Achieving Digital Excellence In Supply Chain Through Advanced Technologies

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ARTICLE INFO	ABSTRACT
	By focusing on the shifting role of the supply chain to drive overarching business strategy, this research presents the journey of three companies in the quest to achieve digital leadership in the supply chain domain. Digital excellence in the supply chain has become more than a desirable goal for companies engaged in production, distribution, and retail activities. It is now a vehicle for communication and for expressing external value. Achieving digital excellence in the supply chain has traditionally meant bolstering the chain's internal performance with a beam of information technology-led light. In today's era of advanced technologies, which include artificial intelligence, machine learning, Internet of Things applications, robotics, and blockchain at its core, that well-lit path has become a highway with multiple lanes stretching toward endless possibilities.
	Companies are reaping huge benefits by developing innovative products and services or using next-generation technologies to transform their businesses. The leaders in each industry have already taken positions by demonstrating the power of digital excellence, but all companies that seek growth are wending their way toward supply chain digitalization, with varying degrees of speed and commitment. In this industry report-based research work, we describe the approaches and lessons learned from three very different companies as they seek supply chain digital leadership. What unites these companies is a belief in the transformative power of advanced technology and a conviction that supply chain performance is a key driver of overall business success.
	Keywords: Achieving Digital Excellence in Supply Chain , Industry 4.0, Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML), Smart Manufacturing (SM)

1. Introduction

The ever-increasing customer expectations, short product life cycles, and dynamic market changes have significantly increased the pressure on supply chain executives to enhance the performance of their supply chains. Traditional supply chain models are no longer sufficient. The combination of advanced technologies such as AI, IoT, big data, blockchain, and the cloud is set to transform the supply chain. The future supply chain will be digital and will be more capable, connected, flexible, scalable, and ultimately more resilient. This digital transformation is not an option but a necessity for companies to achieve operational excellence.

Many companies are still in the early stages of their digital supply chain journey. Leaders in incorporating digital advancements today set the foundation for the future. To accelerate the journey, leaders, managers, and decision-makers in supply chain and operations need a clear roadmap on what the digital supply chain entails, a vision of the possibilities, strategies for refining operations, and overcoming the challenges to implement as well as leverage digital technologies to achieve breakthrough performance in the supply chain. This chapter outlines the vision of digital supply chain 4.0, presents the benefits and challenges of the digital supply chain, and discusses the solutions and services offered and the framework to deploy them. The aim is to assist companies in achieving supply chain digital excellence by leveraging advanced technologies.

1.1. Background and Significance

Digital supply chain has become a popular concept over the last few years. Many companies are eager to digitize their supply chain to utilize the benefits of digital technologies. As a result, a large number of technology vendors offer digital solutions. However, achieving digital excellence is not just about implementing a series of

digital technologies. It is the integration and combination of advanced technologies that will enable the creation of breakthrough value propositions.

Research and development in the area of advanced technologies are progressing at an unprecedented speed, including artificial intelligence, big data, cloud computing, the Internet of Things, robotic process automation, and blockchain. These advanced technologies, in combination with digital maturity, will reshape supply chain structures and create entirely new supply chain mechanisms, leading to far superior performance outcomes. This book presents how to achieve digital excellence in the supply chain through the integration of advanced technologies as well as organizational collaboration.

1.2. Research Objectives

Our study focuses on exploring the impacts of implementing three advanced technologies (3D printing, Internet of Things, and Blockchain) on supply chain and operations. Broadcasting their benefits is important to encourage companies to overcome their fears and to start investing in becoming part of the 4th Industrial Revolution. Even the combination of two or more of these technologies is a revolution by itself. Therefore, our first objective is to study the transformation of supply chain operations when one of the advanced technologies is implemented, even without necessarily changing the rest of the existing technologies.

The second objective is to study the changes in the supply chain and operations when a combination of two or a set of all three advanced technologies is implemented. There is no identified precursor study in this context. Our third objective is to propose a concept framework that will help supply chain and operations managers understand the changes and the challenges that may appear along the activities in the supply chain when the advanced technologies are implemented, and how to overcome those challenges. Since the concept framework will be built from the ground of literature review, and our study is qualitative, the content of this paper has a descriptively explorative character.
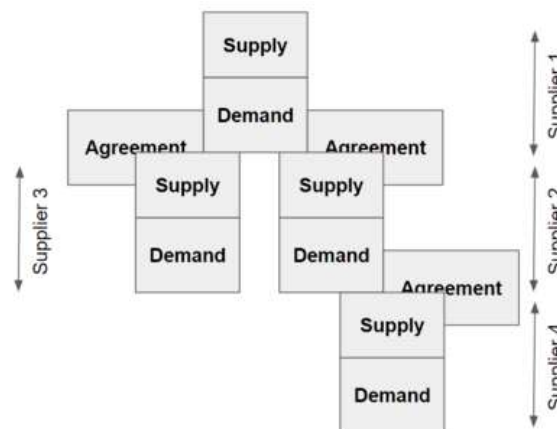

FIGURE 1:In an efficient supply chain, agreements are aligned.

1.3. Scope and Structure of the Study

This study concerns itself with the challenges and imperative of achieving digital excellence in the supply chain. Digital excellence refers to navigating the digital ecosystem and creating the organizational and leadership capabilities to harness a wide range of digital technologies for transformative and breakthrough performance. Specifically, this study provides an industry roadmap and some guidelines for improving supply chain processes using advanced technologies. First, we highlight the growing importance of the supply chain from stakeholder as well as performance perspectives. Next, we outline some key macro and industry trends and challenges in the supply chain. In the subsequent section, the scope and structure of the study are provided. Following that, discussions on some key digital technologies that are transforming supply chains, implications for supply chains, and enablers of the digital supply chain are outlined. The study is then concluded.

Supply chains operating at an advanced level of performance are sensitive to customer needs and preferences, adapt to changing business environments, and evolve towards linking the business processes of an increasingly extended enterprise. Supply chains have direct access to crucial information on price, cost, and availability embedded in the market transaction. They are exposed to measurable performance parameters in areas such as inventory management or transportation services. The increased visibility of supply chain performance has led to the recognition of the supply chain as a driver of shareholder value. Consequently, managers in the business and industry have shown a growing interest in utilizing the supply chain as a source of competitive advantage. Gains from internal business process reengineering appear to be leveling off. The supply chain, both within and across its organizational boundaries, presents the next significant opportunity for substantial improvements in business performance. Indeed, failure to address supply chain performance can result in stock-outs, excessive inventory, loss of sales, and decreased customer satisfaction, and ultimately lead to loss of market share and business failure. Over the long term, underperforming supply chains erode shareholder value.

2. Digital Transformation in Supply Chain Management

Nowadays, companies are being pressured to transform their traditional supply chain operations into digital supply chains. These digital supply chains integrate and extend end-to-end processes using digital technologies to provide better customer service at a lower cost, resulting in higher revenue. Supply chain management is comprised of a complex matrix of functions, which include production planning, sourcing, logistics, inventory management, order fulfillment, and customer service. These supply chain functions serve as the primary link between a company and its customers, as they are responsible for the flow of products and information throughout the company's network of suppliers, production facilities, warehouses, distribution centers, and sales outlets. The ultimate goal of supply chain management is to create value for the end customer while increasing profitability for all companies involved in the chain.

Over the years, supply chains have evolved from internal to extended and global chains, as companies have outsourced non-core functions to focus on their core capabilities. Although the concept of the supply chain is not new, the application of digital technologies to integrate supply chain processes internally and externally with customers and suppliers is a new development. As companies pioneer digital technologies, they must develop a clear roadmap to achieve digital excellence in supply chain management. This roadmap will involve a gradual transformation of existing supply chain processes, which will ultimately lead to the digitalization of the entire supply chain. The transformation will also involve the use of advanced technologies, such as Big Data Analytics, the Internet of Things, Blockchain, and Artificial Intelligence, to improve supply chain capabilities.

2.1. Definition and Concept of Digital Transformation

From a business perspective, digital transformation is the process of creating new or modifying existing business processes, culture, and customer experiences to meet changing business and market requirements as a result of advances in digital technology. Digital transformation is not necessarily about digital technology, but rather about the fact that technology, which is digital, allows people to solve their traditional problems. And ultimately, digital transformation is the result of these radical changes. It is the specific use of these technologies that enables new types of innovation and creativity and allows companies to create more immersive and engaging experiences with customers. Technologies that are the foundation for a digital transformation include mobile, social, cloud, Internet of Things (IoT), advanced analytics, big data, and artificial intelligence.

However, to achieve these radical changes, organizations must go through many technological advancements that pave the way for true digital excellence. At present, this road is called the readiness road to digital transformation. This is a road where organizations need to become ready by taking incremental steps to embrace advanced technologies that enable digital transformation. These technologies include robotics, artificial intelligence, 3D printing, and the blockchain, which are also called the distinguished five technologies. Quantum computing, biotechnologies, and other human-enhancing technologies are also on the far end of this roadmap.
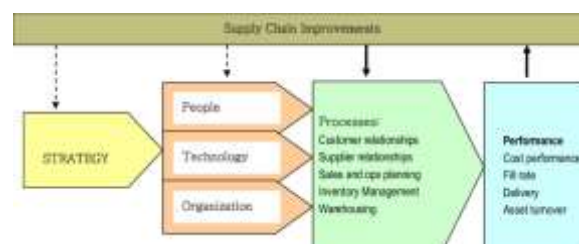

FIGURE 2: Supply chain excellence model Enablers Performance

2.2. Key Technologies Driving Digital Transformation

• Robotics: With the help of robotics, supply chains can be made more flexible and responsive. Autonomous Mobile Robots (AMRs) are now commonly used for repetitive tasks in various warehousing environments. They can work alongside human operators and enhance the speed and accuracy of operations. Different kinds of robots are being tested and implemented to perform tasks like picking, packing, and loading/unloading, which are hard for humans to perform continuously. The deployment of robots in the warehouse environment can bring about a significant transformation in warehouse operations.

• Artificial Intelligence (AI) and Machine Learning (ML): AI and ML are helping companies automate decision-making processes, which is enabling greater agility in responding to changing conditions in the supply chain. From chatbots for customer service to autonomous planning, scheduling, and forecasting processes, AI is enhancing various facets of supply chain operations.

• Big Data and Analytics: Data has always been at the heart of supply chain operations. But now, with big data, companies can not only use structured data but also incorporate unstructured data from various sources and derive valuable insights from it. Advanced analytics can help in predictive modeling for demand and supply planning, risk assessment and management, and much more. With the vast amount of data generated from IoT devices, the potential of analytics in supply chain operations can be fully realized.

Digital transformation in the supply chain is complex, and multiple technologies are at play fueling this shift. The major technologies that are enhancing digital supply chains are: • Internet of Things (IoT): By enabling physical objects to connect to the internet, share information, and communicate with other 'things', IoT is transforming supply chains. It is creating a vast pool of data that is helping improve operations at each step. From real-time tracking of objects to using smart bins for inventory management, IoT is enabling companies to operate more efficiently.

3.Benefits and Challenges of Digital Excellence in Supply Chain

Benefits of digital excellence in supply chain Organizations that achieve digital excellence in the supply chain can connect, collate, and derive insights from various data sources to propel themselves at the breakneck speed of today's business environment. In addition to enabling speed and flexibility, a digital supply chain results in improved customer service and satisfaction, optimal inventory levels, lower operating costs, and the ability to make more informed decisions.

Challenges of digital excellence in the supply chain Along the journey to achieving digital excellence in the supply chain, organizations are faced with a unique set of challenges. Some of these include new forms of data that come in large volumes and at a high velocity, the transition from using descriptive and diagnostic analytics to more predictive and prescriptive forms of analysis, a rapidly evolving cyber threat landscape, and a shortage of a specialized workforce that can execute the vision of a digital supply chain.

Conclusion Digital is the way forward. Companies that embark on the journey to achieve digital excellence will realize a multitude of benefits that result in world-class supply chain performance. In addition to the standard benefits of speed and flexibility, an organization can achieve improved customer service and satisfaction, optimal inventory levels, lower operating costs, and more informed decision-making.

3.1. Benefits of Digital Excellence

Digital excellence in the supply chain is essentially about integrating the traditional processes with advanced technologies—such as big data, artificial intelligence, machine learning, the Internet of Things, robotics, blockchain, etc.—to co-create a unique customer experience, foster innovation, lower operational costs, and maximize revenue. This results in enhanced growth and profitability for a company in the long run. The ultimate use of advanced technologies is in creating a breakthrough customer experience. When a company can understand customer needs and fulfill them in a unique way that adds exceptional value to the customer, price then becomes secondary in the customer's decision-making. By offering unique value propositions, price resistance can be overcome, customer loyalty can be cemented, and new market segments can be developed. This, in turn, leads to revenue maximization and dynamic growth.

Another key benefit of digital excellence in the supply chain is in fostering supply chain innovation. By integrating with external partners and using digital platforms, a company can co-create with external partners, such as suppliers, logistics service providers, distributors, retailers, and even customers. This co-creation of new products, services, and business models enhances supply chain innovation. Over time, constant innovation becomes a source of competitive advantage. Companies that innovate their supply chains and deliver products and services to the market faster than their competitors gain market share and maintain a lead over their competitors in the long run. This dynamic growth is the result of supply chain innovation, made possible by digital excellence in the supply chain.
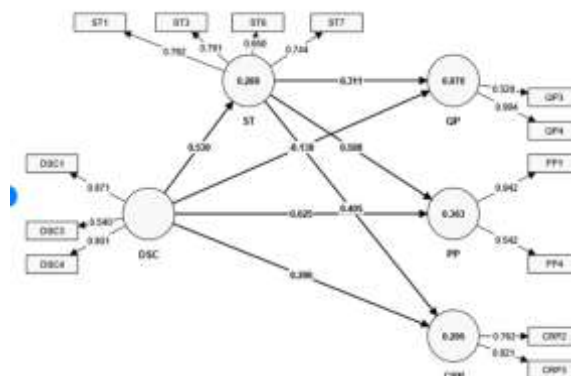

Fig 3 :Digital supply chain

3.2. Challenges and Barriers to Implementation

Despite the range of potential benefits of the application of advanced technologies in the supply chain, many companies have not yet embarked on their digital journey. Those who have initiated this process are at varying stages of implementation and reap a diverse range of benefits. There are several challenges and barriers which hamper progress. These can include a lack of awareness of the digital technologies available and the benefits to

be gained, a lack of strategic commitment at the senior management level, concerns over data security, privacy, and ownership, the presence of several disparate legacy systems that were not designed for digital compatibility, a shortage of digital skills and knowledge, a reluctance to share information and collaborate across the supply chain, and the perceived high cost of investment, and the risk of implementing unproven or immature technologies. The nature and scale of these challenges will differ between companies and supply chains. Internal challenges are likely more significant for companies at the more advanced stages of digital implementation, while broader supply chain challenges may be more significant for companies at the less advanced stages.

4.Case Studies and Best Practices

To help convey the complex, cross-cutting nature of digital supply chains and to provide full, real-world examples of tools, technologies, and techniques in action, a series of case studies and examples are presented in this section. These examples, which span a variety of industries and mission areas, support the themes and best practices outlined earlier in the paper. Many of the examples feature companies and organizations that have embraced digital supply chain concepts and have moved from "business as usual" to "business as exceptional." Through the innovative use of technologies and a reimagining of processes and operations, they have improved customer service, slashed cycle times, reduced costs, managed risk, and, in general, created smarter, more resilient supply chains that confer a competitive advantage.

Summary Digital technologies have continued to evolve, enabling advanced analytical applications to address persistent supply chain challenges. Digital excellence in the supply chain is an achievable goal, and advancing along the digitization spectrum is a necessary journey. The experiences and lessons learned from leaders can serve as guides to others who are embarking on this journey. The case studies and examples in this section highlight the power and potential of digital supply chains and describe in specific detail how tools and technologies enable supply chain stakeholders to create value, optimize performance, and achieve mission goals through better decision-making.

4.1. Successful Implementation Cases
Global electronic leaders such as Apple, Dell, IBM, and Cisco have excelled by mastering the design and coordination of both physical and information flows. Leaders of this group are called "supply chain digitizers". In markets that offer a plethora of versions, options, and short life cycles, digital supply chains have access to institutional revenue pools. Brands may be exploited without actually making physical products, thus reducing working capital requirements to a very low level. Their manufacturing services are contracted out to electronics manufacturing services (EMS) and original design manufacturing (ODM) suppliers. For example, Apple controls the design and thin product management and branding process and produces at its network of EMS suppliers led by Foxconn.

These product makers all become supply chain digitizers with intense market access and IT capability. The leaders in that group are further advanced to become "supply chain IT innovators". They use advanced technologies not only to perform the basic functions that digitizers do but also to pioneer new capabilities. The "supply chain IT innovators" aspire to build front and back interconnected supply chain capabilities, linking them to channels and suppliers. The goal is to sense the market demand and proactively collaborate with upstream suppliers. This group, for the most part, does its manufacturing. High-tech sectors like semiconductors, consumer electronics, computer equipment, and the enterprise software industry are the more likely candidates to be in the group of "supply chain IT innovators".

FIGURE 4: Operational excellence core functionalities.

4.2. Lessons Learned and Best Practices
From these case studies and our broad experience, we extract the following lessons learned and best practices to achieve supply chain digital excellence:

Continuously reassess: Digital technology is constantly evolving. What was impossible just a few years ago is now not only possible but often an attractive new option. Companies at the digital frontier are those that have developed a systematic technology reassessment process. They evaluate emerging technologies, experiment to understand the potential benefits and implementation challenges, and then prioritize and implement the most promising new technologies.

Fast followers benefit too: Companies do not have to be digital pioneers to benefit from technology evolution. Fast followers often have an easier path, profiting from the mistakes and experience of the first movers. Many of the challenges of implementation of specific technologies are generic and can be managed with knowledge that is now widely available. The lack of internal experience with a new technology can be rapidly overcome by working with technology providers or other companies that have already implemented the technology.

Use technology to enable partnerships: Advances in digital technology make it easier to share data and collaborate with external partners in the supply chain. This enables much tighter coordination of activities up and down the supply chain, enabling important new capabilities like synchronized planning and shared real-time inventory visibility. These new capabilities can enable significant supply chain performance improvements across the entire network of companies. Since 2019, one of the key enablers of digital supply chain success is the advancement of technologies such as AI, machine learning, the Internet of Things (IoT), robotics, and blockchain.

Companies that grasp these new technologies are using them to create smarter, more adaptable digital supply chains. AI and machine learning are being embedded into planning and execution applications, making products and supply chains more intelligent. IoT is used to monitor the condition of products as they move through the supply chain. Robots and autonomous vehicles are being deployed in manufacturing, warehouses, and distribution centers. Blockchain technology is being used to ensure the integrity and security of transactions between supply chain partners. The benefits of early technology investments are clear and well-proven. According to a recent survey, 48% of companies that consider themselves "leaders" or "fast followers" expect to increase supply chain technology investment by 11% or more compared to 32% of other companies. The companies intending to increase investment have the right idea: Technology is the key to continued supply chain improvement.

5. Future Trends and Opportunities

Due to the sheer volume of data in the supply chain from various sources within and outside the organization, it is nearly impossible for humans to manage, monitor, and glean insights to make the right strategic and tactical decisions daily. However, with the advent of advanced artificial intelligence algorithms, this is quickly changing. In this chapter, we present several use cases that demonstrate how firms are harnessing the power of AI to support various supply chain decision-making processes – from sales and operations planning, to logistics and transportation, to inventory management, and beyond. In addition, we discuss several key implementation challenges that firms need to address to successfully make the transition to an AI-enabled supply chain.

In conclusion, the power of the digital supply chain is in the ability for organizations to connect people, data, processes, and things, in a collaborative, innovative, and productive environment to achieve operational, and ultimately financial, excellence. The exponential growth of data, combined with emerging technologies such as distributed ledger technologies, advanced analytics, and artificial intelligence, offers unprecedented opportunities for organizations to enhance their supply chain capabilities. However, embarking on a digital transformation journey is neither easy nor straightforward. While some organizations may struggle with the high costs of innovation, others may feel overwhelmed by the sheer number of emerging technologies and the potential hype surrounding them. The key is for organizations to identify clear use cases in which advanced technologies can help solve specific supply chain problems, experiment with small-scale projects, learn from the results, and then gradually scale up the projects that show demonstrable value. Only then can organizations move from playing catch-up to becoming trendsetters in the age of the digital supply chain.
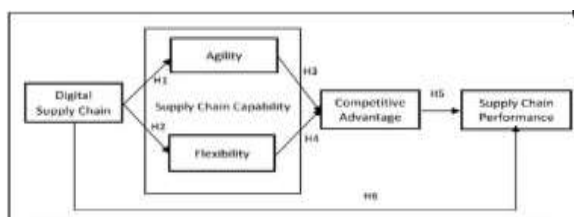
Fig 5;Theoretical framework of digital technology for supply chain performance.

5.1. Emerging Technologies in Supply Chain Management

This section examines the supply chain management's emerging techniques and technologies that are contributing to an enhanced digital supply chain. The following are some examples:

Artificial Intelligence - It is a digital computer-based technological system that represents and applies human expert behavior, knowledge, and decision-making skills. In supply chain management, AI technologies include

expert systems, neural networks, and robotics. Some applications of AI in supply chain management are as follows:
- Market analysis and forecasting. - Product and service design. - Scheduling and control of manufacturing, warehousing, and distribution. - Support of human activities (training and problem-solving).
Autonomous and Collaborative Robots - Supply chain management systems include mobile and fixed robotics that can "see" to perform their specified tasks. Autonomous robotic technologies are employed to perform various supply chain functions such as picking, packing, and staging orders. Autonomous robots are used in the distribution center for inventory and warehouse tasks. They can move, store, and retrieve inventory items within a defined facility. The technology used by these robots is a vision-based navigation system, which allows them to travel in a dynamic environment. Collaborative robots ('cobots') can work in the same environment as human workers.
Data Science - It is an emerging interdisciplinary field that uses scientific methods, processes, algorithms, and systems to extract knowledge and insights from data in various forms, both structured and unstructured, which is the foundation of the supply chain's big data. Data science technologies encompass machine learning, data mining, statistics, and predictive modeling. These technologies automate data processing and derive valuable information that can be used to make better supply chain decisions. Data science helps improve processes related to transport and logistics as well as customer service in supply chain organizations. It also supports the improvement of various strategic procurement-related activities.

5.2. Potential Impact on Industry and Society
The advancements in artificial intelligence, machine learning, and robotics are poised to revolutionize human society. In no industry is this more evident than in the supply chain, where the application of these technologies offers the twin promises of unprecedented performance and transforming outdated and under-performing logistics infrastructures? By delivering a step-change in digitization, the supply chain can become the responsive, responsible industry that safeguards the future for which it is entrusted.
The supply chain's responsibility for the careful stewardship of the flow of production goods from source through to consumption has not always been reflected in its performance. Its reliance on over-capacity in transportation, leading to environmental degradation and questionable labor practices, has tarnished the industry's reputation. This is why, in the era of hyper-urbanization, the demographic time-bomb of an aging population, and the creeping evidence of man-made climate change, the supply chain must step up to these societal challenges and embrace the enabling technologies of AI, machine learning, and robotics to become an industry that is both excellent and responsible. The industry structure will then be re-defined, with incumbent organizations re-inventing to survive, while agile new entrants take advantage of the democratization of technology to carve out their niches.

6. Conclusion

The supply chain is considered the lifeblood of any industry. In the past, companies competed mostly on individual components of the supply chain, such as production speed or product quality. In today's interconnected, technology-driven global economy, companies are realizing that they have to collaborate with their partners to fight against all types of dysfunctions. Today's supply chain is from suppliers all the way to end customers and ideally should be transporting materials, converting them into products, and serving customers most efficiently. In this context, digital excellence is no longer an aspiration but a necessity to achieve breakthrough performance. Not only can digital technologies help today's supply chain operate more efficiently, they have the potential to completely transform these chains.

6.1. Future Trends
It is no longer sufficient for supply chains to simply "do digital": to deliver excellence, the best digital technologies of the Fourth Industrial Revolution must be harnessed. This paper outlines key future trends (responsible for the enhancement of nine supply chain drivers), such as using artificial intelligence (including machine learning, robotics, and drones), the Internet of Things, blockchain, and advanced analytics, adding to and enhancing the established digitization technologies. These trends are burgeoning, growing, and adding value at an ever-increasing pace. As these advanced digital technologies become available, supply chain and logistics professionals must embrace and embed enabling mindsets (proactivity, collaboration, risk management, lifelong learning, and advancing with the times) to constantly upgrade the capabilities of both themselves and their supply chains. Capturing these advanced digital technologies and evolving with the times is the trajectory that can take supply chains into the sphere of achieving digital excellence in the future.
Propelling supply chains towards that excellence picture that is in their future, this paper has extended the Fourth Industrial Revolution technologies beyond the established digitization technologies, enabling them to harness these burgeoning, evolving, value-adding technologies that are driven by mindsets. These technologies combined with the enabling mindsets will be the propellers, with the drivers of the supply chain as the benefactors. These propellers will propel the supply chain toward the horizon of digital supply chain excellence into the future.

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