

5G Technology Adaptation in Supply Chains

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Supply chains have become digital, keeping sync with consumer demands and preferences. The recent pandemic has reinforced the need of embracing digital technologies in managing supply chains effectively. Therefore, it is necessary that supply chains adopt 5G mobile technologies.

Keywords: supply chain management ; 5G technology ; digital age

1. Introduction

The previous 20 years have seen a significant evolution in mobile networks. Fourth-generation wireless broadband offers data speeds of 100 Mbps after the voice digitalisation and SMS messaging capabilities of 2G and the Internet-based and multimedia-enabled capabilities of 3G ^[1]. However, 5G communications provide an important development in performance by using the multiple-output technique and mm wave technology, with a 10–100-fold rise in the data-communication rate, a more than 1000-fold growth in the communication ability, up to a 99.999% improvement in the communication reliability, a 10–100-fold expansion in large-scale connections, and a less than 1 ms delay ^[2]. The significant features of the 5G communication system include enhanced mobile broadband (eMBB), ultra-reliable and low-latency communications (uRLLCs), and massive-machine-type communications (mMTCs). Unlike 5G network slicing, which supports end-to-end network sharing, 4G technologies do not provide end-to-end network sharing. According to research on network slicing, 5G NHNs (neutral-host networks) will be able to accommodate a greater number of users and can scale to meet demand ^[3].

Previous researchers had envisioned a future communication network as something that would connect the tiniest personal matters to the biggest continents digitally according to the requirements and preferences of the society. The prominence of 5G technologies is making true the past myth of wirelessly connecting everything and everywhere, as well as offering some of the advanced characteristics, such as cell-less designs, enormous three-dimensional processing, concrete response times, huge data processing and virtualisation, etc. ^[4]. The high-bandwidth and low-latency capabilities of the 5G network are thought to offer an integrated platform for connecting various devices in real time. Supply chain management is significantly impacted by the trending notions of “Smart Manufacturing” or the “Factory of the Future (FoF)” in the framework of Industry 4.0 (SCM). The path for the FoF is made concrete by 5G by linking a massive number of smart devices with each other anywhere and at any time ^[5]. In this wireless communication age, Internet devices such as smart phones, hotspots, and Wi-Fi zones are important players in the rapid growth of data usage. The Internet of Things (IoT) is a new technology that improves the way people live by tackling a wide range of different applications and service areas. The connectedness for this IoT ecosystem is delivered by fifth-generation (5G) wireless networks. Network slicing is one of the important technologies which acts as a significant enabler for the realisation of the IoT in 5G ^[6]. The technologies of 5G and beyond, which span over various unheard-of requirements, services, and applications, are anticipated to not only permit hyperdigitalisation but also to present fresh opportunities for economic and industrial development ^[7]. The evolution of mobile broadband services is being shaped by consumer expectations. Inventive resolutions will be needed to address the predicted intensifications in traffic (expected to increase 10–100-fold between 2020 and 2030), the progression in the quantity of devices and services, along with the need for boosted affordability and consumer expectations.

A recent report has estimated that, from 2025 onward, there will be 50 billion Internet-connected gadgets. Fifth-generation technology links people, things, data, apps, transportation systems, and cities in intelligent-networked communication environments. The networks transfer a high quantity of data with no lag time, consistently link a very large number of devices, and process a tremendous amount of data with the least interruption. The 5G technology and subsequent mobile communications network aim to hasten the attainment of the Sustainable Development Goals (SDGs), from reasonable and clean energy to zero hunger ^[8]. Additionally, 5G will have a positive socioeconomic impact. Upcoming players will enter the market in the new 5G era, while established businesses will need to change their business strategies to subsist.

Players in the market are vying for the first 5G commercial deployment, which is anticipated in 2019 ^[9]. With the deployment of three communication satellites, India achieved success in the satellite-based Internet-services market. India has successfully implemented 5G communication, achieving a 10 Mbps speed per second ^[10].

One of the most recent IT innovations, the Internet of Things (IoT), is a new IT revolution that is bringing about a paradigm shift in many domains, including SCM. By enabling human-to-things communication and autonomous coordination among “things” while they are being held in a facility or being transferred between various supply chain entities, the Internet of Things (IoT) raises the bar for supply chain communications. The potential to address SCM issues more skilfully is enormous given these additional skills. The IoT offers new degrees of supply chain agility, adaptability, and visibility to handle varied SCM difficulties. When efficiently gathered, analysed, and transformed into meaningful information, the data released by smart devices can provide unprecedented visibility into all facets of the supply chain and early warnings of internal and external conditions that need correction. Supply chain efficiency can reach new heights if these indications are acted upon quickly. The methods for gathering and processing large amounts of data as well as the time lag between data collection and action are what have been lacking, not the accessibility of information, up until this point. Supply chains will be able to respond to changes in real time thanks to the IoT, which will shorten the time between data collection and decision making. This degree of agility and reactivity has never been achieved before. The IoT will also make it possible to remotely control supply chain operations, improve partner cooperation, and can deliver more precise data for more effective decision making ^{[11][12][13][14]}.

The 5G mobile technology enables supply chains to stay competitive in Industry 4.0. The acceptance of emerging IoT, cloud technologies, big data analytics, robotics, drones, machine-to-machine interfaces, and business intelligence in the perspective of Industry 4.0 supports the occurrence of the digital supply chain proposed in context of Supply Chain 4.0 ^[15]. Therefore, the 5G–IoT ecosystems will support a combined database of procurement and purchasing, production and sales, storage and distribution, retailing and aftersales operations. According to the theory of organisational capability, 5G will probably improve the ability to incorporate suppliers, consumers, and internal logistical processes. As a result, 5G adoption can be seen as an additional competence that might enhance any organisation’s present form of information and communication technology (ICT) capabilities. The 5G capacity is thought to facilitate communication and information exchange between and within organisations ^[5].

2. Challenges for Adaptation of 5G Technology

The high aims of 5G networks have presented many difficulties. Beyond the technology utilised in 3G and 4G systems, the additional capacity and data speeds made possible by 5G may require a greater spectrum and significantly more spectrally efficient technologies ^[8]. At the countrywide, local, and international levels, there is fierce competition for this spectrum because it is a limited and highly valuable resource. Since the radio spectrum is distributed into frequency bands that are allotted to diverse radio-communication services, each band should only be applied by the services that are allotted to it and that have the recognised technical requirements in order for them to coincide without causing harmful interference to other users. The initial signs of evidence suggest that the system idea for integrating the many progressive technological building blocks is the utmost important aspect for the success of 5G. These trends in usage, deployment, and technology are now unfolding ^[4]. The implication of this notion necessitates the progress of knowledge, not only in the hardware and software areas, but also in the managerial field. This expertise is desired so to comprehend the issue of how to use that information and communication for the beneficial improvements of the stakeholders ^[16].

IoT implementation in SCM faces a number of challenges from both a technological and administrative standpoint. There is concern that less security and privacy are possible in an interconnected world. This is particularly factual in the setting of a supply chain, where information sharing has hitherto been quite difficult. Interoperability is another difficulty. According to the research by McKinsey, interoperability will be necessary to unleash 40% of the IoT’s value. There is not a lot of research on how to handle these difficulties successfully ^[11]. These technologies cause interruptions and force businesses to reconsider how they structure their supply chains. A striving activity is a form of digital transformation. To flourish in the long term, business units need top–down leadership commitment, strategy, and discipline. Businesses must set and rearrange goals, work with a feeling of resolution and determination, and define significant aspects of successful change projects, including the adoption of Driving Sustainable Change (DSC) ^[12].

The advantages of the IoT do not come without organisational, legal, and technological difficulties. In this regard, collaborative work is required to enhance the technical capabilities of IoT devices, develop IoT implementation policies and strategies, and sensibly strategise their investments in IoT technologies to create more reliable data-driven supply chains and intelligent logistics ^[13]. Telecommunication infrastructures, including spectrum frequency and transit, legislation and regulation, the innovation ecosystem, and societal effect, are among those in need of consideration from 5G

participants in some countries. Despite these alarming elements, there are still important reasons that encourage the development of 5G in countries, including consumer demand and wants, cost savings and new revenue sources for mobile-network operators, industry automation, and national competitive advantage ^[17]. Rajeb and Keogh ^[14] also advocated for the upgrading of security, performance, adaptability, and flexibility for successful implementation. The former research suggests that the highest level of management needs to support efforts to digitise logistical operations. There is a need of strategic resource allocation in logistics businesses to adopt, test, and implement I4.0 technologies. In this line of thinking, technological infrastructure and manpower preparedness are pivotal for the effectual application of technologies. Firms must improve long-term strategy in line with government policies. On the other hand, the logistic firms must go for alternative risk-mitigation strategies to prevent technological malfunctioning. During this disrupting situation of the supply chain, resource collaboration, involvement, and coordination through technology are advantageous. In this connection, interpreting the change in customers' tastes and preferences with the help of technology may support enhancing customers' satisfaction ^[18].

3. Relevance and Application of 5G in SCM

The word 5G comprises massive input–massive output (MIMO), which enables the attainment of network competencies better than the present 4G LTE and “small cells” and which permit an additional condensed-network structure ^[19]. The 5G-enabled IoT in SCM expands the bandwidth for protected-data transmission. The authors of ^[20] examined and constructed a conceptual model of the IoT in SCM to address the challenges related to it. Previous research on 5G-enabled IoT has several applications in SCM ^[21]. In manufacturing–manufacturing communication, it can establish a better dynamic pattern, where the issues are detected much earlier and in detail along with resolving those issues without the need for human engagement. In automated warehouses, the application of the IoT in conveyor and sortation systems cannot be ignored. It can enhance inventory management by offering the real-time visibility of inventory counting. The installation of highly advanced RFID (radio-frequency identification) chips used in IoT technologies enables the tracking of a variety of manufacturing data, production dates, expiry dates, warranty periods, and sales information, permitting real-time SCM. The IoT implants smart things as the logistic operator. It screens the products and carefully creates an alert if the carriage situations are no longer proper. Therefore, the transporter is notified and the products have a better possibility to be maintained. It decreases the cost of the return, excludes faulty products, and drops carriages because of reduced reshipping costs, since the load becomes clearer by providing its data position. As an outcome, a transporter can correctly grasp the number of faulty products and can efficiently support and augment logistics transparency along with customer satisfaction. On the other hand, loads with IoT-enabled sensors can deliver data to the transporter for improved navigation and security. The automated design of navigation directions can have an influence on the transporter because they need to regulate the route by providing a broader mapping of unforeseen situations. Therefore, in SCM, from the manufacturer to the consumer, the IoT signifies richer information and higher judgment for all the members of a supply network.

There are certain decentralised applications (DApps) in the market integrating the blockchain and IoT. By applying the IoT infrastructure, the data sharing of devices can be implemented with the application of implanted chips and adequate network connectedness. In the present day, constant network connectivity can be provided only by the 5G network, as 4G diminishes the latency. Furthermore, adding blockchain with the IoT permits the keeping of an absolute record of transaction-related data. By attaining it in a decentralised P2P (peer-to-peer) pattern, the ‘middle-man-attack’ can be removed ^[22]. There is a requirement for an effective decentralised access control system for device-to-device (D2D) communication in IoT-enabled industrial automation. Therefore, the 5G-enabled IoT, as the pillar for blockchain-based industrial automation, can support areas such as smart agriculture, autonomous vehicles, and SCM ^[23]. Presently, the 5G–IoT scenario has been foreseen both in individual and professional areas. In the professional segment, it is present in the smart supply chain, remote monitoring, logistics, etc. ^[24]. The foremost competencies of 5G to improve and develop the digital supply chain are intelligence, visibility/transparency, dynamic networking, and connectivity ^[25]. In spite of the complication and variety in the system, and the diverse execution of sensors and systems, 5G provides real-time data, while 5G in SCM has paved the path in various organisational–technological concepts such as cloud manufacturing, digital twins, data-driven modelling, etc. Moreover, 5G provides novel potential for artificial-intelligence (AI)-based applications in manufacturing systems and SCM ^[26]. The IoT provides probable advantages such as automated structures, bioregulation, environmental feedback, energy supervision, and dematerialisation ^[27].

Human society is moving towards digital technology from age-of-information technology. In light of this, digital leadership is a fundamental component to revolutionise the technology along with its capacity. COVID-19, which dealt with an unforeseen blow to the economy, has generated different necessities for state governance. Therefore, it is time for governments to go for a digital mindset by acclimating to various new requirements. This can launch a model of governance attuned to digital technology and empower a government with digital capabilities to develop into a regular

element of a digital society. Several occurrences, such as COVID-19, demonstrated that the government needs to develop digital technology. Linking the big data on Internet cloud platforms permits improved and efficient procedures in public judgment supervision, industry policymaking, and macroeconomic regulation ^[28]. Investment in 5G has swiftly turned into a strategic importance for the government and policy builders in various low-income and middle-income economies ^[29]. Mobile network operators (MNOs) are frequently hesitant to move forward with a 5G deployment because of their current investment responsibilities and the uncertain returns from 5G, especially in private discussions. These countries are inspiring private players for investment. An important factor of this technology is its significantly amplified technical complexity, which produces advanced levels of capital investment. Some of the consequences of implementing advanced technologies such as 5G include higher unemployment, a lower-skilled workforce, scarcer technical infrastructure, etc. ^[29].

Additionally, 5G has a significant impact on rural value chains and MSMEs. The IoT in the agricultural and food supply chain (AFSC) helps in attaining sustainability ^[30] and accomplishment in areas such as logistics ^[31], cold chain ^[32], governance ^[33], and risk control ^[34]. Such modern technological developments assist in accomplishing sustainability by lowering greenhouse gases ^[35] and water depletion ^[36]. Information and communication technology (ICT) empowers farmers with dynamic information and assists in progressing the total productivity ^[27]. By 2050, it is predicted that there will be 9.6 billion people on Earth ^[27]. Therefore, there is a need to focus on sustainability by diminishing wastage and raising the agri-output ^[37].

References

1. Rao, S.K.; Prasad, R. Impact of 5G technologies on industry 4.0. *Wirel. Pers. Commun.* 2018, 100, 145–159.
2. Agiwal, M.; Navrati, S.; Abhishek, R. Towards connected living: 5G enabled internet of things (IoT). *IETE Tech. Rev.* 2019, 36, 190–202.
3. Ghosh, A.; Maeder, A.; Baker, M.; Chandramouli, D. 5G evolution: A view on 5G cellular technology beyond 3GPP release 15. *IEEE Access* 2019, 7, 127639–127651.
4. Alexiou, A. The road to 5G—visions and challenges. In *5G Wireless Technologies*; Alexiou, A., Ed.; The Institution of Engineering and Technology: Stevenage, UK, 2017; pp. 1–15.
5. Taboada, I.; Shee, H. Understanding 5G technology for future supply chain management. *Int. J. Logist. Res. Appl.* 2021, 24, 392–406.
6. Wijethilaka, S.; Madhusanka, L. Survey on network slicing for Internet of Things realization in 5G networks. *IEEE Commun. Surv. Tutor.* 2021, 23, 957–994.
7. Agiwal, M.; Kwon, H.; Park, S.; Jin, H. A survey on 4G-5G dual connectivity: Road to 5G implementation. *IEEE Access* 2021, 9, 16193–16210.
8. ITU Report. 5G—Fifth Generation of Mobile Technologies 2022. Available online: <https://www.itu.int/en/mediacentre/backgrounders/> (accessed on 31 August 2022).
9. Neokosmidis, I.; Rokkas, T.; Xydias, D. Roadmap to 5G success: Influencing factors and an innovative business model. In *2017 Internet of Things Business Models, Users, and Networks*; IEEE: Piscataway, NJ, USA, 2017; pp. 1–8.
10. Yadav, P.; Upadhyay, A.; Prasath, V.B.S.; Ali, Z.; Khare, B.B. Evolution of Wireless Communications with 3G, 4G, 5G, and Next Generation Technologies in India. In *Advances in Electronics, Communication and Computing*; Springer: Singapore, 2021; pp. 355–359.
11. Ben-Daya, M.; Hassini, E.; Bahroun, Z. Internet of things and supply chain management: A literature review. *Int. J. Prod. Res.* 2019, 57, 4719–4742.
12. Attaran, M. Digital technology enablers and their implications for supply chain management. In *Supply Chain Forum: An International Journal*; Taylor & Francis: Abingdon, UK, 2020; Volume 21, pp. 158–172.
13. Rejeb, A.; Simske, S.; Rejeb, K.; Treiblmaier, H.; Zailani, S. Internet of Things research in supply chain management and logistics: A bibliometric analysis. *Internet Things* 2020, 12, 100318.
14. Rejeb, A.; Keogh, J.G. 5G networks in the value chain. *Wirel. Pers. Commun.* 2021, 117, 1577–1599.
15. Tjahjono, B.; Esplugues, C.; Ares, E.; Pelaez, G. What does industry 4.0 mean to supply chain? *Procedia Manuf.* 2017, 13, 1175–1182.
16. Frazzon, E.M.; Rodriguez, C.M.T.; Pereira, M.M.; Pires, M.C.; Uhlmann, I. Towards supply chain management 4.0. *Braz. J. Oper. Prod. Manag.* 2019, 16, 180–191.

17. Hutajulu, S.; Dhewanto, W.; Prasetyo, E.A. Two scenarios for 5G deployment in Indonesia. *Technol. Forecast. Soc. Chang.* 2020, 160, 120221.
18. Gupta, A.; Singh, R.K. Applications of emerging technologies in logistics sector for achieving circular economy goals during COVID 19 pandemic: Analysis of critical success factors. *Int. J. Logist. Res. Appl.* 2021, 2021, 1–22.
19. Dewey, J.N.; Hill, R.; Plasencia, R. Blockchain and 5G-enabled Internet of Things (IoT) will redefine supply chains and trade finance. *Proc. Secur. Lender* 2018, 43–45.
20. Kothari, S.S.; Jain, S.V.; Venkateshwar, A. The impact of IOT in supply chain management. *Int. Res. J. Eng. Technol.* 2018, 5, 257–259.
21. Machado, H.; Shah, K. Internet of Things (IoT) impacts on supply chain. *APICS Houst. Stud* 2016, 77007.
22. Huckle, S.; Bhattacharya, R.; White, M.; Beloff, N. Internet of things, blockchain and shared economy applications. *Procedia Comput. Sci.* 2016, 98, 461–466.
23. Mistry, I.; Tanwar, S.; Tyagi, S.; Kumar, N. Blockchain for 5G-enabled IoT for industrial automation: A systematic review, solutions, and challenges. *Mech. Syst. Signal Process.* 2020, 135, 106382.
24. Shafique, K.; Khawaja, B.A.; Sabir, F.; Qazi, S.; Mustaqim, M. Internet of things (IoT) for next-generation smart systems: A review of current challenges, future trends and prospects for emerging 5G-IoT scenarios. *IEEE Access* 2020, 8, 23022–23040.
25. Dolgui, A.; Ivanov, D. 5G in digital supply chain and operations management: Fostering flexibility, end-to-end connectivity and real-time visibility through internet-of-everything. *Int. J. Prod. Res.* 2022, 60, 442–451.
26. Beldiceanu, N.; Dolgui, A.; Gonnermann, C.; Gonzalez-Castañé, G.; Kousi, N.; Meyers, B.; Prud'Homme, J.; Thevenin, S.; Vyhmeister, E.; Östberg, P.O. Assistant: Learning and robust decision support system for agile manufacturing environments. *IFAC-PapersOnLine* 2021, 54, 641–646.
27. Narwane, V.S.; Gunasekaran, A.; Gardas, B.B. Unlocking adoption challenges of IoT in Indian agricultural and food supply chain. *Smart Agric. Technol.* 2022, 2, 100035.
28. Peng, B. Digital leadership: State governance in the era of digital technology. *Cult. Sci.* 2022, 5, 210–225.
29. Forge, S.; Vu, K. Forming a 5G strategy for developing countries: A note for policy makers. *Telecommun. Policy* 2020, 44, 101975.
30. Yakovleva, N. Measuring the sustainability of the food supply chain: A case study of the UK. *J. Environ. Policy Plan.* 2007, 9, 75–100.
31. Lamsal, K.; Jones, P.C.; Thomas, B.W. Harvest logistics in agricultural systems with multiple, independent producers and no on-farm storage. *Comput. Ind. Eng.* 2016, 91, 129–138.
32. Raut, R.D.; Gardas, B.B.; Narwane, V.S.; Narkhede, B.E. Improvement in the food losses in fruits and vegetable supply chain-a perspective of cold third-party logistics approach. *Oper. Res. Perspect.* 2019, 6, 100117.
33. Routroy, S.; Behera, A. Agriculture supply chain: A systematic review of literature and implications for future research. *J. Agribus. Dev. Emerg. Econ.* 2017, 7, 275–302.
34. Astuti, R.; Marimin, M.; Machfud, M.; Arkeman, Y. Risks and risks mitigations in the supply chain of mangosteen: A case study. *Oper. Supply Chain. Manag. Int. J.* 2014, 6, 11–25.
35. Farooq, M.S.; Riaz, S.; Abid, A.; Umer, T.; Zikria, Y.B. Role of IoT technology in agriculture: A systematic literature review. *Electronics* 2020, 9, 319.
36. Zhang, Z.; Yu, X.; Wu, P.; Han, W. Survey on water-saving agricultural internet of things based on wireless sensor network. *Int. J. Control. Autom.* 2015, 8, 229–240.
37. Tripathi, A.D.; Mishra, R.; Maurya, K.K.; Singh, R.B.; Wilson, D.W. Estimates for world population and global food availability for global health. In *The Role of Functional Food Security in Global Health*; Academic Press: Cambridge, MA, USA, 2019; pp. 3–24.