IJEASM
International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 5 Issue 5, May 2024

OPTIMIZATION OF THE SUSTAINABLE SUPPLY CHAIN IN THE ROLE OF TECHNOLOGY ADOPTION IN MARKET CHANGE

Mrs. Shweta Dubey
Mechanical Department, Madhyanchal Professional University, Bhopal, (M.P.) India
Dubeyshweta2512@gmail.com

Abstract: *In rapidly changing business conditions, it has become extremely important to ensure the sustainability of supply chains and further improve the resiliency to those events, that can cause unexpected disruptions in the value supply chain. Although glob- alized supply chains have already been criticized for lack of control over sustainability and resilience of supply chain operations, these issues have become more prevalent in the uncertain environment driven. The use of emerging technologies such as blockchain, Industry 4.0 analytics model and artificial intelligence driven methods are aimed at increasing the sustainability and resilience of supply chains, especially in an uncertain environment. In this context, this research aims to identify the problematic areas encountered in building a resilient and sustainable supply chain in the era and to offer solutions to those problematic areas tackled by an appropriate emerging technology. This research has been contextualized in the automotive industry; this industry has a complex supply chain structure and is one of the sectors most affected. Based on the findings.*

Keywords: *Industry 4.0, Sustainability materials, Supply chain.*

1. Introduction

The supply chain (SC) is transforming into a more delicate and complex structure due to increasing competition, costs and rapid technological developments worldwide This drives supply chain management (SCM) toward achieving green growth, although this is challenging from the sustainability. It becomes difficult for these SSCs to be monitored, controlled and to be sustainable and resilient. Furthermore, being sustainable and resilient has now emerged as the most important issue for companies throughout the world.

Sustainable supply chain management (SSCM) is the management of supply chain oper- ations, resources, information and funds to maximize social welfare and supply chain profitability while minimizing environmental impacts. Moreover, SC resilience can be defined as the power of supply chains to cope with unexpected changes at the minimum level to resist crises and to maintain their continuity despite changes in the market. Therefore, sustainability and resilience of SCs are concepts that affect each other. In order to build an effective sustainable SSCM concept and further increase its performance and resilience, organizations can adopt emerging technologies such as blockchain, Industry 4.0 and artificial intelligence. Using these emerging technologies, especially artificial intelligence (AI), greatly benefits organizations to become more sustainable and resilient to cope with disruptions occurring in SSCs.

AI is a branch of computer science, with a main goal of developing computer technology that can act and think like a human being. These thinking machines can then imitate, learn and eventually replace human intelligence. AI is a technology that can be used especially for SSC planning, demand forecasting and optimization problematic areas arising in SSCM before and during COVID-19 are identified. In addition, these problematic areas related to sustainable and resilient supply chains pre-COVID-19 and during COVID-19 should be evaluated to rank the AI driven solutions according to their importance. In this study, the fuzzy DEMATEL method, one of the best multi-criteria decision-making techniques, is used to analyse

cause and effect relations of the criteria them- selves. Moreover, to match problematic areas with AI technologies, the Delphi method, a structured communication technique developed as a systematic, interactive forecasting tool based on a panel of experts, is implemented towards the end of the study.
Section 2 addresses the problematic areas encountered in resilience and SSCM in pre- COVID-19 times and during COVID-19; the importance of AI and its use in SSCM is also examined. Section 3 covers methodology with Sect. 4 detailing the case study undertaken. Section 5 highlights the discussions that have emerged and the conclusions drawn

2. Literature Review

(Maslaric et al., 2013). These demand fluctuations cause problems in the current inventory management of many companies (Klibi et al., 2018). Therefore, in order to increase resilience in SC, companies have to give importance to real- time inventory management, optimization of production and stocks by providing visibility, automation of replenishment strategies and safety stocks (Gunasekaran et al., 2015). For this reason, there is a need for the adoption of technologies such as AI. Optimization in Logistics Operations (C2): Problems arising from lack of optimization in logistics operations are experienced in complex and multi-supplier SSC structures

(Foster & Rhoden, 2020) as they become more vulnerable to disruptions. Failure to achieve optimization in logistics operations in SCs harms resilience of the SC (Pavlov et al., 2019). In logistics processes, the role of logistics facilities, warehouses, the geographical area where the facilities are located, the capacity of warehouses, information and technological infrastructures must all be fully planned

(Kaur & Singh, 2019). Therefore, technologies that emerge as a result of AI are required to manage the SC as they minimize the errors that may occur in the logistics process and facilitate optimization in operations (Mouammine et al., 2020). Purchasing Process Planning (C3): Increasing competition in the business environment requires companies to make better quality purchasing decisions with lower costs (Dumi- trascu et al., 2020; Min, 2010). Decisions made in the purchasing process are extremely difficult and strategic

(Rodríguez-Espíndola et al., 2020). In order to ensure resilience and sustainability, especially in the face of unexpected situations (Pereira et al., 2020), compa- nies should also show alternative planning behaviors in their purchasing process planning (Ambulkar et al., 2015). For this reason, companies may need systems that include technolo- gies such as AI in their purchasing processes to determine alternative purchasing scenarios and to put them into operation (Allal-Chérif et al., 2021). Demand Planning and Production Management (C4): Demand planning and production management are the most important factors to determine the performance of SSCs

(Nguyen et al., 2018). Effective demand planning and production management ensure the correct functioning of operations in the SSC (Raut et al., 2019). Unexpected events may cause unex- pected fluctuations in demand and cost increases in SC; this affects production management (Nguyen et al., 2018). In unexpected crisis environments, it becomes difficult for companies to maintain resilience in their SCs. In other words, traditional demand and supply planning approaches are inadequate; sharp changes in market and commercial dynamics, pandemics or natural disasters can cause damage to the resilience of SCs

(Purwaningsih & Hermawan, 2021). Therefore, in companies with high and increasing demand levels, the adoption of tech- nologies such as AI is necessary to balance supply and demand and to plan future production processes (Husna et al., 2020).
SC Traceability (C5): Monitoring every stage in multi-layered global SSCs makes it easier to take measures against unexpected problems (Kamble et al., 2020). The traceability of the SC helps to find instant solutions to the problems that arise in the SC, to eliminate problems without delay in the other processes and to ensure the resilience of the SC

(Roy, 2021). An increase in efficiency is observed in the operations of a company with high SC traceability; the traceability of SSCs is possible with the implementation of digital technologies such as AI (Wu et al., 2021). Top Management Support (C6): Integration of digital technologies into operations in corpo- rate companies with a developed SSC structure is possible with high levels of management support. The use of digital technologies in SSC structures supported by management brings

operations closer to perfection. Top management support acts as a decision-making mecha- nism in order to find solutions to problems that arise in SSCs and to increase the resilience and sustainability of SSCs

(Olaleye et al., 2021). Especially in disruptive times, it is necessary to adopt digital technologies such as AI. From the literature review, it can be seen that there is a research gap in defining which problems are encountered before and during COVID-19 and whether there is a difference in importance of the problems. To sum up, emerging technologies provide increased resilience and sustainability in SCs

(Ramirez Lopez & Grijalba Castro, 2021). AI is an emerging technology associated with the decision-making processes in companies; to a large extent, AI improves SSC tracking systems, tactical planning and execution, allowing managers to learn the complex patterns that lead to errors (Dauvergne, 2020). AI technology already plays an important role in advanced SSCM and logistics solutions, increasing efficiency and effectiveness, resilience and sustainability (Singh et al., 2020). Therefore, in the following section, the importance of AI and its use in SCM is explained.

(Kaur et al., 2020). Therefore, many companies prefer to switch from remote monitoring to control, optimization (Notte et al., 2020) and advanced autonomous AI-based systems to improve resilience of their SSCs (Paschen et al., 2020). Although AI technologies can be used in many areas such as marketing, logistics and production, they can also be used in almost all areas and sub-fields of SSCM, providing advantages such as high accuracy, solving problems with more inputs and producing high-speed solutions

(Jones et al., 2020). Planning is one of the most important issues in SSCM. Problems such as errors made in the planning period, prolonged delivery times or fluctuations in the preparation times of products can be eliminated by AI technologies (Grover et al., 2020). In addition, problems that arise in manufacturing processes (machine failure, product related problems etc.) may cause delay in shipments and interruption to the SSC, threatening resilience in SSCs (Gunasekaran et al., 2015). AI technology provides real-time and continuous information about machine failures, thus improving the process

(Grover et al., 2020). Methods such as genetic algorithms, ant colony optimization (Pedemonte & Cancela, 2010) machine learning, artificial neural networks and data clustering are sub-technologies of AI; these should be applied at different stages of SSCs as solutions to different problems (Dzalbs & Kalganova, 2020). AI in SCM provides improved SC automation through the use of virtual assistants, both in a specific organization and between SC members

(Schniederjans et al., 2020). One AI technology, the genetic algorithm, is frequently used to solve complex problems that are difficult to decipher with traditional methods (Gholizadeh & Fazlollahtabar, 2020). The genetic algorithm makes the SSC more efficient by conducting surplus and deficiency analyses, especially in stock management, in order to minimize the costs arising in SSCM

(Rostami et al., 2020). Ant colony optimization algorithms are derived from ants that leave a volatile substance called "pheromone" when searching for food (Pedemonte et al., 2011; Vijayan et al., 2018). Ant colony optimization in SSCM aims to find optimal results with different algorithm options (Delgoshaei et al., 2019). For example, distribution time optimization in logistics operations, network optimization or ant colony optimization can be used to minimize losses (Zhang et al., 2019).

3. Methods

After determining the problematic areas with fuzzy DEMATEL, the opinions of the same expert group are taken in order to find solutions to these problems with AI technologies through the Delphi method. The implementation of the Delphi method consists of systematic stages—revealing the approaches and perspectives of the experts on the problem situation, examining them and reaching a consensus. Expert opinions are col- lected for six problematic areas separately, using the Delphi method. For example, experts evaluated the use of five different AI technologies; these are genetic algorithm, ant colony optimization, machine learning, artificial neural networks and data clustering for the inven- tory management (C1) problem. As a result of conducting the Delphi method, AI technologies recommended by each expert for each problem area are determined for the case study.
The results from the Delphi study are combined with observations from literature to determine which AI technologies would be most beneficial to use for each of the problematic areas. Therefore, based on the results obtained from the Delphi method, AI sub-technologies that can be used in problematic areas encountered in SSCs are presented. According to the fuzzy DEMATEL results, the most important change is seen in the support of top management (C6). The support of top management was in the effect group before COVID-19; however, it became the most important in the cause group during COVID-19. Top management support becomes crucial to arrange funding, provide necessary support to the workforce and deal with the ongoing crisis. AI accelerates the decision-making process of top management in order to increase the resilience in SSCs during such disruptions (Rodríguez-Espíndola et al., 2020). Based on implementation of the Delphi study, it is seen that genetic algorithm, ant colony optimization, machine learning, artificial neural networks

and data clustering technologies are beneficial in supporting top management (C6). In the automotive industry, these technologies provide traceability, tracking and control of SC operations.

4. Discussion

This research examines the problematic areas encountered in SSCM before and during- COVID-19. The results of previous studies that deal with similar issues and methods are examined for more in-depth insights. Gultekin et al. (2022) listed the risks arising from COVID-19; they presented the risk of change in demand in the cause group, while in this study, demand planning and production management problems are seen in the effect group during the COVID-19 period. From Zhan et al. (2021)'s study, sales criteria is found to be the most important among the criteria they considered to measure resilience. Purchasing process planning is included in the cause group of problems listed in our study. These results show that the issue of purchasing process planning is extremely important with or without disruptions in SSCs. In contrast with this study, Jindal et al., (2021) focused on improving the agility of supply chains. Similar to our study, Finkenstadt and Handfield (2021) stated that SC traceability and visibility are crucial problematic areas in SC; they concluded that if you can't trace, you can't manage your SC operations. Gunessee and Subramanian (2020) and Hakovirta and Denuwara (2020) determined that demand management is one of the problems areas in SC before and during COVID-19; this is in agreement with our study. They stated that problems occur when there are fluctuations in demand leading to failure in delivery times. This has increased due to COVID-19. Moreover, decreasing production capacity and workforce unavailability may cause production planning problems according to Lozano-Diez et al. (2020); this is also in agreement with our study. Lozano-Diez et al. (2020) stated that these problems occurring in SCs are among the major threats to resilience and sustainability of a SC.

References

[1] Ahmadi, O., Mortazavi, S. B., Mahabadi, H. A., & Hosseinpouri, M. (2020). Development of a dynamic quantitative risk assessment methodology using fuzzy DEMATEL-BN and leading indicators. *Process Safety and Environmental Protection, 142*, 15–44.

[2] Allal-Chérif, O., Simón-Moya, V., & Ballester, A. C. C. (2021). Intelligent purchasing: How artificial intelli- gence can redefine the purchasing function. *Journal of Business Research, 124*, 69–76.

[3] Alonso-Muñoz, S., González-Sánchez, R., Siligardi, C., & García-Muiña, F. E. (2021). New circular networks in resilient supply chains: An external capital perspective. *Sustainability, 13*(11), 6130.

[4] Alzoubi, H. M., Elrehail, H., Hanaysha, J. R., AI-Gasaymeh, A., & AI-Adaileh, R. (2022). The role of supply chain ıntegration and agile practices in ımproving lead time during the COVID-19 crisis. *International Journal of Service Science, Management, Engineering, and Technology (IJSSMET), 13*(1), 1–11.

[5] Ambulkar, S., Blackhurst, J., & Grawe, S. (2015). Firm's resilience to supply chain disruptions: Scale devel- opment and empirical examination. *Journal of Operations Management, 33*, 111–122.

[6] Bas¸han, V., & Demirel, H. (2019). Application of fuzzy Dematel technique to assess most common critical operational faults of marine boilers. *Politeknik Dergisi, 22*(3), 545–555.

[7] Bayramova, A., Edwards, D. J., & Roberts, C. (2021). The role of blockchain technology in augmenting supply chain resilience to cybercrime. *Buildings, 11*(7), 283.

[8] Belhadi, A., Kamble, S., Jabbour, C. J. C., Gunasekaran, A., Ndubisi, N. O., & Venkatesh, M. (2021). Man- ufacturing and service supply chain resilience to the COVID-19 outbreak: Lessons learned from the automobile and airline industries. *Technological Forecasting and Social Change, 163*, 120447.

[9] Benbarrad, T., Salhaoui, M., Kenitar, S. B., & Arioua, M. (2021). Intelligent machine vision model for defective product inspection based on machine learning. *Journal of Sensor and Actuator Networks, 10*(1), 7.

[10] Birkel, H. S., & Müller, J. M. (2020). Potentials of industry 4.0 for supply chain management within the triple bottom line of sustainability—A systematic literature review. *Journal of Cleaner Production, 289*, 125612.

[11] Chawla, A., Singh, A., Lamba, A., Gangwani, N., & Soni, U. (2019). Demand forecasting using artificial neural networks—a case study of American retail corporation. In *Applications of artificial intelligence techniques in engineering* (pp. 79–89). Springer, Singapore.

[12] Chowdhury, M. T., Sarkar, A., Paul, S. K., & Moktadir, M. A. (2020). A case study on strategies to deal with the impacts of COVID-19 pandemic in the food and beverage industry. *Operations Management Research, 2020*, 1–13.

[13] Dauvergne, P. (2020). Is artificial intelligence greening global supply chains? Exposing the political econ- omy of environmental costs. *Review of International Political Economy*, 1–23. https://doi.org/10.1080/ 09692290.2020.1814381

[14] Delgoshaei, A., Aram, A., & Ali, A. (2019). A robust optimization approach for scheduling a supply chain

sys- tem considering preventive maintenance and emergency services using a hybrid ant colony optimization and simulated annealing algorithm. *Uncertain Supply Chain Management*, *7*(2), 251–274.

[15] Deloitte (2020). *COVID-19 Managing supply chain risk and disruption.* Report Authors; Kilpatrick, J. & Barter, L. Contributors; Alexander, .C, Brown, J., Calderon, R., Carruthers, R., Joyce, P. & Xu, L. Deloitte Development LLC. Deloitte Design Studio, Canada. 20–6536T.

[16] Di Vaio, A., Boccia, F., Landriani, L., & Palladino, R. (2020a). Artificial intelligence in the agri-food system: Rethinking sustainable business models in the COVID-19 scenario. *Sustainability*, *12*(12), 4851.

[17] Di Vaio, A., Palladino, R., Hassan, R., & Escobar, O. (2020b). Artificial intelligence and business models in the sustainable development goals perspective: A systematic literature review. *Journal of Business Research*, *121*, 283–314.

[18] Dong, W., Yang, Q., Fang, X., & Ruan, W. (2021). Adaptive optimal fuzzy logic-based energy management in multi-energy microgrid considering operational uncertainties. *Applied Soft Computing*, *98*, 106882.

[19] Dumitrascu, O., Dumitrascu, M., & Dobrotaˇ, D. (2020). Performance evaluation for a sustainable supply chain management system in the automotive industry using artificial intelligence. *Processes*, *8*(11), 1384.

[20] Dzalbs, I., & Kalganova, T. (2020). Accelerating supply chains with Ant Colony Optimization across a range of hardware solutions. *Computers & Industrial Engineering*, *147*, 106610.

[21] Eaneff, S., Obermeyer, Z., & Butte, A. J. (2020). The case for algorithmic stewardship for artificial intelligence and machine learning technologies. *JAMA*, *324*(14), 1397–1398.

[22] Elavarasan, R., & Pugazhendhi, R. (2020). Restructured society and environment: A review on potential technological strategies to control the COVID-19 pandemic. *Science of the Total Environment.*, *725*, 138858.

[23] Faasolo, M. B., & Sumarliah, E. (2022). An Artificial Neural Network examination of the intention to imple- ment blockchain in the supply chains of SMEs in Tonga. *Information Resources Management Journal (IRMJ)*, *35*(1), 1–27.