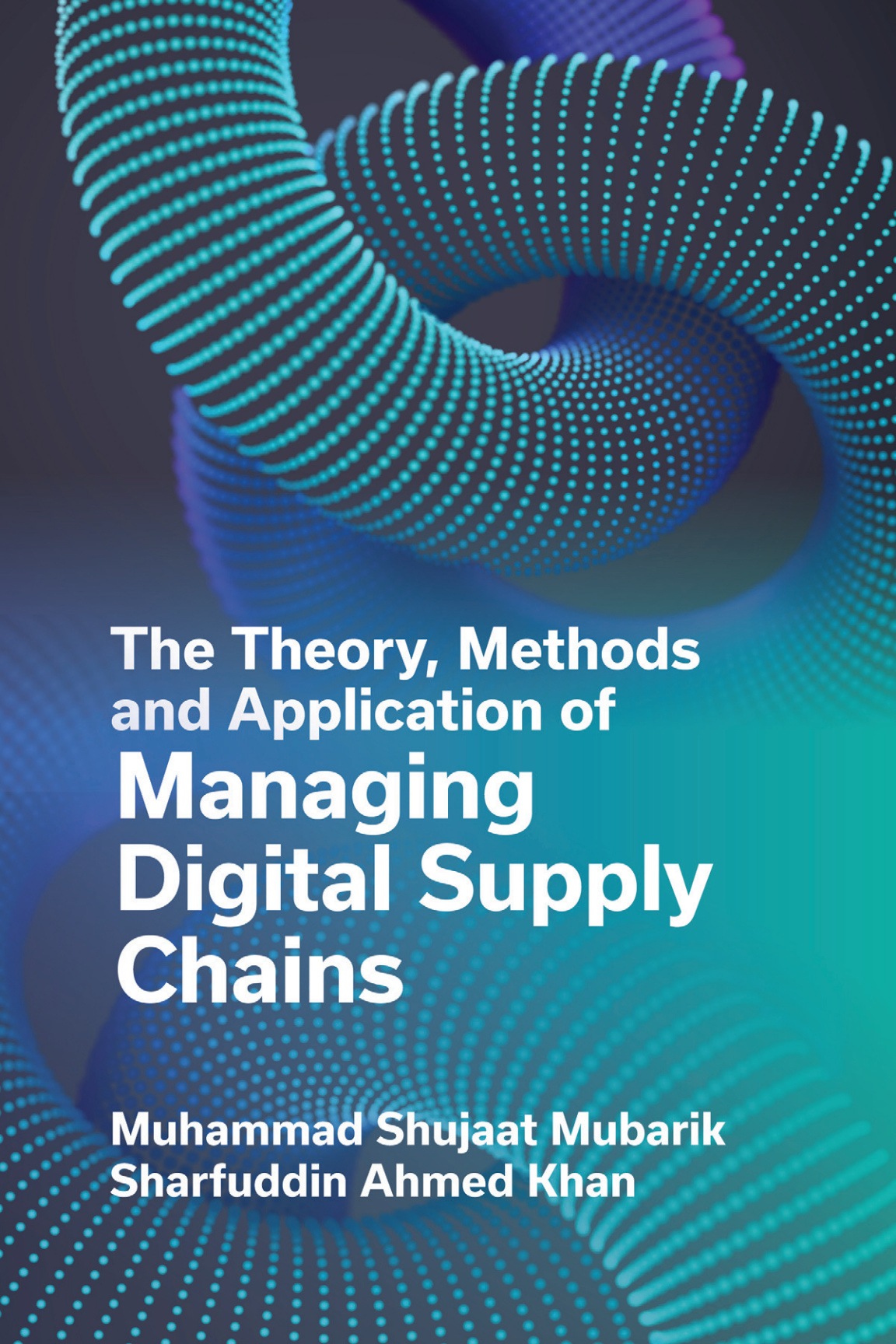
The Theory, Methods and Application of
Managing Digital Supply Chains
Muhammad Shujaat Mubarik
Sharfuddin Ahmed Khan

The Theory, Methods and Application of Managing Digital Supply Chains

Sustainability is one of the most pressing issues today, and this book brilliantly explores how digital supply chain management (DSCM) can be harnessed to address the sustainability challenges. The authors have carefully integrated sustainability considerations throughout the book, culminating in Chapter 9's in-depth examination of sustainability challenges in the digital supply chain. I find this approach particularly commendable. It underscores the critical role that DSCM plays in creating more environmentally and socially responsible supply chains. The holistic perspective presented in this book is a testament to the authors' expertise and dedication to advancing the field.

—***Dr Shakeel Sadiq Jajja***,
Fulbright Fellow, Stanford University, SA
Associate Professor of Operations and Supply Chain management
LUMS University, Pakistan

While working on the various industry-driven projects, I have witnessed firsthand the challenges and opportunities presented by the integration of digital technologies into supply chain operations. This book provides a comprehensive and well-researched guide to understanding and navigating this transformation. The expertise and dedication of authors to advancing the field shine through in this work, making it an invaluable reference for senior executives and decision-makers looking to drive innovation and efficiency within their organizations.

—***Ishizaka Aessio***
Distinguishe Professor of Decision Analysis
NEOMA Business School, France

This book is a significant contribution to the field and a vital resource for professionals seeking to navigate the digital transformation of supply chains. I particularly appreciate the book's exploration of disruptive digital technologies and their real-world applications, as well as its discussions on Industry 4.0 technologies.

—***Dr Charbel Jose Chiapetta Jabbour***
Professor of Green, Circular, and Responsible Supply Chains
NEOMA Business School, France

The Theory, Methods and Application of Managing Digital Supply Chains

BY

MUHAMMAD SHUJAAT MUBARIK

Heriott-Watt University, UK

AND

SHARFUDDIN AHMED KHAN

University of Regina, Canada

United Kingdom – North America – Japan – India – Malaysia – China

Emerald Publishing Limited
Emerald Publishing, Floor 5, Northspring, 21-23 Wellington Street, Leeds LS1 4DL

First edition 2024

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-80455-969-7 (Print)
ISBN: 978-1-80455-968-0 (Online)
ISBN: 978-1-80455-970-3 (Epub)

To my parents, wife, children, and friends.

—Muhammad Shujaat Mubarik

To my late parents, family, and friend.

—Sharfuddin Khan

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About the Authors

Dr Muhammad Shujaat Mubarik is currently serving as an Associate Professor of Logistics and Supply Chain Management at the Edinburgh Business School, Heriot-Watt University, UK. He has also been a Visiting Professor at Copenhagen Business School, Denmark. His academic journey has been marked by a wealth of experience, including his prior role as the Professor and Dean of the College of Business Management (CBM) at the Institute of Business Management (IoBM) in Karachi. Dr Mubarik's research interests are diverse, encompassing the behavioural and technological dimensions of supply chains, with a particular emphasis on the critical aspects of intellectual capital and sustainability within firms. He has made significant contributions to the field of supply chain management, focusing on the role of supply chain mapping and digital twin technologies in enhancing the triple bottom lines of supply chains. His scholarly work has been published in esteemed journals such as the *Supply Chain Management: An International Journal*, *International Journal of Production Research*, *Technological Forecasting and Social Change*, *Business Strategy and Environment*, *Journal of Cleaner Production*, *Journal of Intellectual Capital*, and *Management Decision.* Notably, he has authored two books titled *Supply Chain Mapping, Sustainability and Industry 4.0* and *Human Capital, Innovation and Disruptive Digital Technology*, both published by Routledge. He has also been PI and CO-PI of projects funded by various agencies. Currently, Dr Mubarik is engaged in a funded project that explores the implementation of blockchain-driven supply chains in the Oil and Gas sector. Beyond academia, he is a sought-after expert in the media, frequently appearing on television shows to share his expert opinions on national and international economics and business affairs.

Dr Sharfuddin Ahmed Khan is an Assistant Professor in Industrial and Systems Engineering at Faculty of Engineering and Applied Sciences, University of Regina, SK, Canada. Prior to joining the University of Regina (U of R), Dr Khan has worked more than twelve years with the Industrial Engineering and Engineering Management department at University of Sharjah (UoS), Sharjah, United Arab Emirates, where he has served as an Assistant Professor (Sept. 2019 to Dec. 2021) and Lecturer (Sept. 2009 to Aug. 2019). Dr Khan has more than 80 archival publications to his credit in high impact factor journals, as well as conference papers/proceedings, and book chapters. He's published in various journals such as *Supply Chain Management: An International Journal*, *International Journal of Production Research*, *IEEE Transactions on Engineering Management*, *Journal of Cleaner Production*,

Technological Forecasting and Social Change, *Production Planning and Control*, *Expert Systems with Application*, *Journal of the Operational Research Society*, *Annals of Operations Research*, *International Journal of Information Technology & Decision Making*, *Corporate Social Responsibility and Environmental Management*, *Knowledge-Based Systems*, etc. He also attended several international conferences such as POMS, IEEE-IEEM, IEOM, GOL, etc. Sharfuddin has also guest edited special issues of prestigious international journals in the areas of Supply Chain Management and Decision Making.

Foreword

I am honored to provide this foreword for the book in hand titled: *The Theory, Methods and Application of Managing Digital Supply Chains*. I have been witnessing the profound changes brought about by the relentless march of digital technologies. In a world marked by its complexity and unpredictability, supply chain management has assumed an ever greater significance for organizations of all sizes and industries. The traditional paradigms that once governed the field have been thoroughly disrupted by the advent of digital technologies. Consequently, understanding and effectively leveraging digital supply chain management (DSCM) has become an imperative for organizations striving to thrive in today's landscape.

This book, *authored by two distinguished scholars: Dr Shujaat Mubarik and Dr Sharfuddin*, offers an expansive and insightful examination of DSCM from various angles. It guides readers through the evolution of DSCM, providing valuable historical context that aids in comprehending the present and anticipating what lies ahead. The book covers a diverse array of topics, from the transformative influence of digital technologies to the sustainability challenges confronting organizations in the digital era. One standout aspect of this book is its multifaceted approach. It not only addresses the "What" and "How" of DSCM but also delves into the "Why." For instance, the economic perspective presented in the book sheds light on the motivations and incentives driving the adoption of digital supply chain solutions. Additionally, the exploration of intellectual capital underscores the vital role of intangible assets in achieving excellence in DSCM.

From the perspective of someone deeply engaged in industry practices, I particularly appreciate the practical relevance of the content of the book. It offers actionable insights that organizations can immediately apply to enhance their supply chain operations in our increasingly digital and interconnected world. The discussions on Industry 4.0 technologies and the economic perspective of DSCM are particularly noteworthy in this regard.

In a nutshell, *The Theory, Methods and Application of Managing Digital Supply Chains* is a timely and indispensable resource for anyone interested in the field of supply chain management. It not only captures the current state of DSCM but also provides a forward-looking perspective on the future of supply chain management in the digital age. I commend the authors for their dedication and

expertise in creating this exceptional contribution to the field. I have no doubt that this book will serve as a guiding light for researchers, practitioners, and students navigating the intricate and dynamic world of DSCM.

M. Affan Badar, PhD, CPEM, IEOM Fellow
Professor and Director of PhD Technology Management
Bailey College of Engineering and Technology
Indiana State University
Terre Haute, IN 47809, USA

Preface

In today's hyperdynamic and highly intertwined digital world, the field of supply chain management has undergone a profound transformation. The emergence of disruptive digital technologies, the global challenges brought about by the COVID-19 pandemic, and the relentless pursuit of sustainability have all converged to shape the landscape of modern supply chains. In this vein, the book in hand is an effort to explore the multifaceted realm of digital supply chain management (DSCM) with the aim of providing a comprehensive and insightful exploration of its evolution, definitions, dimensions, and applications.

The journey into the world of DSCM begins in Chapter 1, where we set the stage by tracing the evolution of supply chain management in the digital age. We explore the various definitions and dimensions of DSCM, laying the foundation for a deeper understanding of the subject. In Chapter 2, we take a closer look at disruptive digital technologies and their impact on contemporary supply chains. The rapid advancements in technologies such as AI, blockchain, and the IoTs are reshaping the way businesses operate and manage their supply chains. We discuss how these technologies are changing the game and explore their practical implications. Chapter 3 shifts the focus to a post-COVID-19 perspective. The pandemic has posed unprecedented challenges to supply chains worldwide, forcing organizations to rethink their strategies and adapt to a new reality. We examine the lessons learned from the pandemic and how they have influenced the trajectory of DSCM. Moving beyond the immediate challenges, Chapter 4 provides an economic perspective on the adoption of DSCM. We explore the economic rationale behind investing in digital supply chain capabilities and discuss the potential benefits and risks involved. Closely connected to this intellectual capital – *comprising human, relational, and structural capital of a firm – and its role in DSCM is discussed.* Particularly, this chapter explores the association between an intellectual capital of a firm and its ability to excel in DSCM. Chapter 6 is yet another closely knitted chapter , where we delve into the association between DSCM and organizational performance. We examine how effective DSCM practices can impact various facets of an organization, from efficiency and cost-effectiveness to customer satisfaction and competitiveness.

Further, we explore the challenges and opportunities organizations face in their journey toward digitalization and provide insights into successful implementation. In this vein, Chapter 7 investigates the strategies and approaches for adopting digital supply chain transformation. Chapter 8 takes a deep dive into the synergy between DSCM and Industry 4.0 technologies. Industry 4.0, characterized by automation, data exchange, and smart manufacturing, is reshaping industries, and we examine

how it aligns with digital supply chains. Sustainability is a pressing concern in modern supply chain management, and Chapter 9 explores the sustainability challenges associated with DSCM. We delve into the environmental, social, and ethical aspects of digital supply chains. In the last two chapter, we gaze into the crystal ball to envision the future of DSCM. We explore emerging trends, potential disruptions, and the evolving role of DSCM in the ever-changing business landscape.

This book is the culmination of extensive research, diverse perspectives, and practical insights gathered from experts in the field of supply chain management and digital technologies. It is our hope that this multidimensional perspective on DSCM will serve as a valuable resource for academics, practitioners, and students alike. Whether you are seeking to understand the foundations of digital supply chains or envision their future, this book aims to provide a holistic and informed view of this dynamic field.

As we embark on this journey through the theory, methods, and applications of managing digital supply chains, we invite you to explore the rich tapestry of insights and knowledge that awaits within these pages. The world of supply chain management is evolving, and DSCM is at the forefront of this transformation. We hope this book will empower you to navigate the digital frontier of supply chains with confidence and expertise.

Muhamad Shujaat Mubarik
Sharfuddin Ahmed Khan

Acknowledgment

We acknowledge the support of Higher Education Commission (HEC), Pakistan (under NRPU#20-11226) and University of Regina, Canada, for completing this book project. We also extend heartfelt thanks to Institute of Business Management, Karachi, Pakistan for in-kind support to write this book.

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Chapter 1

Digital Supply Chain Management: Evolution, Definitions, and Dimensions

Abstract

The present chapter discusses evolution, definitions, dimensions, capabilities, and the present state of the art of digital supply chain management (DSCM). The objective of the chapter is to offer a detailed understanding of DSCM, by shedding light on its historical development, exploring its multipronged definitions, and highlighting its core dimensions and capabilities in the contemporary business landscape. The evolution of DSCM appears as a central theme, rooted in the background of industrial revolutions. It starts by relooking at the First Industrial Revolution (IR) with its mechanization and steam power, progresses through the Second IR with electrification and mass production, and arrives at the Third IR, characterized by the rise of computers and the internet. The pivoting transition into the Fourth IR, also called Industry 4.0, marks the start of DSCM with its fusion of digital technologies (DTs) in the supply chain (SC) processes. Analysis of key definitions of DSCMs unveils their role as an enabler of SC collaboration, customer-centric nature, having overarching reliance on DTs. Moreover, the chapter explores the core dimensions of DSCM, exposing its ability to improve SC resilience, sustainability, visibility, efficiency, and agility. These capabilities stem from seamlessly woven DT developments into SC: artificial intelligence (AI), machine learning, the Internet of Things (IoT), and advanced analytics. The chapter concludes by highlighting the present state of the art in DSCM, reflecting its indispensable role in the contemporary turbulent business dynamics. In short, this chapter offers a synthesized view of DSCM's definitions, dimensions, evolution, capabilities, and present status within the larger context of supply chain management (SCM) literature.

Keywords: Digital supply chain management; industrial revolution; agility; digital technologies; resource planning

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doi:10.1108/978-1-80455-968-020241001

1.1 Introduction

The concept of supply chain management (SCM) has been around for centuries, dating back to ancient civilizations like the Romans, and the Egyptians who managed complex networks of producers, suppliers, and distributors to support their economies. However, SCM as a formal discipline started taking shape in the latter half of the 20th century. Over the last 100 years, supply chain (SC) has evolved from manual, hodge-podge, and *physically driven* processes to the highly complex, extended, and interconnected networks of organizations (Qader et al., 2022). Many of the scholars and experts believe that at the forefront of this evolution is digital supply chain management (DSCM). Before investigating the DSCM, it is important to understand the historical context and the practices that shaped the modern SCM. In the mid-20th century, SCM primarily involved manual processes and fundamental record-keeping. Organizations managed their SCs using ledger books, stock record cards, and manual registers. A cursory review of SC evolution highlights that these were the *1960s and 1970s* that marked the beginning of computerization in SCM. The invention of mainframe computers allowed organizations to automate certain facets of their SC operations, like production planning, inventory management, and order processing (Mahmood & Mubarik, 2020; Mubarik, Khan, et al., 2023). Although this automation was a significant advancement of that time, it lacked in scope and real-time capabilities, which are now considered key capabilities of SCM. Overcoming these inherent flaws, during the *1980s and 1990s* witnessed the growth of enterprise resource planning (ERP) systems. ERP systems enable organizations to integrate diverse business processes and functions, including human resources, SCM, and finance, into a single software platform (Alzarooni et al., 2022; Azmat et al., 2022). This interdepartmental integration improved coordination across the organization. Nevertheless, most of the ERP systems relied on batch processing, having various limitations in terms of real-time data accessibility, and visibility (Brau et al., 2023).

The dawn of the 21st century marked a transformative trend in SC. From 2000 to 2010, SCM function improved drastically with the help of technologies. This was the reason that the era was also known as "Decade of Integration and Optimization." First, ERP systems were tremendously improved and became widely adopted. The massive shift toward ERP systems enabled organizations to seamlessly data exchange and coordinate across business functions, including SCM (Frederico et al., 2020; Khan, Mubarik, & Paul, 2022). Globalization was another major hallmark, which expanded organizations beyond national boundaries, making supply chains extended, and more complex networks (Cecere, 2016; Mubarik, Shahbaz, et al., 2022). The era also witnessed an exponential increase in quality management methodologies like Lean and Six Sigma. These methodologies emphasized process optimization and waste reduction in SC operations (Khan, Hassan, et al., 2022). Furthermore, the exponential growth of e-commerce platforms pushed organizations to relook at their distribution strategies to make their SCs more agile, aligned, and adaptable (AAA). Technological developments like radio-frequency identification (RFID) and Global Positioning System (GPS) helped improve, not fully but

partly, SC visibility, offering real-time or near real-time tracking capabilities and allowing informed decision-making. This decade played a major role in SCC transformation, marked by technological integration and the pursuit of responsiveness, visibility, and efficiency. This era also triggered a journey of SC transformation, which was carried on during 2010–2015 (Khan, Hassan, et al., 2022; Kusi-Sarpong et al., 2022; Mubarik, Khan, Acquaye, et al., 2023).

From 2010 to 2015, SCM underwent significant developments mostly centered around data analytics, sustainability, collaboration, resilience, and the increasing demands of omnichannel retail. This period saw the emergence of advanced analytics tools, and big data enabling organizations to gain greater and deeper insights into their SC operations (Ageron et al., 2020). During this period, predictive analytics also appeared as vital for tasks like demand forecasting and inventory management, enhancing overall efficiency. Likewise, collaboration among SC partners gained importance, with an increasing need of the need for real-time information sharing, and risk management (Mubarik et al., 2023; Mubarik & Naghavi, 2021).

From 2015 to 2020, SCM experienced another wave of transformation characterized by digitalization and automation as the apex drivers of SC innovation. The integration of Industry 4.0 technologies, including the Internet of Things (IoT), artificial intelligence (AI), and blockchain, reshaped SCM processes and practices. IoT sensors enabled real-time tracking, promoting visibility, transparency, and responsiveness, while AI revolutionized demand forecasting, optimizing decision-making. Blockchain technology (BCT), which was introduced in 2009, gained substantial traction during this period. The adoption of BCT helped improve transparency and traceability in SCs, improving trust, particularly in sectors like food and pharmaceuticals (Ageron et al., 2020; Oyedijo et al., 2023). It started playing a key role in preventing incidents like the horse meat scandal and the Rana Plaza tragedy. Concurrently, the era witnessed an exponential increase in "e" SCM and e-commerce, demanding highly efficient inventory management and last-mile delivery (LMD) solutions. SCM strategies, "revolving around," evolved swiftly to meet the increasing demands of the digital marketplace, ensuring timely deliveries and meeting customer expectations (Hanifan et al., 2014; Mubarik et al., 2023). Various organizations adopted robotic process automation (RPA) for warehouse automation to improve warehousing functions such as sorting, picking, and packing. This era also witnesses an ever-increasing concern about climate change as evidenced by the Paris Accord (2015). It brought sustainability as the center of SCM strategies (Mubarik, Naghavi, et al., 2021). This is the reason that a large proliferation of SC eco-friendly practices like sustainable sourcing, sustainable packaging materials, green logistics, and carbon-neutral initiatives could be seen. Overall, this period entailed a major shift toward a more digitalized, transparent, automated, and sustainable approach to managing SCs.

From 2020 to date, the world of SCM has been facing a major transformation, in response to the COVID-19 pandemic, evolving market dynamics, and the Russia-Ukraine conflict. Key developments during this era include an overwhelming focus on SC resilience, with effective risk mitigation strategies

(Mubarik et al., 2023). The pandemic accelerated the pace of the already growing shift toward platform-based businesses, digital technologies (DTs)-driven value chains, prompting an exponential increase in demand for highly agile SCM (Mubarik, Khan, Kusi-Sarpong, et al., 2023; Nasiri et al., 2020). The digital transformation led by technologies like digital twins and AI-driven SC modeling has gained significance in optimizing operations and managing disruptions (Shujaat Mubarik et al., 2023).

Presently, organizations are diversifying sourcing locations and exploring nearshoring or reshoring options to decrease dependency on a single region, reflecting a greater emphasis on supply chain mapping and risk management. SC sustainability initiatives are becoming an integral part of identity and customer expectations, leading companies to adopt more environmentally responsible supply chain practices (Mubarik, Khan, Kusi-Sarpong, et al., 2023). In short, in the present era, the role of SCM as a predominantly operational function to a strategic asset, with digital transformation, advanced analytics, mapping, and sustainability as central themes.

The above backdrop reveals that SC has resumed a strategic role and the success of a firm is directly tied to the success of its supply chain. The proceeding sections of this chapter explain how the incorporation of DTs in SC uplifts the SC performance, helping the firm to improve the strategic role of SC. Before explaining how the fusion of DTs results in DSCM, it is essential to provide a brief background of the technological evolution. The following section has been dedicated to this task.

1.2 Evolution of Digital Technologies

The influx of DTs in the first decade of the 21st century marked the radical transformation of SCM. Since then, the pace of SC transformation has been unprecedented. Before explaining how DTs have, and continue to transform SCs, it is important to give a brief snapshot of the backdrop of technological development. To truly understand this, we refer back to the series of industrial revolutions. The concept of industrial revolutions refers to significant and transformative shifts in the way industries operate and produce goods (Mubarik, Khan, Kusi-Sarpong, et al., 2023). These revolutions are featured by advancements in technology, changes in technological, economic, and societal structures, and shifts in human resource practices. The industrial revolutions have been categorized into five distinct phases, from Industry 1.0 to Industry 5.0, each representing a new era of industrialization and innovation. Below is a brief explanation of each of these industrial revolutions in detail:

- *Industry 1.0: The First Industrial Revolution (Late 18th Century–Early 19th Century):* The First Industrial Revolution, spanning the late 18th century and early 19th century, was a transformative period, notably associated with Britain (Lasi et al., 2014). Key developments defined this era: mechanization, which shifted labor from manual to machinery in industries like textiles

through innovations like the spinning jenny and power loom; the pivotal role of the steam engine, pioneered by James Watt, powering factories and transportation, revolutionizing energy use; the emergence of centralized factories, marking a transition from decentralized, cottage-based production to mechanized, efficient production centers; the growth of transportation infrastructure, including railways and canals, facilitating the movement of goods and expanding markets; and urbanization, as industrialization drew people from rural areas to cities in pursuit of work, fueling significant urban growth. This period laid the groundwork for subsequent industrial revolutions and reshaped the fabric of society and economy (Mubarik, Khan, Kusi-Sarpong, et al., 2023).

- *Industry 2.0: The Second Industrial Revolution (Late 19th Century–Early 20th Century):* The Second Industrial Revolution, often referred to as the Technological Revolution, primarily unfolded in the late 19th and early 20th centuries, marking a period of profound technological advancements. Major developments in Second Industrial Revolution entail the large-scale adoption of electricity, radically improving the manufacturing processes by enhancing machines efficiencies. The introduction of the Bessemer process – *economical and inexpensive process of steel making at massive scale* – and the expansion of the steel industry offered diverse and stronger materials, greatly influencing the manufacturing and construction sectors. Innovations such as assembly line, by Henry Ford, leading to mass production, changed the manufacturing processes and enabled the efficient production of goods (Lasi et al., 2014). Likewise, telecommunications also improved, owing to the developments in the telegraphy and telephony technologies. It enabled long-distance communication and global trade operations (Mubarik, Khan, Kusi-Sarpong, et al., 2023). Further, the chemical industry grew exponentially, allowing the development of innovative materials like synthetic chemicals and plastics. Another sector which saw significant improvement was transportation sector. The expansion of railways, the development of the internal combustion engine, and the emergence of the automobile industry revolutionized the transportation systems and putting the foundation for today's industrialization.
- *Industry 3.0: The Third Industrial Revolution (Late 20th Century–Early 21st Century):* The Third Industrial Revolution, *also known as the Digital Revolution*, started in the late 20th century and lasted until the early years of 21st century. This revolution brought significant technological advancements. One significant development in this regard was the adoption of information technology (IT), which significantly changed the data processing and transmission approaches. Automation though technologies, like use of robots in day-to-day repetitive tasks, started replacing humans in various industries like automotive, chemical, and textile to name a few. Most of the industries underwent a transition from analog to digital systems, resulting in the digitization of processes, data, and communication. Improved transportation and communication systems facilitated globalization, allowing companies to expand their reach internationally. The rise of e-commerce, driven by online shopping and electronic payment systems, brought significant changes to the retail and commerce

sectors. Additionally, biotechnology saw notable advances, leading to breakthroughs in healthcare, agriculture, and the pharmaceutical industry. This era profoundly reshaped industries, economies, and societies, laying the foundation for ongoing digital transformation.

- *Industry 4.0: The Fourth Industrial Revolution (Present and Ongoing):* The ongoing Fourth Industrial Revolution, also known as Industry 4.0, represents the convergence of digital, physical, and biological technologies, significantly impacting industries worldwide (Hirschman & Mogford, 2009; Lasi et al., 2014). Key developments within this era encompass the proliferation of IoT devices, facilitating data collection from connected systems for real-time monitoring and decision-making. Advanced data analytics and AI process large datasets, optimizing operations and decision-making. BCT bolsters security and transparency, particularly in finance and SCM. 3D printing advances additive manufacturing, enabling the production of intricate, customized parts with reduced waste. Cyber-physical systems integrate sensors, actuators, and AI into physical systems, resulting in highly adaptable and responsive production processes (Mubarik, Khan, Kusi-Sarpong, et al., 2023). Autonomous systems, including vehicles, drones, and robots, find applications in manufacturing, logistics, and transportation, embodying the transformative potential of Industry 4.0.
- *Industry 5.0: The Fifth Industrial Revolution (Emerging):* Industry 5.0 is an emerging concept that envisions the future of industrialization with several key themes and technologies. It emphasizes collaboration between humans and machines, particularly in complex decision-making processes, fostering customization, and personalization of products and services. Sustainability takes center stage, with a focus on environmentally responsible practices (Hirschman & Mogford, 2009). Resilience and flexibility become paramount as industries adapt to disruptions through adaptive systems, and cybersecurity gains heightened importance in an increasingly connected world (Mubarik, Khan, Kusi-Sarpong, et al., 2023). Ethical concerns related to AI, automation, and job displacement are expected to be addressed. Industry 5.0 represents the ongoing evolution of technology and society, blurring the lines between the physical and digital realms, and ushering in new possibilities and challenges for industries and society as a whole.

1.3 Defining Digital Supply Chain Management

The backdrop provided above serves as a crucial foundation for comprehending and delineating the essence and structure of DSCM. Indeed, the profound transformation of SCM commenced with the advent of the 21st century and the widespread proliferation of DTs, often referred to as Industry 4.0 technologies. These digital innovations have played a pivotal role in reshaping and revolutionizing supply chains (Khan, Mubarik, Kusi-Sarpong, et al., 2022). While there is a general consensus on the macro-level definition of DSCM, there exists difference in its definition at firm level (Mubarik, Khan, Kusi-Sarpong, et al., 2023).

Few scholars consider DSCM as the complete digitalization of SC processes, whereas other define it the adoption of DTs to improve existing SC processes efficiencies. For gaining a comprehensive understanding of DSCM, both at the broader and more granular levels, it is imperative to explore existing definitions of DSCM. The present section fulfills this purpose by offering a selected spectrum of DSCM definitions and conducting a comparative analysis to highlight their similarities and differences.

Since the inception of DTs, could be traced back to the late 2000s, the definition and measurement of DSCM have significantly evolved. There are diverse perspectives on what constitutes DSCM, and handful of studies shed light on this concept. For example, Raab and Griffin-Cryan (2011) argue that traditional SCs are heavily driven by paper-based documentation with few of electronic processes. Such SCMs result in creating organizational silos, whether functional or geographical, tend to erupt open information sharing, leading toward suboptimal performance. Whereas, DSCM make information widely available, improving collaboration and communication across stakeholders and platforms. This, in turn, improves reliability, agility, and overall effectiveness. Furthermore, Bhargava et al. (2013) offer an insightful definition of DSCM, characterizing it as a digital supply chain (DSC) system comprising hardware, software, and communication networks. These elements collectively support interactions among globally distributed organizations, effectively orchestrating the activities of supply chain partners. These activities encompass everything from procurement and production to storage, transportation, and sales. Additionally, Xue et al. (2013) offer a perspective that highlights the role of interorganizational systems (IOSs) within DSCM. They emphasize that firms implement these systems to digitize transactional processes and collaboration with their supply chain partners, encompassing both upstream suppliers and downstream customers. These systems serve as the backbone of DSCs, facilitating the seamless flow of information and resources.

Raj and Sharma (2014) assert in their Accenture Consulting report that the advent of digitalization holds the transformative potential to revolutionize supply chains. They argue that this transformation should be viewed through a different lens, one that envisions supply chains as digital supply networks (DSNs) instead of DSCM. These DSNs not only encompass the physical flows of products and services but also the integration of talent, information, and financial resources. In a figurative sense, these elements must journey together across the extended enterprise. This perspective stands in stark contrast to traditional or hybrid supply chains, which, as pointed out by Hanifan et al. (2014), have limited capacity to unlock new synergies, engage more deeply with customers, swiftly enter new markets, and rapidly develop and scale new offerings due to their inherent vulnerabilities. Hoberg et al. (2015) elaborate on the concept of DSCM, which encompasses a holistic organizational change facilitated by DTs such as cloud computing, 3D printing, the IoT, and big data analysis. This transformation not only reshapes how companies create value in their products but also how they interact with their suppliers, partners, and customers while competing effectively in the global market. Kinnet (2015) further defines DSC as an intelligent,

value-driven network that harnesses innovative technological approaches and analytics to generate new revenue streams and business value.

Expanding on this perspective, DSC can be characterized as a tailored integration of technologies that harmonize supply chain processes. This integration encompasses warehouse and transportation systems, RFID, advanced picking technologies, and innovative planning and scheduling systems. The primary goal is to swiftly address pain points within the supply chain, especially in an environment marked by volatile demand and elevated risks. DSCM is a multifaceted concept, and various researchers have defined it from different perspectives. Rouse (2016) characterizes DSC as a supply chain built on Web-enabled capabilities, distinguishing it from traditional supply chains that often employ a mix of paper-based and IT-enabled processes. In contrast, Cecere (2016) emphasizes DSC as a process leveraging new technologies to sense, respond, and orchestrate bidirectionally across markets, highlighting its adaptability and responsiveness. Agrawal and Narain (2018) view DSCM as the utilization of DT capabilities to process vast amounts of information, fostering collaboration and communication among supply chain partners on digital platforms. Moreover, DSC is frequently described as customer-centric, capturing and maximizing the utilization of real-time information from diverse sources. It enables demand stimulation, sensing, matching, and management, ultimately optimizing performance and minimizing risks (Khan, Hassan, et al., 2022). At its core, DSCs harness data produced by traditional supply chains, stored in data warehouses, and analyzed for insights. Researchers often emphasize the integration of DTs in enabling supply chain processes (Alzarooni et al., 2022; Kusi-Sarpong et al., 2022; Qader et al., 2022). For example, Mubarik et al. (2023) underscore the role of DTs such as cloud computing, big data, RPA, AI, and machine learning (ML) in improving decision-making within the supply chain. Lastly, Dimitry Ivanov (2023) highlights the implementation of advanced DTs, including the IoT, blockchain, ML, AI, and predictive analytics, to drive enhancements in traditional supply chains.

This diversity of perspectives underscores the evolving nature of DSCM, where the integration of DTs is central, but the specific focus and applications may vary depending on the context and goals of each supply chain.

1.4 Digital Supply Chain Management: Capabilities and Capacities

The above discussion underscores that DSCM represents a strategic approach that harnesses the power of DTs, data analytics, and real-time information to transform the supply chain into a more agile, efficient, and responsive entity. It integrates various aspects of supply chain operations, from sourcing and procurement to production, logistics, and distribution, enabling organizations to streamline their processes, reduce costs, enhance customer satisfaction, and gain a competitive edge in the global marketplace (Ivanov et al., 2019; Mubarik, Khan, Kusi-Sarpong, et al., 2023). Following are some essential nuts and bolts of DSCM.