autonomous. (Nitsche, 2021)

2.4. Blockchain technology:

Particularly in delicate industries like food and pharmaceuticals, traceability is essential for improving transparency and visibility inside supply chains. Blockchain has emerged as the most promising technology among those under investigation. It makes it possible to record transactions and data securely and

openly on a distributed digital ledger. All parties engaged in the supply chain will have access to this shared, permanent record of vital information, including product origin, shipping information, and quality certificates. Supply chains may improve their traceability, security, and transparency by using blockchain technology. Blockchain's decentralized and unchangeable structure guarantees safe and trustworthy transactions, lowers the chance of fraud, and promotes cooperation among supply chain actors. This technology helps organizations comply with rules, build solid relationships with suppliers, and accurately educate customers about the origin of their products while strengthening traceability, provenance, and confidence in supply chain operations. Furthermore, by enabling quick and precise identification of impacted items, blockchain-based traceability systems offer considerable operational advantages, notably during product recalls, therefore reducing risks and liabilities. (Thomas K. Dasaklis, 2022)

2.5. Sustainability and Green Initiatives :

The supply chain's sustainability and ecological activities are greatly aided by IoT. Organizations may streamline their processes, cut down on waste, and make sure they are in compliance with sustainability laws by monitoring their energy use, carbon emissions, and environmental effect. By using alternative methods for manufacturing, services, and customer contacts, "smart green business" improves the performance and quality of businesses. Green and smart supply chains use IoT for energy-efficient equipment and integrate operational operations with social and environmental concerns. The information produced by sustainable enterprises has great value. Utilizing a green supply chain increases productivity and profitability while lowering waste and environmental threats. IoT integration into the supply chain provides benefits in the marketplace and guarantees environmental compliance. Smart and sustainable supply chain strategies that integrate IoT, ICT, and big data analytics improve business quality, efficiency, and competitiveness. For environmental sustainability to be achieved, big data management must be effective. A framework may make use of the physical and informational components of sustainable organizations by successfully combining IoT and Big Data. As a result, the supply chain may monitor and improve its energy use, carbon emissions, and environmental effect, enabling sustainable practices and legal compliance. (H. Nozari, 2021) (Akkartal E. &., 2021)

2.6. Fog Computing :

A new paradigm in computing called fog computing brings computational power to the edge of the network, supporting low-latency applications with little

congestion, low power use, and maximum bandwidth. It supports cloud computing and offers several benefits for logistics systems, such as better energy efficiency, reduced latency, cost savings, and increased mobility. Logistics systems may accomplish enhanced automation, improve product quality, maximize production efficiency, monitor real-time circumstances, and facilitate well-informed decision-making by incorporating fog computing.But there are still difficulties and issues that need to be tackled. By decentralizing data storage and processing, enabling real-time answers for latency-sensitive applications, and enabling flexible inventory management in fiercely competitive retail marketplaces, fog computing overcomes the drawbacks of centralized data centers. Fog computing is an excellent tool for assisting supply chain management because of its promising methodology. (Branka Mikavica, 2019)

2.7. 5G Technology and IoT Connectivity:

A possible option for allowing real-time networking among several devices is the fast and reliable connections offered by 5G networks. The study literature on the application of 5G in supply chain management is lacking, despite the revolutionary wireless technology's many potential benefits. Faster and more consistent connectivity is brought about by the launch of 5G networks, allowing for easy data exchange and communication amongst Internet of Things (IoT) devices throughout the supply chain. (Shee I. T., 2020) (Akkartal E. , 2018)

VII. Conclusion:

Supply chain management entails monitoring supply chain operations to maximize customer satisfaction and establish a sustainable competitive advantage. Traditional supply chains confront several difficulties, including uncertainty, expense, complexity, and weaknesses. Supply chain intelligence must be improved to solve these issues. The Internet of Things (IoT) is utilized in supply chain management to set up an intelligent and secure SCM system that connects data, information, goods, physical items, and all supply chain operations. (Mohamed, 2018) IoT devices play a significant role in supply chain management, enhancing visibility, efficiency, and control across different operations. In this article, there are some examples of loT devices used in supply chain management such as RFID (Sun, 2012) , Smart Plug (Musleh, Debouza, & Farook, 2017) , EV load (Shivam Singh, 2022) , Power and energy meter (Shishir Muralidhara, 2020) , Bluetooth beacon (Jeon, She, Soonsawad, & Ng, 2018) , LoRaWAN sensor (Silva, Rodrigues, Alberti, Solic, & Aquino, 2017) , GPS trakers (R. Bajaj, 2002) , Smart Pallets (J.P.S. PIEST, 2020). Industrial facilities and factories use IoT in distinctive ways. By extending IoT into the

manufacturing sector and utilizing the benefits of IoT, the complete design of an IoT-enabled manufacturing execution system creates a new paradigm. With sensors that communicate with a variety of sensing devices and other IoT systems, this design incorporates production elements, information exchange, fleet management, and other components. The use of real-time, data-driven monitoring and optimization strategies improves task responsiveness, productivity, quality, resource efficiency, and logistics cost reduction. Implementing IoT in supply chain management presents various challenges, including data security and privacy, standardization, cost considerations, reliability and maintenance, integration with existing systems, and effective data management. Overcoming these challenges necessitates strategic planning, close collaboration with technology partners, continuous evaluation, and ongoing improvements in IoT implementations. Companies should prioritize data security, privacy, and compliance, allocate resources for robust infrastructure and reliable connectivity, and carefully assess the scalability and interoperability of IoT systems to ensure seamless integration into supply chain management. (Tadejko, 2015) In the next section, as a case study, the focus was on a real-time logistics system implemented by a third-party company, which takes advantage of IoT technology. The primary objective of this system is to enhance the efficiency and effectiveness of logistics operations by making use of IoT devices and connectivity. The case study delves into the ways in which IoT technology enables the monitoring, tracking, and collection of data in real-time throughout the entire logistics process. (Wei Wu, 2020) Finally, we pointed out some predictions for the future of IoT in supply chain management and mentioned emerging trends and technologies in IoT for SCM such as; enhancing Supply Chain Visibility (Shehzad Ahmed, 2021) integration of AI and Machine Learning (Hao, 2020) Increased Adoption of Autonomous Technologies (Nitsche, 2021) Blockchain technology (Thomas K. Dasaklis, 2022) Sustainability and Green Initiatives (H. Nozari, 2021) Fog Computing (Branka Mikavica, 2019) 5G Technology and IoT Connectivity (Shee I. T., 2020) IoT has been widely adopted in supply chain management, revolutionizing the field by offering real-time visibility, increased productivity, and better decision-making. To truly profit from IoT, however, businesses must overcome issues with data security, standards, cost, and integration. Businesses may effectively use IoT to enhance their supply chain operations and get a competitive edge in the dynamic global market by giving priority to these factors and working with technology partners. (Mohamed, 2018)

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After graduating from Dz.H.O. as an Electronics Engineer in 1989, Dr.Akkartal worked as a senior manager in various procurement, warehousing, and distribution areas of logistics for 15 years. Parallel to his professional life, he completed his Master's Degree from Istanbul University Social Sciences Institute Statistics Department in 1994, and his PhD from the Econometrics Department of the same Institute in 2000, and received his Associate Professorship in the field of Quantitative Decision Methods in 2014. He has taught postgraduate and doctorate courses as a visiting professor at INHOLLAND Uni/Netherlands and the College of Logistics/Czech. Dr. Akkartal is a Jury Member of the Turkish Informatics Association and a referee in various journals. There are more than 200 citations to his sudies in many journals within the scope of SCI, and many papers in international congresses and publications. Dr. Akkartal's areas of expertise include Supply Chain Information Systems, Statistics, and Econometrics. Dr. Akkartal is currently a faculty member of Yeditepe University, Faculty of Economics and Administrative Sciences and Head of Logistics Management Department.

DUVAR

sertifika no : 49037
9 786256 507005
duvaryayinlari.com