IMPACT OF INDUSTRY 4.0 ON SUPPLY CHAIN SUSTAINABILITY

Current Status and Future Pathways

Edited by

K. MATHIYAZHAGAN

AAKANKSHA KISHORE

BEHZAD BEHDANI

HEENA THANKI

Impact of Industry 4.0 on Supply Chain Sustainability

This page intentionally left blank

Impact of Industry 4.0 on Supply Chain Sustainability: Current Status and Future Pathways

EDITED BY

K. MATHIYAZHAGAN

Thiagarajar School of Management, India

AAKANKSHA KISHORE

FORE School of Management, India

BEHZAD BEHDANI

University of South-Eastern Norway, Norway

AND

HEENA THANKI

Shri Jairambhai Patel Institute of Business Management and Computer Applications, India

emerald PUBLISHING

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 2025

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

ISBN: 978-1-83797-778-9 (Print)
ISBN: 978-1-83797-777-2 (Online)
ISBN: 978-1-83797-779-6 (Epub)

Contents

This page intentionally left blank

About the Editors

Dr K. Mathiyazhagan is the Chairperson – Research Center and Associate Professor, Thiagarajar School of Management, Madurai, Tamil Nadu. He is an Assistant Editor in Technological Forecasting and Social Change (Elsevier) – IF: 12, an Associate Editor in Business Strategy and the Environment (Wiley) – IF: 13.4, Management Decision (Emerald) – IF: 4.9 and *Environment, Development and Sustainability Journal* (Springer) with an impact factor of 4.1. He is a leading Guest Editor of special issues in *Journal of Business Logistics* (JBL), *the International Journal of Physical Distribution & Logistics Management* (IJPDLM), *the International Journal of Logistics Management* (IJLM), *Sustainable Production and Consumption* (Elsevier), and *Socio-Economic Planning Science* (Elsevier). He has also been an editorial member in many reputed journals. Also, he has been listed among the Top 2% of scientists (Stanford's list World's Top 2% of scientists). He has published in numerous journals, including IJPE, IJPR, PPC, IEEE TEM, JCP, RCR, etc., with more than 5,000 research citations. One of his papers was awarded the Excellence Citation Award by Emerald Publisher Ltd. In addition, he is editing international books on Blockchain & Lean-Green & Society 4.0 in Elsevier, Taylor & Francis, and Springer publishers. He was invited to visit Roma TRE University, Italy, in February 2023 for research collaboration and invited to visit Nottingham Trent University, United Kingdom, to organize a joint international research excellence workshop on September 7, 2023. He is an active reviewer of more than 30 reputed international journals, receiving the best reviewer certificates from reputed journals.

Dr Aakanksha Kishore is working as an Assistant Professor in the area of Operations Management at FORE School of Management, New Delhi. She is a graduate in Mathematics Honors from Sri Venkateswara College, University of Delhi, and holds a Master's degree in Operational Research from Hindu College, University of Delhi. She has a doctorate in Inventory Management from Department of Operational Research, University of Delhi. She is also CSIR-NET qualified in Mathematical Sciences in the year 2013. She is an expert in devising inventory strategies/policies for operations managers through mathematical modeling. To her credit, she has various international research publications in ABDC/SCI/SCIE/SCOPUS indexed journals viz. *Journal of Cleaner Production*, *Expert Systems with Applications*, *Process Integration and Optimization for Sustainability*, *Scientia Iranica*, *RAIRO – Operations Research*, *Control & Cybernetics*, *Mathematics*, *International Journal of Industrial Engineering Computations*, *International Journal of Services Operations and Informatics*, and *International Journal of Mathematical, Engineering and Management Sciences*, to name a few. She has also received Best Paper Awards for four of her publications. She is a recipient of "Award of Excellence in Research 2022," by *International Journal for Modern Trends in Science and Technology* in October 2022. She was also awarded "Distinguished Faculty Award" for her academic contribution in the session 2021–2022.

Dr Behzad Behdani is a Professor in Supply Chain and Operations Management at USN School of Business. He has done extensive research on some ground-breaking aspects of operations and supply chain management, among others, supply chain analytics, operations management at the early-stage innovative companies (the link between innovation/technology management and operations management), food supply chains and operation, and intermodal transport, and logistics. Behzad's research also deals with how we can embed the UN Sustainable Development Goals in the design and operations of global supply chains.

Dr Heena Thanki is working as an Associate Professor for the MBA program at the Gujarat Technological University's Shri Jairambhai Patel Institute of Management and Computer Applications (SJPI) (formerly known as National Institute of Cooperative Management) Gandhinagar, Gujarat, India. Before joining the academic and research sector, she worked at the ICICI Prudential Limited – India's leading insurance provider. She holds a PhD in Finance, a Diploma in Export–Import Management, and has completed BBA and MBA. She was awarded Junior Research Fellow (JRF) for being among the top 6% of the University Grants Commission's National Eligibility Test (UGC NET) qualified candidates. She has been extensively working in teaching, training, and research domain for over a decade and specializes in financial management, behavioral finance, research methodology, entrepreneurship, and ethics and corporate governance. Her research papers are published and presented at various national- and international-level journals and conferences. Most of her research work has also been published in top-ranked reputed journals of globally acclaimed ranking lists, such as the Australian Business Deans Council (ABDC) and Chartered Association of Business Schools (CABS). She has also won many awards for her research papers.

List of Contributors

Babangida Abdulkarim	Bauchi State University, Nigeria
Sunusi Abdulkarim	Nigerian Army University Biu, Nigeria
Abdulazeez Olamide Abdulquadri	University of Ilorin, Nigeria
Nishant Agrawal	ICFAI Business School, India
Anzar Ahmad	Graphic Era Deemed To Be University, India
Nidhi Ahuja	Amity University, India
Aamer Al-Aflak	Chandigarh University, India
K Anitha	Meenakshi Academy of Higher Education and Research, India
Sakshi Arora	Amity University, India
Fevzi Bİtİktaş	Dokuz Eylül University, Turkey
Sedat Baştuğ	Bandirma Onyedi Eylul University, Turkey
Nafiu Abubakar Babaji	Tertiary Education Trust Funds, Nigeria
R Bargavi	SRM Institute of Science and Technology, India
Abubakar Basiru	Nigerian Army University Biu, Nigeria
Parul Bhatia	Shri Vishwakarma Skill University, India
Abdelkabir Charkaoui	Hassan First University of Settat, Morrocco
Niyati Chaudhary	SGT University, India
Anass Cherrafi	Cadi Ayyad University, Morrocco
Jyoti Dhingra Darbari	University of Delhi, India
Dheeraj	Shri Vishwakarma Skill University, India
Anubhuti Dwivedi	EdMaestro Pvt. Ltd., India

Khadija Echefaj	Hassan First University of Settat, Morrocco
Said Elfezazi	Cadi Ayyad University, Morrocco
Enes EmİnogIu	Iskenderun Technical University, Turkey
Narendra Gariya	Graphic Era Deemed To Be University, India
Shanul Gawshinde	Symbiosis International University, India
Poonam Gulati	Amity University, India
Rodrigo Goyannes Gusmão Caiado	Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Brazil
Nadia Hamani	Picardie Jules Verne University, France
Zuhra Junaida Husny	Universiti Teknologi, Malaysia
Anushka Lydia Issac	Westford University College, United Arab Emirates
P.C. Jha	University of Delhi, India
Youssef Jouicha	Université de Picardie Jules Verne Saint Quentin, France
Ajay Khurana	Chandigarh University, India
Divyansha Kumar	Amity University, India
Rajesh Kumar	Himachal Pradesh University, India
Kee-Hung Lai	The Hong Kong Polytechnic University, Hongkong
Maria Evelyn Jucunda. M	Vellore Institute of Technology, Chennai, India
Umar Abdullahi Mai' Auduga	Abubakar Tafawa Balewa University, Nigeria
Maroof Ahmad Mir	Asian Business School, India
Farouk AB Mohammed	Nigerian Army University Biu, Nigeria
Sadiq AB Mohammed	Nigerian Defence Academy Kaduna, Nigeria
Yusuf Ismaila Mustapha	University of Ilorin, Nigeria
Manuela Lacerda Paiva Sampaio	Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Brazil
Parikshit	Shri Vishwakarma Skill University, India

S Preetha	Vels Institute of Science, Technology & Advanced Studies, India
Said Elfezazi	Cadi Ayyad University, Morocco
Annie Sam	Vels Institute of Science, Technology & Advanced Studies, India
Preyal Sanghavi	Som -Lalit Institute of Management Studies, India
Renan Silva Santos	Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Brazil
Amir Shaikh	Graphic Era Deemed To Be University, India
Ashwini Sharma	Graphic Era Deemed To Be University, India
Kapil Sharma	Graphic Era Deemed To Be University, India
Vishal Sharma	Himachal Pradesh University, India
Varimna Singh	K J Somaiya Institute of Management, India
Kirti Sood	Chandigarh University, India
Teresa Turzo	UnitelmaSapienza University of Rome, Italy
Kazim Yenİ	Dokuz Eylül University, Turkey
Naísy da Silva Morais	Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Brazil
Khalid Benhida	Cadi Ayyad University, Morocco
Sana Elhidaoui	Cadi Ayyad University, Morocco
Srinivas Kota	Birla Institute of Technology and Science, India

This page intentionally left blank

New-Age Digitalization Impact on Sustainability in Industry 4.0

Yusuf Ismaila Mustapha and Abdulazeez Olamide Abdulquadri

University of Ilorin, Nigeria

Abstract

This chapter explores the symbiotic relationship between digitalization and sustainability in the context of Industry 4.0. Examining key technologies such as blockchain, artificial intelligence (AI), and the Internet of Things (IoT), this chapter unveils their transformative impact on industries, emphasizing the role of data-driven decision-making, supply chain transparency, and circular economy principles. Real-world case studies illustrate successful implementations, showcasing how organizations leverage digital twins, blockchain for supply chain transparency, and extended reality for sustainable training. The regulatory landscape emerges as a crucial factor, shaping the adoption of digital technologies for sustainability, while emerging trends like 5G, edge computing, and AI promise to redefine the future. As a conclusion, policymakers are urged to strike a balance between innovation and regulation, fostering an environment conducive to responsible digital practices. Industries are encouraged to embrace emerging trends, and researchers are invited to explore the synergies between 5G, edge computing, and AI for holistic sustainability solutions. Together, these efforts aim to propel Industry 4.0 toward a resilient and sustainable future.

Keywords: Digitalization; sustainability; Industry 4.0; blockchain; artificial intelligence; supply chain transparency

1. Introduction

The term "Industry 4.0" represents intersection of digitization and manufacturing revolution that characterizes many modern industrial scenes. As coined by the German government, Industry 4.0 refers to a confluence of cyber-physical systems, Internet of Things (IoT), as well as smart information system in production

Impact of Industry 4.0 on Supply Chain Sustainability, 1–13

doi:10.1108/978-1-83797-777-220241001

process (Schwab & Sala-i-Martín, 2016). It is a step departing from the conventional ways of manufacturers, where intelligent networks are set to completely change work efficiency and effectiveness.

This transformative journey has many linchpin technologies (Manyika et al., 2015). Smart factories represent a transformation which is analogous to a form of metamorphosis due to synergies among related technologies. Until now, industry has been about silos with separate processes but low interconnectivity. Yet in the light of Industry 4.0, the vision evolves. Machines begin talking to each other and are able to exchange information within increasingly complex factory ecosystems (Lu, 2017). The transformation goes further than just the shop floor, affecting the entire value chain that involves suppliers, manufacturers, and ultimately customers within an integrated digital fabric. This transformation has nothing to do with mere technical development; it implies that the genetic code of the industrial world has changed, which requires flexibility and responsiveness. Smart factories represent the union between digital acumen in manufacturing and enhanced efficiencies as well as minimized downtimes in solving problems head-on before they arise (Wollschlaeger et al., 2017). As we traverse this juncture between tradition and transformation, Industry 4.0 beckons, not just as a technological milestone but as a harbinger of a new industrial era.

1.1 Sustainability

The idea of sustainability serves as a guide in the transformation journey in the age of digital revolution within the Industry 4.0. However, the idea goes beyond environmental concerns alone as it adopts a triple bottom line approach that encompasses the environmental, social, and economic aspects in unison for the sake of the balanced progression with accountability. Sustainability in Industry 4.0 goes beyond its previous definition. The coexistence of the collaboration between digitalization and sustainable initiatives provides an impetus for industries toward a regenerative stage. However, in this circumstance, the environmental aspect becomes a key issue. Smart technology convergence leads to efficient use of resources, reduced wastage, and energy saving (Deloitte, 2019). By adopting smart grids and predictive maintenance in wastage of resources, Industry 4.0 combines technical excellence with sustainable environment. In a nutshell, social sustainment in context with Industry 4.0 enriches a tapestry of inclusiveness and ethics. In the fabric of the economy where digitization is becoming a common phenomenon, issues that touch on human-centered workspaces and fair sharing of technology benefits must be taken into consideration (Buckner, 2019). This paradigm is illustrated by collaborative robots referred to as cobots that work together with people to increase productivity and create an environment that remains kind to workers.

Sustainability acts as a key factor of economic viability in the long run. The integration of digital technology and sustainability practice is not only just moral but also economical. Profitable returns are obtained through operational cost reductions, increased efficiency, and a better image for the organization as a result of investing into sustainable approaches that are supported by Industry 4.0 technologies (Kagermann, 2014). Thus, Industry 4.0's approach to economic development must balance these two opposing poles if it is to be economically viable. Unfolding of Industry 4.0, it calls on industry to imagine their place in a world that looks toward future rather than past where sustainability and achievement are no more mutually exclusive but the same path. Sustainability does not act as optional adornment for eco-resistance and social justice. Rather, these are the same threads that produce the pattern of sustainability within Industry 4.0.

2. New-Age Digitalization

The New-Age Digital Revolution is the modern and advancing methods of integrating the latest digital technology into business, society, and daily life (Gupta et al., 2020). This encompasses the utilization of technologies including, but not limited to, artificial intelligence (AI), IoT, big data analytics, cloud computing, and other disruptive technologies to impact on systems, services, and interactions.

On the contrary, sustainability is when the present generation meets its needs in a way that does not deprive future generations the opportunity to meet their own needs (Elsawy & Youssef, 2023). It emphasizes the wise and proper application of resources, attention to environmental consequences, and the encouragement of social and economic sustainability to create a system that is both peaceful and everlasting. Industry 4.0, often referred to as the Fourth Industrial Revolution, is a concept that incorporates the use of digital technologies, the IoT, and cyber-physical systems into manufacturing and industrial processes. It makes smart technologies to enable integration and flexibility in industrial sector. The Industry 4.0 term was introduced by the German governing body as part of the High-Tech Strategy for 2020. Schwab (2017) said in his book that "The fourth industrial revolution which involves AI and machine learning as well as robotics, nanotechnology, 3D printing and genetic engineering and biotechnology" will cause significant changes not only to business models but also to labor market over the next five years.

3. Smart Manufacturing and Resource Efficiency

The evolution toward smart manufacturing heralds a departure from the conventional, often resource-intensive, production methodologies. Digitalization becomes the catalyst, imbuing machinery with a cognitive layer that not only facilitates automation but orchestrates a symphony of resource optimization. The real-time connectivity afforded by IoT allows machines to communicate seamlessly, enabling a dynamic response to production demands while minimizing resource wastage (Rüßmann et al., 2015). At the heart of this transformation are sensors, acting as the sentinels of efficiency. They permeate the manufacturing landscape, monitoring variables ranging from temperature to energy consumption. These sensors, in concert with IoT, create a responsive ecosystem where machines adapt to fluctuations in demand, ensuring that resources are allocated with precision, reducing excess and curbing waste (Monostori et al., 2016). Data analytics emerge as the alchemist in this digital crucible, transforming raw data into actionable insights that redefine resource utilization strategies. Advanced analytics algorithms, powered by AI, scrutinize vast datasets generated by sensors and IoT devices. Through predictive maintenance and process optimization, they not only identify potential inefficiencies but also prescribe adaptive measures to enhance resource efficiency (Schwab, 2017).

The digital symphony of smart manufacturing orchestrates an intricate ballet where every movement is calibrated for maximum efficiency. Whether it's the predictive maintenance of machinery, the real-time adjustment of production parameters, or the optimization of supply chain logistics, Industry 4.0 technologies synergize to minimize resource consumption while maximizing output. In this epoch of smart manufacturing, resource efficiency ceases to be an aspiration and becomes an intrinsic characteristic. The amalgamation of IoT, sensors, and data analytics transforms the manufacturing floor into a sentient entity, where every process is not just automated but refined, ensuring that each resource is utilized judiciously, resonating with the ethos of sustainable and efficient production.

3.1 Digitalization Creating Transparent and Sustainable Supply Chains

Imagine a world where you can trace the journey of a product from the factory to your hands. Digitalization makes this possible by bringing transparency and sustainability to supply chains.

- *Real-Time Visibility:* Digital tools, like sensors and IoT devices, act as the eyes and ears of the supply chain. They provide real-time information about the movement of goods, temperature conditions, and other crucial details. This transparency helps in identifying inefficiencies, reducing waste, and ensuring products are handled with care (Wamba et al., 2017).
- *Data Magic:* With digitalization, a massive amount of data is generated at every step of the supply chain. Big data analytics and AI swoop in to make sense of this information. This data magic helps in predicting demand, optimizing routes, and minimizing the environmental impact of transportation (Ivanov, 2020).
- *Collaboration Spells:* Digital platforms enable seamless collaboration between different players in the supply chain – from manufacturers to suppliers to distributors. This collaborative magic ensures that everyone is on the same page, working together toward sustainability goals (Touboulic & Walker, 2015).

In the digital age, supply chain sustainability is not just a buzzword; it is a transformative journey.

3.2 Data-Driven Decision-Making for Sustainability

In the dynamic landscape of sustainability, data-driven decision-making powered by analytics and AI emerges as a potent tool, guiding industries and policymakers toward informed and impactful choices. The following are some of the importance of data analytics and AI:

- *Insights from Data Magic:* Imagine data as a treasure trove brimming with valuable insights. Data analytics employs intelligent tools to sift through this treasure, discerning patterns, trends, and meaningful information. AI, acting as a layer of intelligence, facilitates learning from the data, enabling systems to make predictions (Manyika et al., 2015). The city of Helsinki exemplifies the application of data analytics to improve energy efficiency in its buildings. By analyzing data on energy consumption, weather patterns, and building usage, the city optimized heating and cooling systems, resulting in substantial energy savings and a noteworthy reduction in the city's carbon footprint (Duman et al., 2021).
- *Precision and Proactivity:* Sustainability decisions demand precision and foresight. Data analytics and AI contribute to a level of precision that empowers stakeholders to comprehend the current landscape, forecast future trends, and proactively plan interventions to enhance sustainability (Caragliu et al., 2013). Agriculture undergoes a transformation through data-driven decision-making. Farmers leverage sensors, satellite imagery, and AI to gather data on soil conditions, crop health, and weather patterns. This data-driven approach enables optimized irrigation, reduced pesticide use, and improved overall agricultural sustainability (Miao et al., 2018).
- *Optimizing Resource Use:* Organizations cannot enhance what they do not measure. Data-driven decision-making allows industries to measure and optimize resource use, a critical aspect for achieving sustainability goals. Whether it involves reducing energy consumption, minimizing waste, or optimizing supply chain logistics, data-driven insights play a pivotal role (Manyika et al., 2015). Singapore's smart waste management system is a testament to the effective use of data analytics. Sensors in waste bins monitor fill levels, and the resulting data are analyzed to optimize waste collection routes. This data-driven decision-making has led to reduced fuel consumption and greenhouse gas emissions associated with waste collection in the city (Woo, 2023).

By harnessing the power of data analytics and AI, organizations and cities are not only making better decisions but also contributing to a more sustainable and resilient future.

3.3 Role of Technologies in Shaping Sustainability

- *5G for Connectivity and Efficiency:* The development of a 5G network is expected to revolutionize the entire connectivity landscape. The IoT will be able to provide faster and reliable communication that will lead to electronic devices being seamlessly integrated and thus facilitating in the collection and analysis of data. These connections are important for real-time monitoring and control and use resources with the minimum wastage, thereby contributing to the entire sustainability efforts (Mohammad et al., 2021).

- *Edge Computing for Real-time Decision-Making:* Edge processing, which refers to real-time processing of data from the source (i.e., on the edge of the network), enables faster decision-making. This is especially relevant for deployments that need prompt reactions, for instance, predictive maintenance and energy management. Edge computing reduces the time-delay, increases efficiency, and does its best to support green practices.
- *Artificial Intelligence for Smart Decision-Making:* AI, fueled by machine learning and advanced analytics, plays a central role in making sense of vast datasets. In sustainable industries, AI can optimize processes, predict resource needs, and automate decision-making for maximum efficiency. For example, AI algorithms can optimize energy consumption, reduce waste, and enhance overall operational sustainability (Schwab, 2017).

The future of digitalization for sustainability is exciting and holds great promise. Emerging trends, coupled with the integration of technologies like 5G, edge computing, and AI, are poised to transform industries. As organizations embrace these advancements, they have the opportunity to not only optimize operations but also contribute to a more sustainable and resilient global future.

3.4 Challenges and Risks of Adopting Digitalization

As industries embark on the digitalization journey to enhance sustainability, they encounter a spectrum of challenges and risks that necessitate careful consideration and proactive management (See Table 1.1).

3.5 How to Overcome These Challenges

As industries embark on the transformative journey of digitalization to bolster sustainability, a myriad of challenges and associated risks surfaces, demanding meticulous consideration and proactive management.

One critical challenge lies in the realm of data security and privacy concerns. The amplification of digital technologies results in the prolific generation and utilization of vast data sets, raising apprehensions about the collection, storage, and sharing of sensitive information. Li et al. (2019) assert that unauthorized access, data breaches, or misuse of personal and business data pose significant risks, jeopardizing stakeholder trust and potentially leading to legal consequences and reputational damage.

Another formidable challenge stems from the environmental impact of digital technologies. While these technologies promise sustainability benefits, their production, usage, and disposal contribute to the carbon footprint. The paradox lies in the potential environmental consequences of the very technologies designed to foster sustainability (Belkhir & Elmeligi, 2018). Without careful management, the

Table 1.1. Challenges and Risk of Adopting Digitalization.

Indicators	**Challenges**	**Risk**
Data Security and Privacy Concerns	The fast-growing dependence on digital technologies leads to the production and use of overwhelming data sets. However, gathering, preserving, and propagating sensitive data evokes data security and privacy concerns which were profoundly talked by various scholars. For example, Smith et al. (2019) stress that between technological advancements and data security, there is a fine line, and the latter is badly needed nowadays. This issue is in harmony with the study of Levine et al. (2024), in which the ethical dilemmas of data collection are addressed, and the importance of securing digital privacy is highlighted.	The risks associated with unauthorized access and data breaches as well as the misuse of personal and business data are substantial. These threats not only jeopardize stakeholders' trust but also may culminate into legal and reputation consequences that can befall the organizations involved (Yang et al., 2020). Such repercussions are underscored by literature since researches show possibilities of legal and reputation implication caused by breaches in data security (Yang et al., 2020). The authors' notions parallel the findings of Johnson et al. (2021), who focuses on the data breaches' complexity and their impact on organizational trust and reputation.
Environmental Impact of Digital Technologies	Sustainability advantages, offered by the digital technologies, may be not without environmental consequences in terms of their production, utilization, and disposal. Electronic devices production, data centers energy consumption, and electronic waste generation	The paradox of digital sustainability arises from the potential detrimental environmental effect of the technologies created to foster sustainability. The uncontrolled advancement in digitalization can exacerbate the depletion of resources and worsen environmental degradation

(Continued)

Table 1.1. *(Continued)*

Indicators	Challenges	Risk
	are carbon footprints' factors. One example is that Rusinko (2007) highlights the environmental consequences of electronic product manufacturing and advocates for sustainability in the technology field.	(Belkhir & Elmeligi, 2018). This paradox serves as a leading theme in present-day literature according to Belkhir and Elmeligi (2018), who focus on the complex interconnection between digital technologies and unplanned environmental outcomes.
Interoperability and Standardization	The integrated use of diverse digital tools and platforms – either within or between organizations – is complex, mainly due to issues such as interoperability and the absence of standardized frameworks. This complexity in digital integration has been well discussed by the literature. As such, Kerber and Schweitzer (2017) highlight the challenges of organizations fostering interoperability among disparate digital tools and thus the need for standardized procedures.	The integration of data and information across supply chain is hindered by incompatible systems, being an obstacle for the efficiency of digitalization initiatives. The literature is abundant with implications of such inoperability. For example, Zhang et al. (2017) identify how incompatibilities can cause inefficiencies, high costs, and opportunities for sustainability improvements. Tiwari (2021) extends this, pointing to the wider implications of interoperability issues in the supply chain, underscoring the necessity for integrated digital systems that ensure process optimization and sustainability objectives.
Resistance to Change	The transformation to a digitalized and green system principle requires	The effective realization of digitalization strategies within an organization