

An examination of supply chain management using emerging technologies

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Abstract---Because so many people could not get hand sanitizer, cleaning products or paper goods during the pandemic due to supply chain problems, many consumers reached out to the media for answers. Around 95 percent of the Fortune 1000 companies said that China has led to problems for their supply chains. Supply chain issues can be solved with new inventions. These improvements make the system more reliable, pollution and trash go down, moving goods are made simpler and prices are greatly decreased. It explores methods for managing supply chains using Industry 4.0, examines automation to improve supply chain processes and reviews supply chain management as it stands now and its main issues. Based on (Woods, 2024), Nasereddin (2024) and (Tong, 2024), along with other sources, the observations in this book are found in the most recent numerical information.

Keywords---new technologies, applications, challenges, supply chain management, and status review.

I. Introduction

Raw material use began in the late 1950s. The single supply chain model emerged as a result of implementing SCM systems using a supply-optimized approach which led to thinking about sourcing, manufacturing, distribution and holism (Herold, 2021).

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While logistics is commonly confused with supply chain, it is only a part of the bigger idea. Logistics, purchasing goods, inventory planning, managing a product's life and handling orders are all vital for supply chain executives in addition to managing transportation and vehicles. SCM is capable of directing production in different countries and oversees suppliers worldwide. A system for supply chain management in the digital realm includes equipment for materials and software suitable for manufacturing and delivery activities. The different parts are vendors, manufacturers, distributors, logistics and shipping companies and retailers. Products and services have always needed distribution chains from the beginning. When industries developed further, managing supply chains (SCM) shifted which made it easier for companies to provide commodities and services more efficiently. Creating similar auto components made it easier for Ford to meet the increased needs of his expanding group of customers. Recently, SCM systems have been improved by the gradual addition of computer systems (Nasereddin, 2024). Although a lot has changed, the internet, technology and the global demand economy have brought about total transformation. Retail sales promptly transmit replenishment requests to manufacturers in a timely delivery supply chain. Then, sales displays can be restocked almost instantly after an item is sold.

1. Research Problem

Modifying the supply chain because of COVID-19 was a challenging task (Ganichev, 2021). Many conversations about the supply chain center on supply issues, but we should also focus on demand concerns. To put it another way, the suspension of work in Wuhan at automotive parts factories or the consequences on U.S. packaging companies. Had demand not risen again, it would have been pointless to keep fixing the supply problem. However, the issue wasn't simple either, as there were cases where supply and demand were both problems.

The COVID-19 pandemic exposed major vulnerabilities in global supply chains, particularly highlighting the critical role of inventory management in maintaining supply chain resilience. Effective inventory prepositioning allows firms to respond swiftly to sudden demand surges, but this strategy faces challenges such as demand forecasting accuracy, product perishability, and delivery coordination under uncertain conditions. In addition, reactive capacity and flexible cooperation contracts can help scale production rapidly and enable resource sharing, which are crucial for mitigating pandemic-related disruptions. Nevertheless, the complexity and unpredictability of modern supply chains, along with changing consumer behaviors post-pandemic, require advanced optimization and stronger collaboration among supply chain partners to ensure effective recovery (Ivanov, 2024).

2. The Importance of Supply Chain Management and Oversight

Doing this process effectively relies on using data provided by supply chain collaborators to locate and address potential issues. The supply chain is what customers, and prospective customers see most clearly. Correctly managing the supply chain is very important for protecting a business's reputation and ongoing sustainability.

3. Changes in the Business World and Customer Needs

With advances in technology and a growing global connection, the business world has seen rapid changes and changing needs in customers. We use an operating approach that relies on demand, joining technology, processes and workers, to provide goods and services more rapidly and with greater precision.

4. The Importance of Supply Networks as a Success Factor

Businesses have always relied heavily on supply networks, but their usefulness as a way to measure success is greater now. Being able to maneuver your supply chain in today's fast-changing market gives companies an edge and better prepares them to withstand risks.

5. The Core Objectives of Supply Chain Management (SCM)

The top objectives in SCM have, for a long time, been to minimize costs and achieve greater efficiency. The rules for SCM have stayed consistent but now emphasize putting the customer first in deciding what to focus on.

6. The Role of Customer Satisfaction and Its Impact on Supply Chain Quality

The quality of the food supply chain depends greatly on what consumers think. If a company meets its customers' needs quickly and correctly, this increases loyalty.

7. Comprehensive Supervision of Supply Chain Components

Efficiently serving one product means you must supervise all the basic parts, manufacturing, delivery, trading and orders carefully. Doing this requires you to focus on the customer's perspective when examining your supply chain. We strive to have orders ready on schedule and to complete every step before, during and after sending the shipment.

8. Planning, Execution, and Coordination to Improve Performance

"Effective supply chain management, supported by emerging technologies, enables cost savings by accelerating shipments and improving distribution accuracy. Logistics technologies ensure that products reach retail stores in the right quantities and on time, reducing excess inventory or shortages of customer-demanded items. Supply chain technology enhances organizational agility by providing accurate data and analytics, allowing managers to quickly address challenges and seize new opportunities. In today's complex market environment, aligning strategic planning with operational execution fosters clear coordination among all employees, which in turn improves customer satisfaction and retention. Accurate forecasting and inventory maintenance are crucial for reducing costs and minimizing warehouse stock, especially given the increasing complexity of multi-channel distribution (Palage, 2019).

II. Challenges and Transformations in Supply Chain Management Amid Crises and Modern Technologies

II.1. Difficulties in Demand Forecasting Amid Market Volatility

They had difficulties anticipating what people would buy in the future because of market instability and a fall in sales for numerous products (Ellis, 2020). The supply chain executive said, "Making projections about demand can be very tough." Even though we can handle a lot of planning, our forecasting still depends on using past data to look into the future.

II.2. Impact of the Russia-Ukraine Conflict on Global Supply Chains

The unstable situation of supply chains was enhanced by trouble with suppliers in Russia and Ukraine. A big network means staying aware of any threats to prevent them. The region is at risk because its use of Russian gas and petrol and its dependence on other countries for key farm products are serious problems. The Food and Agricultural Organization of the World Health Organization reports that almost 25% of the world's wheat trade is controlled by Russia and Ukraine. More than 60% of the global sunflower oil sector is controlled by these countries.

Additionally, most of the barley exported around the world comes from these countries (Toygar, 2023). Any disruption in Russia's export of fertilizers could result in big drops in crop yields worldwide. There is more to worry about than farming products and fuels. The impressive results for Russia are partly due to its exports of crucial goods, explained in a recent report (Tsanga, 2024). The US Department of the Interior thinks that dependence on Russia for nearly every one of the 35 minerals needed for the country's economy and security must be maintained.

II.3. Innovation in Sustainable Materials: The MOBIOTEX Project

The MOBIOTEX project focuses on developing sustainable materials by recycling textile waste fibers to replace petrochemical-based vapor barriers and rain-screen membranes used in timber-framed construction. These innovative nonwoven fabrics, manufactured from a mix of synthetic and natural recycled fibers, underwent various functionalization processes such as chemical water repellency treatment and lamination with breathable membranes to meet the performance requirements for vapor and rain barriers. Characterization tests revealed that untreated nonwoven fabrics were unsuitable for these applications due to insufficient water and air tightness. However, after treatment, certain fabrics exhibited performance comparable to commercial products, with enhanced water vapor resistance, mechanical strength, and dimensional stability. This approach not only offers a technical alternative but also contributes significantly to reducing the exploitation of non-renewable resources by reusing substantial volumes of textile waste, aligning with circular economy principles and environmental sustainability goals (Ramírez, 2023).

II.4. Trade Disputes and Their Impact on Semiconductor Manufacturing

Sadly, both the US and China are facing rising disagreements about Taiwan and semiconductor production. The manufacturing of semiconductors in China was strongly affected by the sanctions ruled by the administrations of Donald Trump and Joe Biden, according to Woods (2024).

II.5. Evolution of Supply Chain Management with Emerging Technologies

It is important to look at and compare how supply chains are managed as new technologies are being introduced. This becomes more important because we are seeing incredible global upheaval due to national, regional and religious conflicts during the COVID-19 pandemic. If supply and demand are compared, most disruptions in supply will be resolved right away. Given these challenges in supply chains, it is likely that current procedures will have to change and that the best existing results are no longer good enough. Supervision of supply chains now heavily depends on new technologies. This study attempts to present the latest technologies shaping the supply chain sector. The combination of tech progress and a leading business strategy will help both sides succeed. How supply chains fit into Industry 4.0.

II.6. Impact of Industry 4.0 on Operations and Workforce

Industry 4.0 has brought significant changes in how organizations manage their workforce and operations. Technologies such as the Internet of Things (IoT), artificial intelligence, and augmented reality have improved employee efficiency and productivity by enabling better communication, coordination, and real-time data access. This technological integration requires firms to adapt their production and customer management processes by adopting innovative ways of interaction and process handling, ultimately enhancing overall business performance and competitiveness (Birkel, 2021).

II.7. Digital Transformation Using Artificial Intelligence and Internet of Things

Industry 4.0 has fundamentally transformed how companies manage their workforce and operations through the integration of technologies such as artificial intelligence (AI) and the Internet of Things (IoT). These technologies enable real-time data collection, predictive maintenance, and smart automation, which collectively improve operational efficiency and workforce productivity. Firms leveraging these innovations can streamline their production processes, enhance decision-making capabilities, and increase competitiveness in rapidly evolving markets (Reischauer, 2021).

II.8. Sustainable Development and Circular Economy in Supply Chain Management

According to the TBL approach, choosing sustainable development means putting importance on fair economic, ecological and social criteria. For these reasons, the idea of Industry 4.0 is growing popular both in the business world and among those working in the field and numerous governments are working to put Industry 4.0 into action. The ability to use technology effectively is very important for

business advantage. Aravindaraj and Chinna have found (Aravindaraj, 2022). that the digital era has allowed many businesses to succeed with strategies that would have failed not long ago. Whether businesses use new technology like 3D printing for small companies or shift to streaming for bigger ones, how businesses operate keeps changing. The idea is to maximize operations and modernize the business, so it can acquire a big edge over the competition, even while concentrating on innovative and disruptive ways of doing business.

A circular economy connects supply chain management, TBL and environmental factors to create one system. Corporations are major sources of waste, environmental damage and energy wastage. Industrial sectors rely on efficient and well-linked facilities formed throughout the whole supply chain. Being sustainable and promoting a circular economy go hand in hand and SCM takes into account different ecological and social matters. You need to look at supply chains as a whole to truly understand different aspects. Because these elements overlap so much and are so large, it requires detailed study. Even so, recent studies point out that just two subjects play a direct part in these research efforts (Tyllianakis, 2022).

II.9. Challenges in Adopting Modern Methods and Risk Management in Supply Chains

While some companies may expect supply chains to operate more flexibly and smoothly by adopting new approaches, many are not seeking help in understanding how these developments will change current and relevant post-delivery operations and issues involving people. This process, referred to as SCM, is important for information and goods to travel smoothly between a firm, its suppliers and its customers. New technological progress in the field of supply chains is changing how businesses operate. Considering how competitive their industry is, these managers constantly look for anything that can go wrong in their supply chain (Mastrocinque, 2022). For this reason, businesses are required to consistently improve their team's abilities and bring fresh ideas into their supply chains—strategies to integrate technology into managing the supply chain.

III.1. Recent changes and trends in the supply chain management world

High-performing supply networks are important for making companies in the logistics industry more competitive. A 2016 review by (Kherbach, 2016). and Mocan found that having good supply chain management gives enterprises an advantage and encourages further expansion. Strategic approaches to supply chains are helpful for businesses, employees and customers all over the business world. By relying on modern technology in our connected society, we can upgrade the strength and resistance of many different processes to challenges. Many problems in the supply-chain industry arose from the COVID-19 pandemic, instability in politics and battles around the world. So, now there is greater interest in its significance and its future is being thoroughly examined. With technology support, the supply chain management system is a useful and lasting alternative to traditional processes.

Artificial intelligence allows machines to learn and perform the activities that regular humans do. Different approaches are used in the strategies for artificial intelligence. Among the methods are fuzzy networks, evolutionary computation and the classical approach of using symbolic mathematical descriptions for problems. Also, Machine Learning is an important element of statistical AI. Starting in the late 1970s, AI has helped businesses improve how decisions are made and how workers are productive. Because it can recognize trends in business, learn about business outcomes, obtain data and analyze smart data, businesses give it the credit (Mediavilla, 2022).

III.2. Artificial Intelligence

Although many use AI for making decisions, its use in the supply chain management area, also known as SCM, has so far been limited. AI's best possible uses in the supply chain industry which is also known as SCM, can be found by studying the previous performance of AI within it—for example, instant reporting and visualizing data instantly. Increasingly, companies are using AI and machine learning to boost operations and automate process because they now gather a larger amount of personal data (Najafabadi, 2015). Thanks to machine learning and predictive analytics, business decisions are

now better supported, it's possible to spot buying trends and certain warehouse chores are fully automated. Both techniques for using AI, understanding and prediction, are just emerging in SCM.

III.3. Augmented Reality

Augmented reality plays a major role in Industry 4.0 because it joins the digital with the physical. AR gadgets work by adding computer-made graphics onto pictures taken by the device's sensors. Augmented reality (AR) should operate without delays, react when needed, bring virtual and physical objects together and comprise both tangible and intangible things in a true environment. Thanks to AR, logistics companies can quickly get needed predictive information. Airplane makers all over the world make extensive use of AR (Devagir, 2022). Augmented reality helps supply chains by displaying real-life problems for people to study.

III.3.1. Warehouse Operations

Automating warehouse tasks can help in many different ways. Using automation within warehouses usually makes work safer as there are fewer mistakes made by people. Efforts in augmented reality have the potential to support supply chain operations by lowering expenses, increasing production, improving sales and reducing machine breakdowns (Lotsaris, 2021). Fousekis, Koukas and Aivaliotis (Esper, 021). argue that this approach may improve worker dedication and efficiency. A supply chain manager is responsible for arranging, overseeing and handling the movement of raw materials from the warehouse to the factory and on to the consumer. A disruption in the supply chain can happen if one or more management steps are done wrong (Cirulis, 2013). stated that relying on automation can really improve efficiency.

For this reason, companies are starting to use augmented reality or AR, in their supply chain activities. Around 20% of the expenses for warehousing come from handling, unloading, measuring goods, sorting them, arranging them and keeping accurate documents. About 55-60% of the total costs are due to these items. If these tasks are moved to digital forms with AR, the costs are likely to decrease (Ginters(2013 'Because of augmented reality (AR) and smart glasses, workers are shown what tasks to do, making it less likely for mistakes. With an AR device, employees can quickly find out what's in stock and its precise location. Using AR, designers and builders can create warehouse layouts that function as storage solutions and help ease the work of maintenance, repackaging and storage. AR depends on item tagging, internal position finding and immediate inventory changes to support staff training and maintenance tasks.

Retail companies rely on transportation operations to deliver their products to people all over the world efficiently. In addition, you have to constantly look after the process to monitor all of your shipments. Using augmented reality in software makes it possible to substitute human watching over freight and paper manifests (Anderies, 2023). Employees will receive a thorough guide to how to load and watch over the containers with the use of the augmented reality program. If used, virtual reality-powered wearable devices can boost last-mile carriers, offer direct traffic advice and streamline handling and delivering of parcels.

III.3.2. Defect and Repair

When used together, augmented reality glasses and advanced image recognition help discover and correct any issues in sorting and repackaging machines. The glasses help the holder review machines and locate problems related to machinery or structure (Stübl, 2022). Because of this, it is possible to keep the system functioning correctly and avoid significant interruptions in the supply chain. In addition, the headsets provide step-by-step help with repairing machinery by streaming tutorial videos in real time.

III.3.3. Customer service

An innovative AR feature in parcel service applications makes it simple for customers to see where their packages are. After the scan, the apps present more data about the shipment, for example, its weight, volume, price and size (Rejeb, 2023). The different apps will also give users a variety of cost and

insurance choices. It's straightforward for customers to monitor where their products are and to replace them if necessary. They will be informed as soon as any refund action happens. Automation is necessary in this field since the world's supply chain network is integrated and challenging. Organizations know that augmented reality (AR) can enhance their supply chain management. Augmented reality apps have already proven useful for increasing how efficient supply chain management is during their early development (Sharma, 2022).

III.4. The world wide web (Internet of Things - IoT)

Currently, businesses focus on marketing and plans that engage customers well in the rapid technological environment. The Internet of Things, often known as IoT, is very popular and greatly affects communication. Such a system can check its surrounds or connect to other devices, then use the insights it finds to adjust how it behaves. To make this happen, sensor and actuator technology is integrated into existing products. The systems are set up on a network, so you can control and view the information from a distance. In just a few years, more of these devices have appeared in the Internet of Things (IoT) to make automation more advanced. Also known as IoT, the Internet of Things makes it easy for the supply chain to transmit messages and connect suppliers with customers. Supply chains benefit from adoptable and flexible operations through thoughtful procedures (Tan, 2022). By using this approach, teams can manage operations, repairs and designs more wisely, since everyone across industries and areas can now access applicable information and work jointly, enhancing ease of service and safety. There is a steady improvement in how the industry uses IoT, available platforms and standard communications to integrate feedback from customers, specialize products and use customer choices for customization and assembly during the making process.

We can now better sense how the organization, tutorials for cataloguing and schedules for future items at a particular place work. Using the data from sensors, you can care for your equipment early on and change any broken parts in time. Because of the Internet of Things, supply chains become more open. The Internet of Things, frequently referred to as IoT, is maturing quickly as a technology. The data shows that businesses will add more Internet of Things devices to their networks by 28% in 2020, much more than the 11% seen in 2013 (Shojaeinasab, 2022). According to the International Data Corporation which mainly uses the Internet of Things analysis, the growth rate will be 13.6% through 2022. IoT makes it possible for businesses to autogenerate orders, follow delivery and instantly access their supply chain stock. That explains why the Internet of Things is so common in business and industry. Using the information from its ROI, firms can raise their total ROI, become more productive, spend less time on breaks and foresee the needs of customers.

III.5. Robotics and Automation Systems

Autonomous systems (RAS) and robotics can improve the way supply chains are managed. Because they are faster, more accurate and precise, robotics will simplify managing logistics operations, lowering the possibility of mistakes. Robots, as found by (Tripath, 2020), are more reliable and productive than people on the job. An automation is used by humans to help them work more efficiently, but it does not replace people. Automation can reveal and correct issues that lead to supply chain waste.

For example, an important part of growing fruits and vegetables, harvesting, is still mostly done by hand. Advanced robots used to handle fruits have both picking methods and advanced vision tools. Specific applications for RAS harvesting have been created to ensure robots move well in greenhouses. There are expectations that the use of RAS technology in these operations will increase and that as many as 20% of all future harvests will be carried out that way (Queiroz, 2020). Various top supply chain corporations around the globe are spending money on autonomous car technology, aiming to reduce labor costs, remove the danger of accidents on roads and promote fuel economy

III.6. Frameworks for Customer Delivery

Firms pay close attention to how efficiently and rapidly products can be delivered. Many people now expect their items to be delivered fast in these industries. For this reason, it often adds the greatest cost to delivering goods. Now, thanks to up-to-date delivery software, you can keep an eye on your

shipments as they are in transit. Besides, it's simple to check how far you traveled and how much time you were still. Logistics and supply chain professionals can now track their fleets better and stop both theft and food spoiling more efficiently (Ekeskär, 2022). Shippers can take advantage of predicted visibility to find out the location of their cargo ahead of the shipment leaving port.

III.7. Software for managing the supply chain

Many organizations in the supply chain management field find significant improvements when they make use of TMS (Transport Management Software). Thanks to TMS, it is possible for supply chain administrators to closely watch the movement of inventory and supplies as they travel along the supply chain. Previously, making management decisions for fleets by hand could often result in mistakes. Fleet management used to take a lot of time and could easily make mistakes. It is used to make inventory management and warehousing process more automated. Because of this, businesses and individuals enjoy better visibility, save costs and improve their precision (Daoud, 2022).

III.8. Computational Intelligence

Although good supply chain management depends on continuous decisions, businesses often require additional systems and abilities. Businesses need tools that allow them to look more clearly into their supply network and how it operates, so they can choose the best courses of action. When technologies are merged, it raises the quality of data intelligence. When used together, they help process difficult data quickly and deliver meaningful advice, projections and reviews. It's easy for businesses to add advanced data intelligence to their existing applications. Technology can collect data, identify relationships and analyze this information to support supply chain administrators with useful results (Sundarakani, 2021).

III.9. Exploring potential and challenges

Many experts in supply chain management have examined ways modern methods can help supply chains become more proactive and predictive. Because of their distinctive traits, the usefulness of new technologies in supply chain management is not the same at each stage. For example, mathematical programming helps companies stay away from and manage risks. At the same time, they have trouble with complex sets of data or with handling and improving automatic actions. Such techniques, which include agents, machine learning and automated reasoning, are not suitable for dealing with the high complexity seen in supply chains. For these reasons, mathematical programming experts should explore hybridization, even though it is not yet a focus of many methods. There are numerous ways for research to improve the joint area where AI and SCM meet. One way to do this is by joining up robust mathematics, modeling and optimization techniques with AI methods capable of making decisions and learning on their own.

Many choices are available to automate how decisions are made in SCM. To improve how adaptable a supply chain is, an SCM decision support system could use semantic reasoning on vast datasets as well as collaborate with multiple agents. When supply chain management (SCM) is explained through rules, choosing suppliers can be automated with the help of rules. Thanks to this system, you can handle activities like identifying risks, analyzing their chances and choosing your response methods. Not only does automated SCM help, but traditional static SCM modeling can now be updated over time using machine learning skills. The goal is accomplished by using machine learning methods. SCM can use the numerous tasks that machine learning provides. Supply chain indicators allow for spotting individual patterns linked to problems and data mining algorithms trace out potential risks within the supply chain. An alternative approach is to give real-life behaviors that experts call out to help the algorithm recognize the risks involved. Following the methods of learning-based grouping and prediction which many disciplines use, is beneficial for understanding, summing up and controlling risks.

III.10. Conclusions and Future Directions for Research

Entrepreneurs and managers involved in supply chain management will see real benefits if they use the latest technology. Reading this review paper allows a company to choose appropriate technology for

their supply chain and implement it properly. The research merged mathematical modeling, optimization and automatic decision-making to support better risk management in supply chains.

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