INNOVATING SUSTAINABLE SUPPLY CHAINS IN INFORMATION TECHNOLOGY INDUSTRY

BY

VIRAJ P. TATHAVADEKAR

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BY

VIRAJ P. TATHAVADEKAR

Supervised by

Dr. Aleksandar Erceg, Ph.D

APPROVED BY

J. Buljubasic

_____

Dissertation chair : Dr. Aleksandar Erceg, Ph.D

RECEIVED/APPROVED BY:

Renee Goldstein Osmic

_____

Admissions Director

Dedication

This research work is dedicated with profound gratitude and love to the individuals who have been instrumental in shaping my academic journey and personal growth.

To my beloved parents, whose unwavering support, endless sacrifices, and constant encouragement have been the foundation of my educational pursuits. Their belief in the power of knowledge and their tireless efforts to provide me with opportunities have made this achievement possible.

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Finally, this work is dedicated to future generations who will inherit our planet. May this research contribute to building more sustainable and responsible supply chains that balance economic growth with environmental stewardship and social responsibility in the ever-evolving information technology lands

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ABSTRACT

INNOVATING SUSTAINABLE SUPPLY CHAINS IN INFORMATION TECHNOLOGY INDUSTRY

Viraj P Tathavadekar

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Dissertation Chair: Dr. Aleksandar Erceg, Ph.D., SSBM

This study looks at how to make the supply chains of the Information Technology (IT) industry more environmentally friendly, with a focus on how digital transformation and including stakeholders may help. As global supply chains get more complicated and harmful to the environment, IT firms are under more and more pressure to use sustainable supply chain management (SSCM) techniques that find a balance between making money and being responsible for the environment and society. The study looks into how technologies like AI, blockchain, and the IoT may make IT supply networks more open, efficient, and ethical. The study also looks at how circular economy models, corporate social responsibility, and national and international laws affect sustainability efforts. We used a mixed-methods approach, which included both qualitative interviews and quantitative analysis with SPSS and MS Excel. The data was looked at using methods like mean, standard deviation, regression, and correlation. The results show that big IT companies are making good progress, but small and medium-sized businesses (SMEs) are still having trouble since they don't have the resources and the rules aren't always clear. The study ends with a proposed framework that shows the drivers, impediments, and strategic enablers that the IT sector needs to create sustainable supply chains.

Keywords :

Sustainable Supply Chain Management (SSCM), Information Technology Industry, Artificial Intelligence (AI), Blockchain, Circular Economy, Corporate Social Responsibility (CSR), SPSS, Stakeholder Engagement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

IT	Information Technology
SSCM	Sustainable Supply Chain Management
IoT	Internet of Things
CE	Circular Economy
SCM	Supply Chain Management
AI	Artificial Intelligence
TBL	Triple Bottom Line
DOI	Diffusion of Innovations
RBV	Resource Based View
TRA	Theory of Reasoned Action
TPB	Theory Of Planned Behaviour
DSCC	Digital Supply Chain Capabilities
GSCM	Green Supply Chain Management
GIS	Geographic Information Systems
SCRM	Supply Chain Risk Management
CSR	Corporate Social Responsibility
SME	Small and Medium Enterprises
KPI	Key Performance indicators
ROI	Return on Investment
EPR	Extended Producer Responsibility

INTRODUCTION

1.1 Introduction

The Information Technology (IT) industry has changed rapidly and become a major player in the world's economy. It helps greatly in making society more digital, connected, automated, and integrated worldwide. IT powers production in hardware, programming for software, building cloud facilities, and providing digital services for modern civilizations (Tebaldi et al., 2018). Since digital infrastructure is more important than ever, the IT supply chain has become much bigger and more difficult to handle. The flow of resources, shared information, and commerce from one country to another depends on many suppliers, vendors, logistics providers, recyclers, and consumers involved in the supply chain (Dao et al., 2011).

However, as the sector keeps developing, it is causing more damage to both the environment and social concerns. Among the issues that arise in IT supply chain operations are the collection of rare earth elements, energy-heavy data centers, the release of greenhouse gases, workers treated unfairly in factories, and more electronic waste (e-waste) (Seuring and Müller, 2008; Frey et al. 2013). Such concerns require us to use eco-friendly and circular approaches instead of the usual step-by-step supply chain approach (Saberi et al., 2019).

In IT, Sustainable Supply Chain Management (SSCM) means using sustainable ideas in every part of the supply chain, like sourcing, production, transportation, keeping, and end-of-life treatment. Some of the principles guiding these companies are cutting down environmental damage, preserving resources, ensuring good labor conditions, and promoting openness and accountability (Ageron et al., 2013). Unlike other ways of thinking, SSCM makes people, planet, and profit the basic guidelines for operating a company (Green et al., 2012). In this way, it is clear that ethics and strategy go hand in hand in today's aware global market.

Developments occurring around the world are forcing IT suppliers to focus on sustainability. First, the rising issue of climate change has caused people and organizations to rethink the effects of industrial activity. SDGs set by the United Nations, mainly Goal 12 and Goal 13, push firms to change their activities so they meet global sustainability requirements (Junaid et al., 2022). Also, brands that keep the environment and society in mind are attracting a bigger crowd

of consumers and investors. If a company does not meet the compliance requirements, it can suffer from a bad reputation, heavy fines, and lower ranking in the market (Piprani et al., 2023).

Third, thanks to new digital tools, there are now more ways to work on sustainability. New technologies may drastically improve how supply chains function by making the overall process more transparent, traceable, and flexible, as suggested by Saberi et al. (2019) and Zhang and Xie (2022). As an example, recordkeeping on the blockchain allows products to be checked for ethical sourcing. Sensors in the IoT can measure and monitor energy usage and trash production whenever it occurs. AI can be used to develop methods that help logistics companies find the best routes to cut fuel expenses and save the ecosystem from pollution (Feng and Jalali, 2024). They play a major role in supporting a resourceful, responding, and durable supply chain framework.

Yet, it is obvious that there is a lack of implementing SSCM ideas in IT organizations. Though big multinational firms have been successful in becoming more sustainable, SMEs are still behind because they lack adequate funds, knowledge, and market opportunities (Setiawan et al., 2023). Besides, since there are no universal regulations across the world and most standards are not the same, along with fragmented supply chains, it is difficult to spread sustainable practices (Pinto et al., 2019).

Along with these outside problems, there are also big problems inside the organisation that make it hard to adopt SSCM. These include resistance to change, a lack of commitment from managers, and a lack of alignment between sustainability goals and business strategy. Many businesses still see sustainability as something they have to do to stay in business, not as a chance to innovate or make money (Li and Li, 2022). Because of this, sustainability projects are typically on the sidelines, not getting enough money, or not connected to the main supply chain activities (Liu et al., 2017). The circular economy (CE) is one of the basic ideas that makes the IT supply chain sustainable. The CE model is different from the old "take, make, dispose" approach in that it focusses on closed-loop systems where materials are reused, recycled, or repurposed. This cuts down on waste and makes products last longer (Geissdoerfer et al., 2017). In the IT sector, CE techniques include remanufacturing of electronics, refurbishing of equipment, reverse logistics, and design for disassembly all of which assist reduce environmental consequences and dependency on finite raw materials. To correctly use CE principles, products and processes must be redesigned, and all players in the supply chain ecosystem must work together (Lieder and Rashid, 2016).

The circular supply chains for IT products play an important part in creating a greener and healthier economy. So, for example, European laws on Extended Producer Responsibility (EPR) require manufacturers to accept old electronics and process them in a safe and responsible way. Because of these policies, businesses are reviewing their supply chain procedures, giving more importance to lifecycle analysis, energy-saving steps, and managing the products they offer. But if enforcement of such laws is weak or you can't find them in a region, the progress of CE projects is usually driven by corporations and businesses, which might not offer very strong incentives.

Together with CE principles, laws and regulations are important in creating a sustainability strategy for IT supply chains. Since international supply chains cover several countries, companies have to comply with different laws, rules, and guidelines from each nation. Even though these frameworks lay out important ideas, the implementation of their goals at the national and regional level can be very different (Testa et al., 2012). Due to this fragmentation, it is not easy for multinational IT companies to use the same sustainability approaches in all their global workplaces.

In many developing countries, since the rules for environmental protection are not strict or are not always properly enforced, the environment suffers, leading to pollution and unsafe labor (Ali et al., 2020). Still, countries like the European Union have tight rules about energy, emission, e-waste disposal, and ethical sourcing(Ali et al., 2020). Therefore, the main problem is finding a way to join these many regulations so that sustainability can be managed consistently. Any company that matches its own strategies to both world targets and the rules in different countries will likely have better success with SCM.

Also, many organizations do not have clear sustainability governance, which also makes it difficult to carry out SSCM. Most IT companies are still treating sustainability as administrative or public relations duty instead of considering it for key decisions that guide the company (Gopalakrishnan et al., 2012). Most of the time, sustainability managers are detached from teams in logistics, procurement, and production, which adds to the difficulties of sustaining sustainability through the supply chain. The organization's culture and structure have to change, so that it easily unites different departments, uses trustworthy data, and consistently focuses on producing benefits for the community and environment over a long period (Hart and Dowell, 2011).

Observing Apple, Dell, and HP among the biggest IT companies, it is clear that support from leaders and original ideas from below are both needed for a successful SSCM program. As a result, Apple's program with its suppliers guides them towards cleaner energy, an example of a large firm urging businesses in its network to become sustainable. Likewise, Dell's initiative ensures that plastic from old electronics is used in making their new products. This proves that allocating enough effort to sustainability allows a company to achieve both an edge in the market and a different identity (Chen, 2008).

Yet, most IT supply chains consist mainly of many small and medium businesses that usually cannot afford to adopt advanced ways to make their operations more sustainable. Because they lack economies of scale, appropriate staff, and advanced tools, the smaller players end up facing harder challenges related to sustainability (Delai and Takahashi, 2011). It is important to use incentives, training schemes, and information sharing to advance these firms' progress.

The social side of sustainability, which deals with labor rights, safety at work, equality between genders, and involvement of communities, should also be considered. Several reports have noted that working conditions in Southeast Asia's electronics factories are unfair, mainly because low-cost workers are in demand there (Crane et al., 2008). To face these obstacles, SSCM should cover not only ecological benefits, but also justice and equity in the whole supply chain. Businesses should not rely only on past ways of checking accountability and should embrace new, transparent, and engaging actions in social responsibility (Marshall et al., 2015).

Basically, securing sustainable supply chains for IT businesses involves factors from technology, policy, economics, and society. Even though more people are aware and technology is better, the process toward 100% implementation is still complex and does not always go in a straight line

(Saberi et al., 2019). If businesses and countries focus on sustainability alone, the results are not going to be optimal. an approach that unites different elements and brings different groups together to use technology, clear policies, and new organizational arrangements to achieve real results is needed.

The adoption of Artificial Intelligence (AI), blockchain, and the Internet of Things (IoT) in IT has greatly advanced sustainable ways of working within the supply chain. The use of these technologies helps businesses to track data in the moment, disclose important information, and use forecasting models to use fewer resources, watch over the environment, and avoid any unethical aspects (Saberi et al., 2019). For example, using a blockchain traceability system, companies can follow their raw materials and make sure they comply with the environmental and labor rules in other countries. In much the same way, AI-based methods can help determine demand, prevent overworking production systems, and save energy in supply chain tasks and manufacturing (Kamble et al., 2020).

Still, the use of artificial intelligence is not the same everywhere, especially for small- and medium-sized IT companies. Because these organizations have to pay a lot, lack certain skills, and worry about security risks, they are held back from using digital sustainability tools (Piprani et al., 2023). Further, for these technologies to be successful, besides the right infrastructure, there must be changes in the organization, cooperation between different parts, and a focus on sustainability objectives (Gligor et al., 2015).

Another valuable factor in having sustainable IT supply chains is when stakeholders work together. Sustainability can be achieved through teaming up with suppliers, regulators, customers, and civil society for solutions, standards, and new ideas. It is suggested in studies that working together as a group leads to better results for both the environment and society, especially when the group shares information, uses joint certifications, and has open ways of sharing information (Vachon and Klassen, 2006).

To sum up, for the IT industry, sustainable supply chains can be achieved by blending digital ideas, shared teamwork, and prominent organization. It is clear that sustainability helps in the success and reputation of companies, yet many problems must be addressed to make sure these benefits are felt everywhere. The objective of this dissertation is to clarify these issues by pointing out main

drivers, barriers, and elements that encourage the use of SSCM in IT, providing useful advice and a roadmap for broadening its use.

1.2 Research Problem

The field of IT is both very vibrant and undergoing fast changes within the world's economy. It introduces new concepts in each sector, helps grow the digital market, and impacts today's societies. Still, the increase in this sector is based on a supply chain that is complex, takes lots of resources, spans many countries, employs numerous workers, and makes a big difference in society and its surroundings (Green et al., 2012; Feng and Jalali, 2024). Such networks are usually spread worldwide and heavily broken into different pieces. Many steps are part of the work, including getting the materials, building parts, developing programs, making systems, shipping items, and looking after products when they are finished (Le et al., 2022). Because of these complex systems, companies struggle to maintain sustainability by using more resources than needed, releasing destructive levels of carbon, throwing out a lot of e-waste, treating their workers poorly, and not being able to see the whole chain of production (Junaid et al., 2022). So, IT companies must work on making their supply chains open, effective, and durable as early as they can.

Increasingly, governments, customers, and international groups are prompting IT companies to act according to the SDGs and come up with better ways to govern their supply chains. With the help of AI, Blockchain, and IoT, supply chains may become more transparent, simple to oversee, and efficient (Saberi et al., 2019). To adopt the CE principles, IT companies are encouraged to give up on linear supply chains and switch to recycling and using resources efficiently to reduce waste (Seuring and Müller, 2008).There are still issues to deal with even after the changes. IT organisations, mainly SMEs, find it hard to adopt sustainable practices because they have to deal with money, the technology they use, and problems with organisation (Setiawan et al., 2023). There are not many detailed investigations on how to put digital technology and law together to improve sustainable computing supply chains (Piprani et al., 2023).

The purpose here is to address these issues by studying how digital tools, getting buy-in from stakeholders and effective rules can help improve sustainability in the IT supply chain. The reason for the study is to share understanding and strategies with those in charge or working in the IT sector that will lead to improved IT supply chains for our economy, people, and the environment.

1.3 Purpose of Research

The study aims to look into how the IT industry can change its supply chain from traditional ways to more environmentally friendly digital approaches. It looks into the use of AI, blockchain, and the IoT in the supply chain to improve sustainability in the fields of the environment, society, and the economy. The study mainly looks at the problem of SMEs and identifies the barriers that prevent them from adopting sustainable techniques. By gathering data and analyzing it with numbers, the research attempts to highlight significant successes and problems, and comes up with a plan in line with world standards. The aim is to build up IT supply chains that are both solid and ethical.

1.4 Significance of the Study

It matters greatly to both academics, the private sector, and policy developers since it concerns digital change along with sustainable supply chain management in the IT industry. In academics, the theory explains how blockchain and other modern technologies could improve sustainability among global supply chains. With these technological tools included in the SSCM approach, the study gives new ideas to a small body of literature on using technology and data to support sustainability in IT supply chains.

This study provides a detailed framework and is backed by research designed to analyze information collected by surveys and using regression and factor analysis. Opting for these approaches strengthens the study and makes it possible to draw findings that apply to many SMEs dealing with budget issues and following regulations. Having different kinds of respondents in the supply chain helps make the findings based on real-world experience.

Policy experts can benefit from the knowledge in this study to form recommendations for setting equal environmental laws and offering unique incentives to IT companies. With global ESG rules being imposed more frequently, this study shows how to develop regional and national policies in support of sustainability.

On the whole, this study promotes creating sure, ethical, and environmentally friendly IT supply chains by bringing together theory, practical reality, and following research protocol.

1.5 Research Purpose and Questions

The research seeks to discover and develop new approaches to guarantee the sustainability of supply chains in the IT industry. Lately, IT has come under pressure from different directions to make its operations more sustainable. The main causes of these pressures are increasing worries about harm to the environment, running out of resources and ethical issues in global commerce. As a result, IT companies are choosing to use AI, Blockchain, IoT, and CE ideas to promote clear business operations, top effectiveness, and a lasting impact.

It aims to fill some of these knowledge gaps with an investigation on how using both technology and well-made policies with joint effort from all parties can strengthen and sustain the IT sector's supply chains. Therefore, this research intends to give useful knowledge and directions that industry can use and inform policymakers.

Research Questions

Research Question 1: What are the current sustainability practices implemented within IT supply chains, and what key barriers hinder their effective adoption and execution?

Research Question 2: What are the primary drivers influencing IT companies to adopt sustainable supply chain practices, including regulatory mandates, market demands, technological advancements, and organizational values?

Research Question 3: How can emerge digital technologies specifically AI, Blockchain, and IoT enhance transparency, traceability, and operational efficiency in IT supply chain management?

Research Question 4: What is the role of national and international regulatory frameworks in shaping sustainable supply chain practices within the IT sector, and how do these frameworks support or constrain implementation?

Research Question 5: What practical strategies and frameworks can be developed to assist IT companies in overcoming existing sustainability challenges and fostering continuous improvement in supply chain sustainability?

These research questions are directly aligned with the study's objectives and are designed to ensure a comprehensive exploration of both the theoretical and practical dimensions of sustainable supply chain management in the IT industry.

REVIEW OF LITERATURE

2.1 Overview

Sustainable supply chains represent a critical notion in organisational performance management and corporate governance, particularly within the IT sector (Dao et al., 2011). The challenges of climate change, natural resource depletion, and environmental pollution compel businesses and companies to mitigate their production's environmental impact while maintaining profitability. The IT sector, characterised by its dynamism, worldwide reach, and substantial investment, has recognised the necessity of integrating sustainability into supply chain management. Moreover, addressing the environmental impact enhances the sustainability and efficacy of future corporate processes. Li and Li (2022) proposed that green IT supply chain value networks are increasingly sustainable through the adoption of sophisticated technologies that reduce waste, enhance environmental conservation, lower emissions, and improve energy efficiency. Such activities are crucial for establishing a necessary equilibrium between the utilisation of contemporary technologies and environmental protection. The increasing significance of green technology and innovation amplifies this necessity, rendering the transition more urgent. The supply chain for contemporary IT companies has emerged as a critical sector that necessitates optimisation via enhanced and more efficient procurement of required materials through the implementation to emerging innovations including AI, blockchain technology, and IoT. Shan et al. (2020) propose that enhancing interconnectivity through collaboration among supply chain participants enhances both operational and sustainability performance. This emphasis signifies novel methodologies in contrast to previous practices and policies that tackle impending sustainability challenges. Thus, fostering innovation can allow organisations to identify novel methods to reduce environmental impact or comply with stringent regulatory standards (Saberi et al., 2019).

The necessity to address social sustainability (SS) in the information technology sector is elucidated by the unique potential and challenges inherent to the industry. The IT industry has elevated obsolescence rates in production technology, substantial resource requirements, and complex supply chains. Surmounting these problems through sustainable practices enhances not

just the company's viability but also its adaptation to societal demands. Frey et al. (2013) assert that implementing sustainable management in IT supply chains enhances confidence among stakeholders, elevates brand image, and ensures sustained profitability. This literature analysis aims to examine the essential elements of sustainability and innovation as pivotal forces transforming the IT supply chain.

2.2 Scope of the Review

This literature review focusses on analysing and synthesising academic perspectives on "SSCM in the IT domain", particularly regarding for incorporation to innovation, circular economy practices, digital transformation, and risk mitigation strategies. The review encompasses a diverse array of peer-reviewed journal articles, empirical investigations, systematic literature reviews, and conceptual papers published predominantly during the past decade, so guaranteeing that the analysis is contemporary and indicative of the latest advancements in the field. The review encompasses various thematic domains, including the impact of nascent innovations on facilitating sustainability within supply chains; the implementation for sustainable supply chain techniques (eco-design, green procurement); and the significance of knowledge transfer and collaboration in improving sustainability outcomes. Furthermore, it examines circular economy models, supply chain resilience and risk management tactics, as well as performance evaluation frameworks relevant to IT-centric supply chains.

The assessment includes worldwide perspectives, focussing on both developed and emerging markets to highlight differences in policy, infrastructure, and industry development. The primary emphasis is on the IT industry, although insights are occasionally derived from related sectors, such as electronics and manufacturing, when they provide transferable ideas or reveal pertinent gaps in IT supply chains. The evaluation intentionally focusses on sustainability, innovation, and resilience within the IT sector, rather than encompassing all facets of general supply chain management. It also circumvents conversations centred solely on technical or engineering aspects of IT systems unless they are clearly pertinent to SSCM results. This focused scope guarantees the pertinence and utility of findings to the study objectives, which seek to cultivate a conceptual comprehension and pragmatic solutions for creating sustainable supply chains in information technology.

2.3 Theoretical Framework

Theoretical frameworks constitute the foundation of academic study, providing organised viewpoints for interpreting occurrences, directing inquiry, and facilitating hypothesis formation. This study, which examines the innovation of sustainable supply chains in IT sector, utilises a theoretical framework that offers a conceptual basis for comprehending the strategic integration of sustainability into supply chain activities. This framework leverages current theories to elucidate organisational behaviour, strategic resource utilisation, and institutional impacts, reflecting the complex facets of sustainability, including environmental, economic, and social aspects. It integrates the Triple Bottom Line (TBL) framework to assess sustainability results, the Resource-Based View (RBV) to investigate internal competencies and technological advancements, Stakeholder Theory to address the expectations and impact of diverse stakeholders, and Institutional Theory to consider regulatory and normative influences. Collectively, these viewpoints create a thorough framework for examining the intricate relationship between innovation, sustainability, and supply chain performance within the IT sector.

2.3.1 Triple Bottom Line (TBL) Framework

"Industry 4.0" signifies the 4th industry revolt, which is defined by the integration of contemporary technology such as AI, IoT, and automation into manufacturing procedures (Vlachos et al., 2023). In the current age of the fourth industrial revolution, production plants are transforming to smart and networked systems, allowing equipment and procedures to communicate and collaborate seamlessly -within real-time**.** The concept of the TBL emerged in response to administrative challenges, providing a structure for evaluating effectiveness that goes beyond economic indicators by incorporating environmental and social factors (Jum'a., et al 2022). The TBL framework essentially focusses economic viability, including attributes like -profitability and operational efficiency**.** The TBL framework underscores the importance of the social dimension, prompting manufacturers to implement proactive methods to tackle social challenges, such as fostering equitable labour practices, creating inclusive workplaces, and participating in community development efforts. Ultimately, by integrating the environmental dimension, the TBL framework evaluates how manufacturers might enhance the ecological ramifications of manufacturing operations, including resource extraction, production methodologies, product disposal, and end-of-life concerns (Mangla et al., 2024).

The application of the fourth industrial revolution is characterised by the utilisation of sophisticated technologies that enhance effectiveness, efficiency, and environmental responsibility for manufacturing procedures (Faisal, 2023). Industry 4.0 enables the deployment of savvy, interconnected systems that utilise IoT sensors and data analytics to monitor and optimise energy consumption in industrial activities, hence decreasing greenhouse gases and energy costs (Chavez et al., 2023). The proactive upkeep and continuous tracking capabilities of Industry 4.0 technology systems can diminish breakdowns in equipment, hence improving resource utilisation and providing both environmental and economic benefits from industrial operations. Furthermore, the incorporation of automation and robotics technologies optimises industrial processes, enhancing production levels and augmenting product quality (Duman and Akdemir, 2021).

In real time data analysis improves decision-making processes, management of inventory, SC logistics, and production planning, potentially resulting in lower operating costs, greater profitability, and increased market competitiveness. The advent of collaborative robots and artificial intelligence technologies can automate hazardous and repetitive tasks, hence reducing the likelihood of workplace accidents and injuries. Furthermore, augmenting individuals' competencies to interact with sophisticated technologies might elevate job contentment and foster personal development. I4.0D improves overall workforce well-being and job security by fostering safer and more pleasant working environments, resulting in enhanced social performance (Mukhuty et al., 2022). The application of I4.0D in the manufacturing sector has several benefits, although it may also negatively affect TBL's performance. A concern is the replacement of human labour by automation and robotics, resulting in job loss and probable societal upheaval (Satyro et al., 2022).

Moreover, the use of sophisticated technology necessitates substantial financial investments, presenting economic difficulties for producers. The dependence on interconnected systems and technological infrastructure engenders cybersecurity risks, such as unlawful access to sensitive information and intellectual property theft, hence jeopardising economic and societal dimensions (Sahoo and Upadhyay, 2024).

Figure 1: Triple Bottom Line Euler Diagram

Source-: https://blog.infodiagram.com/wp-content/uploads/2021/09/Triple-Bottom-Line-Euler-Diagram-1024x576.png
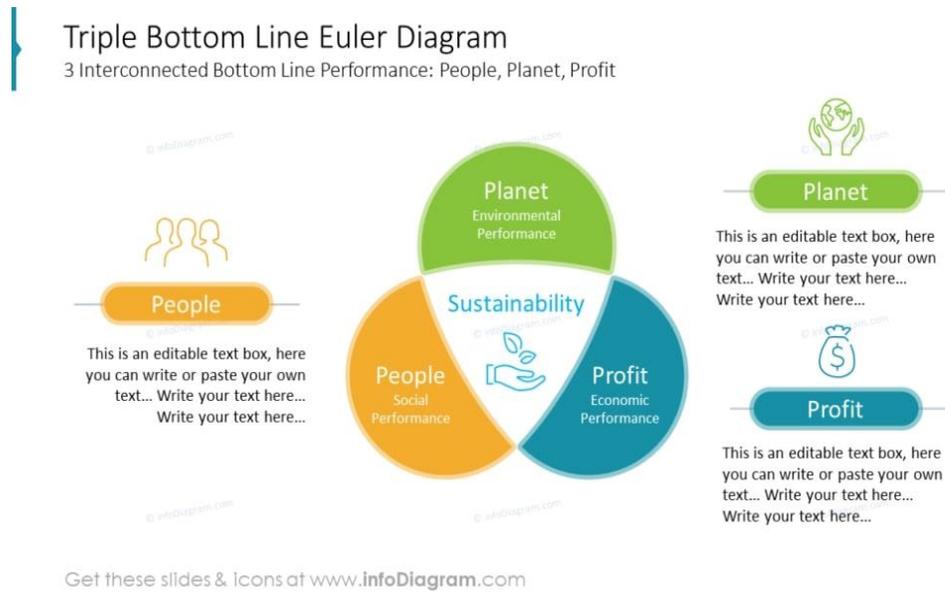
2.3.2 Diffusion of Innovation (DOI) Theory

The DOI fundamentally depends on the characteristics for technological innovation and opinion of customers towards the invention. A business is a far more complex unit than individuals. Rogers (1962) asserts that creativity is an interpersonal activity that employs multiple pathways within the societal environment. Three factors influence the integration of innovation into businesses. The organisation possesses individual qualities (leadership's attitude towards change), internal structural features (centralisation, complexity, interconnectivity, personnel count, and organisational slack), and external characteristics (system openness). Numerous definitions exist for innovations. Innovation is predominantly defined as any novel idea, process, product, or technology. According to Rogers (1962), new persons recognise that each innovation possesses distinct features that affect its transmission within society. The five fundamental attributes of any innovation were compatibility, complexity, relative advantage, ,trialability, and observability. Comparative advantage is defined as "the degree to which an innovation is perceived as superior

to the concept it supersedes" (Sharifani et al., 2022). Relative advantage frequently exerts a beneficial effect on the transmission of innovation. Compatibility refers to "the extent to which an innovation is regarded as aligned with the established values, prior experiences, and requirements of prospective adopters(Amini et al., 2023)." The compatibility of innovation positively affects the rate of its adoption within a society. An innovation that aligns with the norms and values of individuals or a social institution disseminates more rapidly than one that does not align. Complexity refers to "the extent to which an innovation is regarded as relatively challenging to comprehend and utilise" (Amini et al., 2023). Typically, complexity adversely impacts diffusion. A more intricate innovation is less likely to be successfully disseminated within society. The capacity for trial is characterised as "the extent to which an innovation can be tested on a restricted scale(Sharifani et al., 2022)." Finally, there is observability, defined as "the extent to which the outcomes of an innovation are perceivable by others." Tornatzky and Fleischer (1990) contend that, among the five attributes, relative advantage, compatibility, and complexity are the most significant factors influencing the adoption rate of diverse innovations.

2.3.3 Circular Economy Model

Supply Chain Integration bridges the gap between digital technologies and the CE. Because smart manufacturing and data processing technologies encourage integration across the supply chain, the mediation analysis is worth looking at. This is because collaboration is key to achieving CE goals like better resource management, allocation, and optimisation (Liu et al., 2019). As an example, the business and its customers work together to share ideas and details for products using 3D printing. Therefore, there may be benefits from a CE perspective as well, in terms of better resource utilisation and industrial site selection (Despeisse et al., 2017). Likewise, research on human–robot collaboration highlights the implications for the CE associated with these collaborative production methods, wherein the partnership between workers and machines in manufacturing facilitates improved disassembly processes and loop-closing dynamics. From this perspective, if an organisation wants to make the most of smart manufacturing technology like robotics and automation, and if it wants to help achieve the CE goals overall, it needs to integrate its supply chain. According to new empirical research, big data analytics can help businesses make better decisions, which in turn encourages them to implement CE supply chain practices and improves supply chain integration and coordination (Del, 2021). Finally, we argue that companies who use

data processing or smart manufacturing technologies can achieve the CE by better integrating their supply chains (Di., 2022).

Figure 2: Circular Supply Chain

Source:https://www.shippingsolutions.com/hsfs/hubfs/Circular%20Supply%20Chain.png?width=560andheight=473andname=Circular%20Supply%20Chain.png
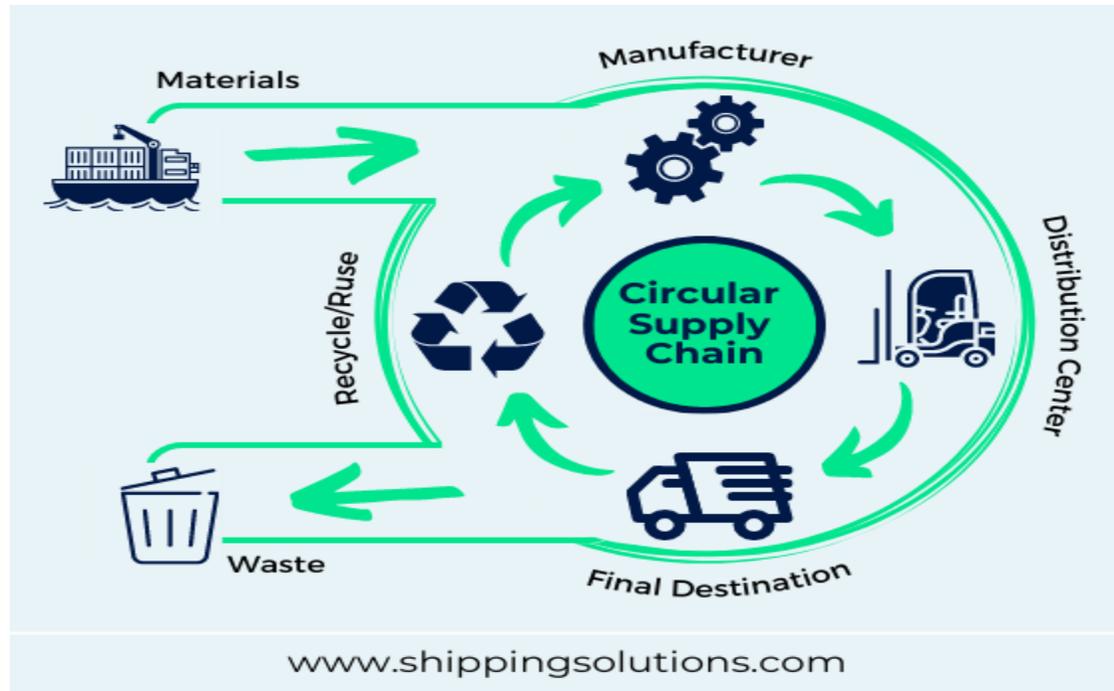
2.3.4 Human Society Theory

The Human Society Theory, within the framework of sustainable supply chains in the IT sector, underscores the interrelation of social, environmental, and economic elements. This theory asserts that SSCM must prioritise not only efficiency and profitability but also the wider societal implications of supply chain operations. In recent years, the IT sector has encountered heightened examination about its sustainability policies. The Human Society Theory posits that organisations should interact with stakeholders, including as employees, consumers, and communities, to promote a more sustainable methodology(Carter and Rogers 2008). This participation can result in higher social performance, including better labour conditions and community development, which are essential in the globalised supply chains characteristic of the IT sector (Carter and Rogers, 2020). A meta-analysis indicates that socially sustainable supply chain methods can markedly improve firm performance. The research demonstrates that organisations emphasising

social sustainability are more adept at managing risks and seizing market possibilities. This corresponds with the Human Society Theory, which promotes a comprehensive perspective on supply chain management that incorporates social responsibility into fundamental business strategy.

Furthermore, the notion of Industry 5.0, which prioritises human-centric methodologies in production and supply chains, is gaining prominence in the IT sector. Research conducted by Villar et al. (2023) examines how this paradigm change can foster more resilient and sustainable supply networks. By prioritising human well-being and environmental sustainability, organisations may generate value not only for shareholders but for all parties involved. The incorporation of technology in sustainable supply chains is also essential. Technological advancements like blockchain and IoT can improve transparency and traceability, enabling organisations to more effectively oversee their supply chains and assure adherence to social and environmental standards (Popović, et al 2021). This technology innovation bolsters the Human Society Theory by empowering enterprises to make educated decisions that advantage society collectively. In summary, the Human Society Theory offers a significant foundation for comprehending sustainable supply chains within the IT sector. By emphasising social sustainability and collaborating with stakeholders, corporations can improve their performance while benefiting society. As the sector progresses, adopting these ideas will be crucial for sustained success.

2.3.5 Institutional theory

This theory provides a framework for researchers to identify and analyse the factors that bolster the survival and legitimacy of organisational practices, including culture, social environment, regulation tradition, history, and economic incentives, while also acknowledging the importance of resources. Implementing sustainable practices that stakeholders consider adequate and appropriate is what we mean when we talk about legitimacy in this context. Institutional theory mainly looks at how organisations and groups strengthen their standing and credibility by following the rules and regulations of their institutional setting (Scott, 2007). This includes things like governmental bodies, laws, judicial systems, professions, and social and cultural practices that demand conformity. According to Institutional Theory, businesses try to win over stakeholders by embracing or legitimising certain practices, which in turn affects their strategy and organisational decision-making(Brunton et al., 2010).

"Green sustainable practices and environmental management decisions" are impacted by changes in social norms, technological advancements, and regulatory frameworks, as explained by Institutional Theory (Ball and Craig, 2010). To determine which organisational strategies lead to the adoption of environmental management practices, Delmas and Toffel (2004) apply Institutional Theory. A key firm in a supply chain and government law are the main drivers of environmentally sustainable regulation changes. Organisational tactics, structures, and processes can be driven by one of three categories, according to Institutional Theory. There are three types of drivers: normative, mimetic, and coercive. The abuse of power by those in authoritative positions is the root cause of coercion. Environmental management and, by extension, sustainability, cannot progress without coercive constraints. According to Sarkis et al. (2011), organisations are pushed to conform in order to be seen as participating in legal activity. According to Ball and Craig (2010), companies are pushed to be more environmentally conscious by normative constraints. They also argue that to understand how organisations respond to environmental challenges and how society as a whole is changing in terms of standards like ethics and ecology, institutional research is necessary. The influence of normative drivers is based on the expected behaviour of an organisation or an individual, as well as on a societal urge to conform. When businesses try to gain legitimacy by acting like their successful competitors, a phenomenon known as "mimetic isomorphic drives" can occur (Aerts et al., 2006; Sarkis et al., 2011). Organisational conduct is shaped by the expectations set by institutions, which in turn define what is considered acceptable and what is seen as natural and compulsory by law and regulation. Thornton (2004: 12-13) elucidated:

"Institutional logics, once they become dominant, affect the decision of organizations ...by focusing the attention of executives toward the set of issues and solutions that are consistent with the dominant logic and away from those issues and solutions that are not.-"

As a result, institutions might establish standards for acceptable or legitimate behaviour (Scott, 2007), marginalising or outright rejecting other pursuits. As a result, this will have an impact on how the company makes decisions. This can shed light on how different parties might help achieve compliance while also advancing sustainable supply chains. According to the institutional perspective (Glover et al., 2014), organisational behaviour is shaped by social, regulatory, and conformity forces.

Figure 3:Component of institutional Theory
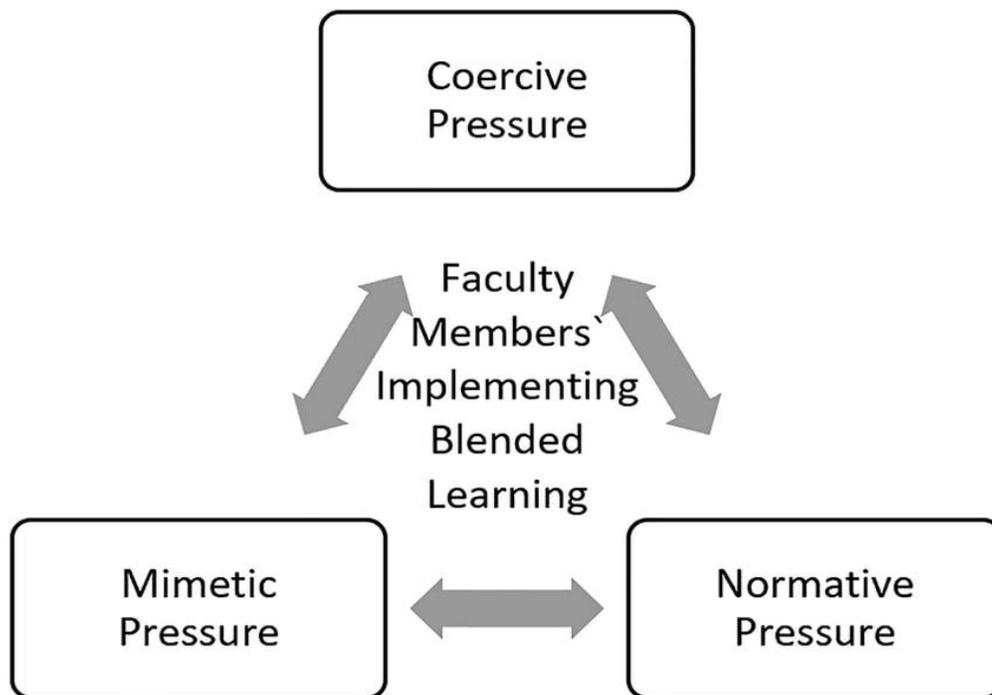
2.3.6 Resource based view

In order to keep tabs on products and operations, streamline transactions, improve inventory management, and make other informed decisions about the supply chain, businesses are currently heavily utilising information technology (Yu., 2015). Every part of the world's economy is constantly being bombarded with massive amounts of data generated by these technologies. Data generation is a massive undertaking; in 2012, it was about 2.5 exabytes per day, and it doubles every three years. More and more details about transactions with trading partners are included in this data. It is possible to improve supply chain performance by making better use of the vast amounts of data available (Fosso Wamba et al., 2015). To improve supply chain skills and competitiveness, managers can gain important insights by using incoming data. The importance of this data for supply chain managers is being more acknowledged (Tan et al., 2015). It helps with process control, planning, capacity and inventory monitoring, production optimisation, and visibility into expenditures and trends in costs and performance. Even though well-known manufacturers are using big data to improve supply chain operations and open up new

opportunities, many companies are still in the early stages of adopting the strategy because they don't fully understand what it is and how to manage it.

There has been a lot of talk recently in practitioner journals and consultancy white papers about how big data could help businesses gain a competitive edge. It is necessary to theoretically improve data-driven supply chains (DDSC) because of the lack of research investigating how DDSC affects supply chain capabilities and performance, despite the importance of DDSC. Research (Hazen et al., 2014), based on the resource-based view (RBV), examines the correlation between Digital Supply Chain Capabilities (DDSC) and Supply Chain Capabilities (SCC), which subsequently affect financial performance. SCC is defined as "the capacity of an organisation to identify, utilise, and integrate both internal and external resources to enhance all supply chain activities.(Yu et al., 2014)" Successful businesses, according to the Resource-Based View (RBV), are those that make the most of their available resources and their internal competencies, which are defined as "complex bundles of skills and accumulated knowledge that empower firms to coordinate activities and leverage their assets(Hazen et al., 2014)" According to supply chain management experts, a company's operational capabilities and competitive performance are greatly influenced by its organisational capacities (Yu et al., 2014). Establishing strategic partnerships with suppliers and customers, exchanging information across supply chain partners, and responding quickly to market demands are all critical competencies in supply chain management. When seen through the lens of the RBV, this shows that DDSCs are a substantial intangible asset for businesses. Both DDSC and SCC are part of a new capacity that could change the way supply chain management and design are done in the future (Hazen et al., 2014). If you follow the RBV, you can make a tonne of money by making good use of resources like big data. Big data's potential to improve supply chain operations has led some to predict that it will continue to help companies save money and gain an edge in the market. Many managers are missing out on big data's potential for their companies' success because they aren't using it. Fewer than 7% of boards use big data to inform their decisions, according to research from Stanford University and The Conference Board (Hazen et al., 2014) the fact that most companies do a poor job of managing the data they have is a major contributor.

According to the RBV of the company, companies can gain a competitive edge by using resources that are rare, valuable, inimitable, and non-substitutable in ways that rivals can't easily imitate. A company can be better understood in terms of its resources and capabilities according

to the RBV. This viewpoint has shown to be very useful in explaining how to gain a competitive edge and, by extension, how to improve financial performance(Yu, 2018). Similar to intermediate commodities created through organisational procedures to increase resource productivity, capabilities relate to a firm's ability to use its resources to accomplish a certain goal. Capabilities, in contrast to resources, may provide a competitive advantage because they are unique to the firm and not easily transferred because they are based on the complex interaction of several types of knowledge (Peng et al., 2008). Two broad types of capabilities exist in any given business: those that allow for the maintenance and improvement of existing processes, and those that facilitate the launch of brand-new ones. Companies have different resources and different abilities to use those resources, according to the RBV. The ability to create new resources, improve existing capabilities, and make those capabilities more unique is crucial to a firm's survival (Yu, 2018).

2.3.7 Theory of Reasoned Action (TRA)

The "Theory of Reasoned Action (TRA)" asserts that individuals' intentions to behave, which precede actual behaviour, are influenced by their attitudes and perceived social influences, known as subjective norms (Ajzen and Driver 1992). In the context of organisational supply chains within the IT industry, the TRA elucidates how the beliefs and normative expectations of decision-makers affect the implementation of sustainable practices. The significance of TRA is apparent in research on sustainable procurement, where the attitudes of procurement professionals towards green sourcing and their readiness to invest in sustainability impact organisational behaviour (Miller et al., 2024). The findings establish a direct correlation between individual attitudes and the selection of sustainable suppliers, indicating that decision-makers must recognise the value of sustainability for it to be integrated into procurement plans. The concept has additionally been utilised in the deployment of green IT solutions. Research of IT professionals revealed that favourable attitudes and supporting external factors substantially enhanced the propensity to embrace Green Information Technologies (GIT), subsequently influencing actual usage behaviour (Mohsen and Rajab, 2019). This reinforces TRA's fundamental assertion that intention precedes behaviour and highlights the functioning of attitudinal and normative factors in technical domains. Translating TRA to SSCM in the IT sector necessitates perceiving sustainability choices such as eco-friendly buying, lifecycle management, or supplier selection as deliberate actions. The favourable assessment of such activities by decision-makers and their perception of stakeholder expectations (e.g., from customers, regulators, investors) influence their behavioural purpose. However, the

traditional TRA model does not have a metric for external constraints or perceived control. Extensions such as "Theory of Planned Behaviour (TPB) incorporate the absent variable— perceived behavioural control" resulting in a more accurate use in professional contexts(Mohsen and Rajab, 2019).
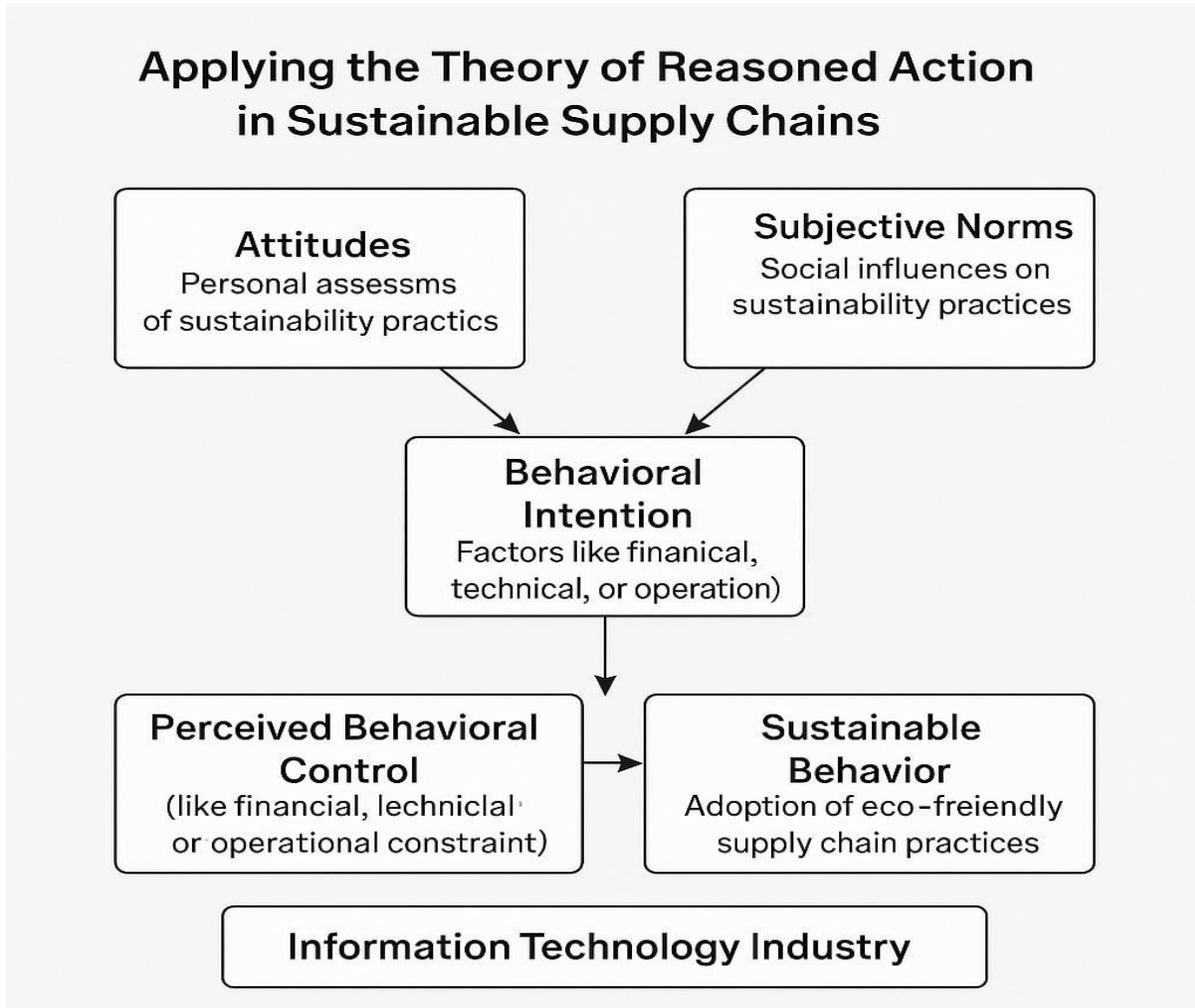
Figure 4: flow diagram of application of TRA

Source: Author creation

In supply chain literature, the categories of the TPB attitude, subjective norm, and perceived behavioural control have been utilised to anticipate organisational behaviours and delineate internal processes(Miller et al., 2024) Internal GSCM procedures were shown to be affected by consumer attitudes and norms, illustrating how TRA-based frameworks can extend from individual choices to organisational results. This study elucidates how cognitive and normative

variables shape the adoption of SSCM on IT SC by aligning the Technology Readiness Assessment (TRA) with organisational behaviour models. Favourable dispositions towards eco-design or green procurement, along with perceived normative pressures from customers, NGOs, and shareholders, bolster a robust intention to embrace sustainable practices. Such intentions are more likely to manifest in action when aligned with organisational capacity and perceived behavioural control. Consequently, TRA and TPB provide fundamental explanatory frameworks for comprehending the psychological processes involved in decision-making within SSCM(Mohsen and Rajab, 2019). Their implementation facilitates the identification of interventions such as awareness campaigns, stakeholder communication, and capacity-building that connect individual intentions with organisational strategic sustainability objectives.

2.4 Major Themes in Literature

2.4.1 Role of Technology and Digitalisation in Sustainable Supply Chains

Technological innovation has emerged as a crucial facilitator of electronic conversion in SCM, especially on IT domain. Agrawal and Narain (2023) conducted an extensive examination of how emerging technologies namely Internet of Things, artificial intelligence, big data analytics, and the blockchain technology facilitated the digitalisation of supply chains. Employing an interpretive structural modelling (ISM) methodology, they suggested a systematic framework for the implementation of these technologies and highlighted that big data, IoT, blockchain, and AI function as the most potent facilitators of supply chain digitalisation.

Simultaneously, Taghipour et al. (2022) established a conceptual framework connecting these technologies to sustainability results. Their research highlighted that digital transformation facilitated sustainable initiatives by decreasing expenses, enhancing transparency, and promoting environmentally friendly operations throughout supply chains. They also emphasised a deficiency in current research, namely on the evaluation of how these technologies jointly influenced the three pillars of sustainability economic, environmental, and social. Queiroz et al. (2021) advanced this topic by examining the emergence of DSCCs. Employing a narrative literature methodology, they discerned critical enabling technologies and suggested a framework to facilitate digital preparedness and transformation in reaction to Industry 4.0 challenges. AlMulhim (2021) discovered that, from the perspective of SMEs, digital transformation alone did not markedly influence business performance; nevertheless, the use of smart technologies produced a mediating

effect that improved organisational outcomes, especially in resource-constrained settings. Menon (2019) established the foundation for comprehending the transformative impact of rapid digital transformation and Industry 4.0 on SCM. His research emphasised that to satisfy global market needs, IT-driven supply chains progressively included automation and innovative technology to improve efficiency and sustain competitive advantage. These studies collectively confirmed that technology and digitalisation are crucial for altering IT supply chains, facilitating sustainability, enhancing performance, and promoting long-term innovation and resilience.

2.4.2 Integration Sustainability in the Supply Chain

Integrating Green Supply Chain Management (GSCM) strategies has become essential for connecting environmental sustainability with operational and strategic objectives. Yang et al. (2020) investigated the synergistic relationship among Geographic Information Systems (GIS) and GSCM, demonstrating that their informal alignment, frequently influenced by employee engagement, markedly improved corporate sustainability performance. The research highlighted the synergistic advantages of merging task-oriented GSCM with technology-centric GIS, indicating that this amalgamation enhanced environmental, operational, and social results. In a similar vein, Balon (2020) presented a thorough literature analysis detailing the progression of GSCM from the Third to the Fourth Industrial Revolution. The author amalgamated insights from over 150 scholarly articles to delineate principal pressures in GSCM, likewise regulatory frameworks and corporate social responsibility, alongside practices like eco-design and waste management, and performance metrics encompassing environmental, operational, and financial dimensions, thereby underscoring the systemic integration of GSCM components within contemporary supply chains. In a related review, Maditati et al. (2018) used bibliometric and co-citation analysis to categorize GSCM research into six strategic streams. They provided a conceptual framework that emphasised how the incorporation of eco-friendly practices and sustainable operations resulted in enhanced performance and strategic alignment. Cherrafi et al. (2018) substantiated this perspective by employing structural equation modelling to illustrate that process innovation, lean techniques, and green strategies collectively produced synergistic advantages for GSCM performance. Their research emphasised the competitive advantage gained when companies embraced a multi-faceted perspective of sustainability encompassing environmental, social, and economic dimensions. Finally, Islam et al. (2017) presented a comprehensive inventory of 58 GSCM practices spanning reverse logistics to carbon management

23

derived from a meticulous literature assessment of 91 high-quality academic articles. Their input was essential in aiding organisations and scholars to comprehend the various methods that could be effectively integrated to establish resilient, sustainable supply chains.

2.4.3 Knowledge Transfer and Innovation

The amalgamation of knowledge transfer (KT) and innovation has become a pivotal element in augmenting the sustainability and resilience of contemporary supply chains. Piprani et al. (2023) established a thorough empirical framework indicating that dynamic data analytics capabilities substantially affected supply chain resilience and innovation capabilities, which mediated sustainable supply chain performance (SSCP) because of DDAC. Their research emphasised that data-driven innovation and resilience must operate concurrently to enhance sustainability results. Pinto et al. (2019) advanced the "KTT-GSCM Multicriteria Model, examining interrelations for GSCM, Knowledge and Technology Transfer (KTT), and innovation". Applying the model to 13 organisations revealed that transmission of expertise and creativity greatly improved GSCM practices, hence demonstrating the interdependence of these factors. Da Silva (2019) emphasised the significance of Technology Transfer (TT) within Industry 4.0, contending that TT facilitated the dissemination of innovations throughout supply chain stages, especially in real-time collaboration and responsiveness. Banerjee et al. (2018) contributed to this conversation by saying that innovation and knowledge must be strategically managed to transform vision into organisational performance. They underscored that KT was both a cognitive and behavioural process necessitating value alignment and leadership involvement. In addition, Lim (2017) examined the significance of knowledge management (KM) in enhancing sustainable supply chain performance, particularly in the textile sector. His studies revealed collaborative knowledge generation, information technology systems, and knowledge dissemination as primary facilitators of organisational performance. Szuster et al. (2016) examined the disparities in information and knowledge transfer among enterprises engaged in ICT outsourcing, indicating that the formulation of knowledge management strategies substantially influenced supply chain competitiveness. These studies collectively emphasised that effective information transfer, combined with innovation, is essential for creating adaptive, sustainable, and high-performing supply chains.

2.4.4 Performance Outcomes and Challenges

Comprehending the performance results and obstacles in SSCM has become increasingly significant, especially with technological integration and changing industrial dynamics. Feng and Jalali (2024) conducted a new empirical study on the influence of technological innovation capabilities (TICs) to implementation for sustainable supply chain management. The study conducted on Iran shown that particular TICs namely learning, resource allocation, and manufacturing capabilities substantially improved SSCM implementation, aiding enterprises in surmounting internal obstacles. This research provided actionable insights for managers and policymakers aiming to enhance organisational sustainability via focused capability development. Elaborating on this discussion, Rad., et al. (2022) performed a systematic literature review for 221 papers about Industry 4.0 technology, elucidating the advantages and essential success elements influencing supply chain performance. Their analysis emphasised the disjointed character of current literature and advocated for further cohesive research on how these technologies acted as facilitators or obstacles in various supply chain situations. Sundram et al. (2020) investigated the Malaysian manufacturing sector and validated the affirmative correlation among IT, information sharing (IS), and supply chain integration (SCI), which collectively improved both organisational and supply chain performance. Their regression analysis substantiated the implementation of digital tools to enhance both internal and external supply chain collaboration. In a same setting, Tripathy (2016) examined SMEs in India, recognising IT, logistics, customer-supplier relationships, and operational efficiency as essential facilitators of supply chain competitiveness. The study utilised structural equation modelling (SEM) to highlight information technology as a crucial factor in attaining sustainable supply chain benefits in the face of market instability and unpredictability. Collectively, these studies demonstrated that although technology integration and innovation capabilities positively impacted performance outcomes, organisations faced challenges such as fragmented systems, contextual constraints, and the necessity for strong strategic alignment to fully leverage the advantages of SSCM.

2.4.5 Circular Economy and Resource Efficiency in IT Supply Chains

The incorporation of CE ideas into sustainable supply chain management have emerged as the critical technique to mitigating environmental impact and fostering long-term value development. Sudusinghe and Seuring (2022) highlighted that the shift from linear to circular supply chains (CSCs) necessitated a redefining of inter-organizational interactions. Their systematic research identified collaborative practices such as information exchange, joint product design, and collective responsibility for product recovery as essential for enhancing sustainability performance in supply chain collaborations. Vertical and horizontal cooperation, especially with governmental entities and NGOs, were demonstrated to improve symbiotic relationships throughout the supply chain. Kazancoglu et al. (2021) provided a framework that analysed policy-related obstacles impeding the adoption of CE in supply chains. Employing the fuzzy DEMATEL technique, they recognised insufficient laws, governmental assistance, and institutional awareness as significant obstacles. Their research emphasised the necessity for legislative reforms and incentives to promote environmental accountability and business circular economy involvement.

Dev et al. (2020) advanced the operationalisation of CE in supply chains by amalgamating Industry 4.0 (I4.0) technology with the ReSOLVE paradigm in reverse logistics. Their simulation-based methodology demonstrated that real-time information exchange and remanufacturing might enhance both environmental and economic outcomes. The research provided a pragmatic framework for achieving excellence in reverse logistics via digital facilitation and circular economy integration. Masi et al. (2017) conducted a thorough literature analysis, highlighting the disjointed comprehension of Circular Economy at the meso-level of supply chains, especially within eco-industrial parks and closed-loop systems. They advocated for a redefinition of CE that transcends prescriptive techniques and focusses on strategic objectives, while acknowledging the necessity of institutional and societal involvement to tackle systemic difficulties. These studies together indicated that the effectiveness of CE in enhancing SSCM relies on multi-level collaboration, legislative alignment, digital innovation, and a unified vision of sustainability.

2.4.6 Risk Management and Resilience in Green IT SCM

The convergence for sustainability and risk managing within supply chains has attracted much scrutiny in recent literature, especially with increasing uncertainties and disruptions. Ferdous et al. (2025) introduced an advanced decision-support system that combines "fuzzy C-means clustering"

with a multi-criteria decision analysis methodology to assess and rank disruption risks in sustainable supply chains. The study employed a Bayesian best-worst method to integrate urgency and vulnerability criteria, providing a thorough framework for identifying and mitigating disruption risks arising from natural and anthropogenic occurrences. Hin and Min (2021) emphasised the significance of Supply Chain Risk Management (SCRM) practices identification, evaluation, mitigation, and monitoring as essential instruments for improving resilience and performance. Their thorough review established a robust correlation between SCRM, resilience, and overall organisational effectiveness in unstable market environments. Rad et al. (2022) highlighted the disjointed influence to Fourth Industrial Revolution technologies on ―SC performance and risk, advocating for enhanced integration of essential success criteria for technology-driven risk mitigation. Gouda and Saranga (2018) examined the efficacy of sustainable initiatives in mitigating actual supply chain risk across 21 nations. Their findings indicated that, particularly in emerging markets, sustainability initiatives surpassed traditional reactive risk reduction techniques, especially when implemented in conjunction. Giannakis and Papadopoulos (2016) developed an operational risk management framework emphasising sustainability-related risks, employing Failure Mode and Effect Analysis (FMEA) to underscore the significance of environmental hazards and its interconnectedness throughout the supply chain. Jain et al. (2017) introduced a verified hierarchical model of supply chain resilience, identifying 13 enablers using ISM and SEM methodologies. Their research offered a systematic approach for organisations to strategically bolster resilience through internal competencies. This research emphasised that integrating sustainability concepts into risk management systems is crucial for minimising disruptions and ensuring long-term resilience and competitiveness in global supply chains.

2.4.7 Stakeholder Engagement and Governance in Sustainable Supply Chains

Stakeholder participation and governance were crucial in promoting SSCM, as emphasised in recent literature. Shee Weng (2025) performed a mixed-methods study integrating case analysis and interviews, highlighting that collaboration among internal and external stakeholders markedly improved environmental, social, and economic outcomes. Essential facilitators including openness, trust, governance, and board diversity were recognised, alongside obstacles such as mismatched incentives and ineffective communication. Ferdous et al. (2025) endorsed this viewpoint by introducing a decision-support framework that combines fuzzy clustering with multi-criteria decision-making to prioritise risks in sustainable supply chains, therefore emphasising the

significance of stakeholder-informed risk assessment. Wu et al. (2020) investigated the intermediary function of transfer of knowledge and the limiting impact of associate social obligation on green supply chain innovation in China. Their research findings indicated that stakeholder involvement was essential in converting specific investments into innovation results. Gurzawska A. (2020) underscored the necessity for multi-dimensional governance frameworks in SSCM, advocating for approaches including collective organisational accountability, stakeholder collaborations, and support for research and innovation (RandI). In a similar vein, Siems et al. (2021) conducted a case study on bioenergy supply chains in Chile, demonstrating that methods such as bidirectional communication and local integration facilitated stakeholder management and established legitimacy. Siems et al. (2023) conducted a thorough literature review, finding NGOs, governments, and rivals as significant external stakeholders that facilitated or endorsed SSCM implementation through proactive participation. Their research confirmed the significance of stakeholder participation in enhancing organisational learning and capability development. Silvestre et al. (2018) presented an opposing perspective by analysing the Brazilian beef supply chain, demonstrating that in certain settings, stakeholder engagement may elevate the risk of corruption. Their findings presented the notion of the "corruption triangle," highlighting the necessity for meticulous regulation of stakeholder interactions to prevent the erosion of sustainability initiatives. This research emphasised that stakeholder participation, although predominantly advantageous, necessitated strategic alignment, ethical oversight, and inclusive approaches to guarantee long-term resilience and legitimacy in SSCM.

2.4.8 Policy and Regulatory Impact on SSCM in the IT Sector

Recent literature has increasingly emphasised the developing aspects of SSCM, particularly with emerging technologies and post-pandemic recovery. Gupta et al. (2025) examined Industry 5.0 as a transition towards human-centric intelligent systems, highlighting the incorporation of new technology including blockchain, artificial intelligence, the IoT, and big data to improve supply chain sustainability in accordance with the triple bottom line. Santiago et al. (2025) proposed a framework that integrates corporate social responsibility (CSR) and CE principles into SSCM as the basis to transitioning to Industry 5.0. Augmenting these advancements Alkaraan et al. (2025) investigated the impact of green servitisation and the adoption of Industry 4.0, revealing that corporate governance, innovation, and SSCM practices collectively affected environmental, social, and governance (ESG) performance. Li et al. (2025) performed a systematic evaluation of

94 research to examine the effects of COVID-19 on SSCM, highlighting disruptions and response measures that may alleviate future concerns. Within the Indian energy sector, Biswal et al. (2018) employed the AHP-TOPSIS methodology to provide a decision-making framework to SSCM on coal-based power generation, focussing on environmental degradation and resource depletion. Silvestre et al. (2018) illuminate corruption inside developing market supply chains, demonstrating how systematic corruption in Brazil's beef sector compromises SSCM aims and advocating for institutional responsibility. Zailani et al. (2012) examined Malaysian manufacturing and empirically confirmed the beneficial impacts of environmental purchasing and sustainable packaging on operational, economic, and social performance.Their research indicated that SSCM should be seen not merely as a moral obligation but as a strategic approach for sustainable value generation. These studies collectively shown an increasing focus on technical advancement, human-centric innovation, stakeholder responsibility, and risk resilience as essential components of SSCM. They emphasised that the effective execution of SSCM necessitated not only strategic alignment with emerging industrial paradigms such as Industry 5.0 but also a cohesive approach encompassing governance, transparency, and socio-environmental factors.

2.5 Comprehensive Examination of Literature

2.5.1 Correspondence in Literature

A careful examination at the literature shows that most experts agree on the main aspects that make up SSCM, notably to IT sector, which is both tech-driven and environmentally conscious. First, most people agree that technology innovation is not just a helpful part of making supply chains more sustainable; it is also an essential one. -AI, blockchain, IoT, and big data analytics are a collection of technology that have been consistently named as key factors in improving visibility, streamlining logistics, reducing waste, and making decisions based on predictions (Agrawal and Narain, 2023; Piprani et al., 2023). Together, these technologies make operations run better and help match business goals with social and environmental goals. In addition, all researchers agree that it is important to include green practices in supply chain operations. Many people agree that eco-design, reverse logistics, green procurement, and waste management are useful ways to lower the environmental effect of a supply chain while keeping it running smoothly (Islam et al., 2017; Cherrafi et al., 2018). These actions are connected to a better brand reputation, more devoted customers, and following worldwide rules that are getting stricter. Also, using circular economy

principles, especially through reverse logistics and closed-loop systems, has been shown to be an important way to extend the life of products and use fewer resources (Dev., et al 2020; Kazancoglu., et al 2021).

The study heavily emphasises the strategic relevance of collaboration and knowledge exchange in attaining supply chain sustainability. Engaging partners across all tiers of the SC, such as suppliers, manufacturers, consumers, and regulatory agencies, helps with innovation, reducing risk, and putting sustainability practices into place (Sudusinghe and Seuring, 2022; Banerjee et al., 2018). It is widely accepted that both tacit and explicit knowledge transfer are important for boosting learning in organisations and encouraging a culture of innovation in supplier networks. Lastly, it is widely accepted that sustainability and risk management are linked by nature. Studies show that proactive efforts to be more environmentally friendly and socially responsible not only help the environment and society, but also greatly lower operational risks, especially in emerging markets (Ferdous et al., 2025; Gouda and Saranga, 2018). In general, the research shows that everyone agrees that technical progress, green integration, collaborative frameworks, and risk-informed sustainability are all important for making IT supply chains that can handle the future.

2.5.2 Differences Highlighted in the Literature

Although there is substantial consensus inside the scholarly discourse concerning the importance for innovation and sustainability in SCM, notable discrepancies and conflicts are also apparent. A significant distinction exists in the influence of technical innovation on corporate performance. Agrawal and Narain (2023) contend that technologies like AI, IoT, and blockchain are pivotal in advancing supply chain digitalisation and sustainability, whereas AlMulhim (2021) indicates that digital transformation may not directly improve firm performance without the mediation of smart technologies, particularly concerning small and medium enterprises (SMEs). This indicates a contextual reliance whereby technical inputs produce outcomes solely when accompanied by organisational preparedness and supportive mechanisms. A further distinction emerges in the correlation between risk management tactics and sustainability practices. Gouda and Saranga (2018) illustrate that traditional risk mitigation measures do not consistently diminish supply chain risk and are more efficacious when integrated with sustainability initiatives, especially in emerging markets. In contrast, Giannakis and Papadopoulos (2016) contend that sustainability needs to be

regarded as a type of risk management, promoting a comprehensive framework that addresses sustainability-related risks with equal urgency as conventional operational hazards.

These divergent viewpoints underscore the persistent discourse on whether sustainability constitutes a component of risk management or an independent, mutually beneficial strategy. The literature reveals inconsistencies in the prioritisation of sustainability factors. Although numerous studies emphasise the environmental and economic facets of supply chain sustainability (Dev et al., 2020; Sudusinghe and Seuring, 2022), fewer investigations accord comparable significance to the social dimension. This disparity indicates a dominant inclination towards quantifiable, efficiency-oriented results, frequently neglecting concerns like labour rights, fair resource allocation, and community effects. Moreover, although circular economy methods are extensively promoted, their actual implementation differs markedly between industries and locations because to variations in governmental support, infrastructure, and consumer behaviour (Kazancoglu et al., 2021; Masi et al., 2017). Ultimately, variances also arise in collaborative methodologies. Certain studies highlight vertical collaboration with suppliers and customers (Taghipour et al., 2022), whereas others underscore cross-functional and inter-governmental relationships (Sudusinghe and Seuring, 2022). These disparities illustrate the varied strategic orientations, regulatory frameworks, and developmental stages of supply chain ecosystems, highlighting the necessity for tailored methods.

2.5.3 Gaps and Unexplored Areas

Even though there is more and more research showing that sustainability and innovation should be combined in supply chain management, there are still some important gaps and areas that haven't been studied yet, especially in the IT industry. There aren't enough real-world studies in specific sectors, which is a big research need. There are some general ideas about how to manage a SSCM, but not much research has been done on how these ideas function in IT supply chains, which are naturally complicated, tech-driven, and spread out over the world. Most of the studies that are out there look at manufacturing or heavy sectors. They don't always take into account the unique problems that IT companies have when it comes to managing electronic waste, getting rare-earth minerals, and keeping suppliers open about their business across regions (Dev et al., 2020; Masi et al., 2017). The integration of the social aspect of sustainability is another area that hasn't been looked at enough. Most of the literature focusses on environmental and economic factors like

energy efficiency, carbon footprint, and cost optimisation. It doesn't pay enough attention to social factors like labour practices, equity, worker safety, and community welfare in IT supply chains (Sudusinghe and Seuring, 2022). This imbalance needs more in-depth research that looks at all three pillars of sustainability as a whole. There is also a methodological gap because longitudinal and mixed-method research are not used enough. A lot of research uses cross-sectional surveys or conceptual models, but they don't evaluate if something causes something else over time or at different levels of supply chain maturity. This makes it harder to understand how sustainability and innovation strategies change or work in changing situations like recovering from a pandemic or going through a digital transformation cycle (Chin and Min, 2021; Piprani et al., 2023).

Also, while many articles talk about how important technology is, not many go into detail on how different new technologies, like AI, blockchain, IoT, and digital twins, depend on each other and how they may be used together to get the best long-term results. The interaction between these technologies and the problems that make it hard to use them together in IT supply chains are still not thoroughly studied (Rad et al., 2022). Lastly, there are still a lot of policy-related hurdles and incentives that affect the implementation of environmentally friendly procedures in the information technology industry. Because of different rules in different areas and not enough enforcement, further research is needed to find out how governance, circular procurement, and public-private partnerships might affect the widespread use of SSCM (Kazancoglu et al., 2021).

2.6 Summary of Literature Review

The literature evaluated in this study gives a broad yet useful base for understanding the changing nature of "sustainable supply chain management (SSCM), especially in the Information Technology (IT) industry". Some of the main topics covered are the role of new technologies, environmentally friendly practices, sharing knowledge, managing risk, integrating the circular economy, and measuring performance. All these topics point to the same main idea: that innovation and sustainability go hand in hand and are both necessary for establishing IT supply chains that are competitive and strong. A lot of research agrees that new Technology such as AI , blockchain, IoT, and big data analytics were very important for making supply chains more sustainable. These technologies make things clearer, let people make decisions based on data, and improve processes. They are essential for dealing with the difficulties of global IT supply chains.

Many people also agree that adding eco-design, reverse logistics, and green procurement to a supply chain makes it work better and is better for the environment.

Also, working together with everyone in the supply chain, including government agencies and NGOs, is often stressed as a key way to make circular economy models work and close the loop in product life cycles. The literature does, however, point out several important distinctions and conflicts. Some studies show that digital transformation has a direct positive influence on company performance, while others say that its success depends on how well the company can use smart technology and how well it can integrate it into its operations. In the same way, there are differences in how sustainability-related risks are handled. Some people see sustainability as a way to reduce risks, while others see it as a separate but connected issue. Also, present research tends to focus more on environmental and economic consequences than on social sustainability aspects. The review shows that there are important gaps in literature. Some of them are a lack of empirical studies that focus on the IT sector, a lack of research on social sustainability practices, a lack of research on how different technologies can work together, and a lack of studies that look at policy constraints in specific regions. Also, most of the research that is out there is either conceptual or cross-sectional, which means it doesn't give us long-term insights into how innovation and sustainability are implemented over time. In short, literature gives strong theoretical and empirical support for moving forward with sustainable and creative practices in IT supply chains. However, it also begs for more in-depth, nuanced, and context-specific research. These observations provide the basis for setting the goals and methods of the current investigation.

CHAPTER 3. METHOODGY

3.1 Overview of Research Problem

The IT industry is one of the most active and quickly changing parts of the world economy. It pushes new ideas in every area, drives the digital economy, and shapes the future of modern civilisations. But the growth of this sector is backed by a convoluted and resource-intensive supply chain that goes across continents, involves many people, and has major effects on society and the environment (Green et al., 2012; Feng and Jalali, 2024). IT supply networks are naturally multinational and quite broken up. They involve a lot of various procedures, like collecting raw materials, creating parts, developing software, putting systems together, shipping things, and taking care of products when they are no longer useful (Le et al., 2022). These intricate networks often cause huge difficulties with sustainability, like utilising too many resources, emitting too much carbon, creating too much e-waste, treating workers unfairly, and not being able to see across the supply chain (Junaid et al., 2022). Because of this, the IT industry needs to make its supply chains more open, powerful, and long-lasting as soon as feasible. More and more, governments, customers, and international organisations are urging IT companies to adopt the United Nations Sustainable Development Goals (SDGs) and employ better ways to manage their supply chains. AI, Blockchain, and the IoT are some of the new digital tools that can make supply chains much more open, easy to trace, and efficient (Saberi et al., 2019). The ideas of the CE also encourage IT companies to cease utilising linear supply chains and migrate to more sustainable, closed-loop systems that use resources more efficiently and cut down on waste (Seuring and Müller, 2008).

There are still a lot of difficulties, even with these changes. A lot of IT organisations, especially SMEs, have issues putting sustainable practices into place because they have problems with money, technology, and organisation (Setiawan et al., 2023). There aren't many in-depth studies that look at how to systematically apply digital technology and legal frameworks to sustainable IT supply chains (Piprani et al., 2023).

The purpose of this study is to fill in these gaps by looking into how digital technologies, engaging with stakeholders, and rules and regulations may be used to make supply chains in the IT industry more sustainable. The study's goal is to give policymakers and professionals in the IT business

meaningful knowledge and frameworks that will help them build IT supply chains that are better for the economy, society, and the environment.

3.2 Operationalization of Theoretical Construct

a. Sustainable Supply Chain Management

SSCM is the planned use of social, economic, and environmental factors in supply chain operations and management to achieve long-term success for the organisation while having as little negative effect on society and the environment as possible (Seuring, et al. 2008) SSCM takes a whole-system approach that goes beyond just following the rules. It focusses on making things better all the time in areas like eco-design, green procurement, working with suppliers, and reverse logistics. SSCM is very important in the IT business because it is globalised and uses a lot of resources. Companies use SSCM methods to make their supply chains more open, lower their carbon footprints, and encourage new ideas that will make them more circular and strong (Seuring, et al. 2008).

b. Digital Transformation

Digital transformation in supply chains involves the use of new digital technology to improve operational visibility, flexibility, and efficiency. It includes things like AI, blockchain, the IoT, cloud computing, and big data analytics. Digital transformation makes it possible to monitor IT supply chains in real time, make decisions automatically, and better track supplies and goods. It also helps the environment by making the best use of resources, cutting down on waste, and allowing for circular practices. The study will look at how far and how well digital technology is being used in supply chain activities to see how much digital transformation has happened (Kraus, et al. 2021).

c. Circular Economy

The CE is a different way of doing business than the traditional linear economy. Its goal is to separate economic growth from resource use. It stresses closing material loops by using methods like reusing, remanufacturing, recycling, and extending the life of products. CE principles are used in IT supply chains by making gadgets easy to take apart, encouraging repairs, and setting up programs to take back old electronics. The goal is to keep the value of materials and products while reducing waste and harm to the environment. This study makes CE real by using indicators like

closed-loop supply chains, remanufacturing processes, and circular business models (Corvellec, et al. 2022).

d. Corporate Social Responsibility

Corporate Social Responsibility (CSR) means that a firm chooses to include ethical, social, and environmental issues in how it does business and interacts with its stakeholders. Fair labour standards, supplier codes of conduct, human rights safeguards, and community participation are all examples of CSR in supply chains. Making sure that all parts of a company's worldwide supply chain follow CSR rules is a big problem for IT businesses. This study looks at CSR procedures by looking at supplier audits, following international standards, and social sustainability efforts in the supply chain (Lindgreen, et al. 2010).

e. Supply Chain Resilience

Supply chain resilience is the ability of a supply chain to predict, plan for, respond to, and recover from problems. Some important skills are being able to be flexible, have backups, see what's going on, and work together to control risks. Resilience is very important in the fast-paced IT business because of risks including technology becoming outdated, political issues, and shortages of supplies. This study makes resilience real by looking at things like how quickly a company can respond to problems, how flexible its sourcing strategies are, and how much it spends on backup systems (Tukamuhabwa, et al. 2015).

f. Blockchain Technology

Blockchain technology is a ledger system that is decentralised and unchangeable. It lets transactions across the supply chain network be safe, clear, and easy to follow. Blockchain is used in IT supply chains to make sure that products are real, that raw materials can be traced, and that partners in the supply chain can trust each other more. It helps the environment and society by encouraging responsibility and making it easier to follow rules. This study will look at how blockchain is being used by looking at things like how well it can be traced and how well it integrates with supplier networks (Yli-Huumo,et al. 2016)

g. Internet of Things in Supply Chains

IoT is the term for connecting physical devices that collect and share data over networks. IoT devices like RFID tags, sensors, and smart logistics systems give supply chains real-time access

to information about inventory, production, and transportation. IoT makes things more sustainable by using energy more efficiently, lowering transportation emissions, and enabling predictive maintenance. This study will look at how IoT is used based on how well it works with digital supply chain platforms and how well it works at different points in the supply chain (Ben-Daya,, et al. 2019).

3.3 Research Purpose and Questions

The research seeks to discover and develop new approaches to guarantee the sustainability of supply chains in the IT industry. Lately, IT has come under pressure from different directions to make its operations more sustainable. The main causes of these pressures are increasing worries about harm to the environment, running out of resources, and ethical issues in global commerce. As a result, IT companies are choosing to use AI, Blockchain, IoT, and CE ideas to promote clear business operations, top effectiveness, and a lasting impact.

It aims to fill some of these knowledge gaps with an investigation on how using both technology and well-made policies with joint effort from all parties can strengthen and sustain the IT sector's supply chains. Therefore, this research intends to give useful knowledge and directions that industry can use and inform policymakers.

Research Questions

Research Question 1: What are the current sustainability practices implemented within IT supply chains, and what key barriers hinder their effective adoption and execution?

Research Question 2: What are the primary drivers influencing IT companies to adopt sustainable supply chain practices, including regulatory mandates, market demands, technological advancements, and organizational values?

Research Question 3: How can emerge digital technologies specifically AI, Blockchain, and IoT enhance transparency, traceability, and operational efficiency in IT supply chain management?

Research Question 4: What is the role of national and international regulatory frameworks in shaping sustainable supply chain practices within the IT sector, and how do these frameworks support or constrain implementation?

Research Question 5: What practical strategies and frameworks can be developed to assist IT companies in overcoming existing sustainability challenges and fostering continuous improvement in supply chain sustainability?

These research questions are directly aligned with the study's objectives and are designed to ensure a comprehensive exploration of both the theoretical and practical dimensions of sustainable supply chain management in the IT industry.

3.4 Research Design

To fully grasp the issues under investigation, this study has opted for a mixed-methods strategy, combining qualitative and quantitative research techniques. By producing quantifiable performance measures linked to innovative practices, the integrated technique enhances research into the difficulties IT organisations face while implementing supply chain sustainability. To get to the bottom of how IT sustainability specialists and managers see stakeholders and their experiences with the supply chain, this study will use qualitative research methods. According to Seuring and Muller (2008), this study will employ quantitative research methods, such as participant surveys, data assessments, and analysis, to confirm and expand upon its findings on the topic of sustainable supply chain management. The results will be based on evidence.

Data Collection Methods:

1. **Surveys and Questionnaires:**

Researchers will poll IT company supply chain managers and sustainability specialists across regions. Examining current sustainability practices, examining obstacles and change drivers, and assessing technological options to improve supply chain sustainability are all parts of the survey questionnaire. Both open-ended and closed-ended survey questions are part of the research instrument; the former is used for quantitative data analysis and the latter for qualitative data.

2. Interviews:

Expert interviews with a selection of supply chain managers, environmental consultants, and executives from IT companies will be conducted utilising semi-structured methods. Participants' IT supply chain activities, as well as the unique problems they faced and the sustainable solutions they employed, can be better understood through in-depth interviews. Researchers can explore other areas that the survey didn't pick up on with a free-form interview technique.

3. Case Studies:

Information technology firms that have long-standing, innovative, and environmentally responsible supply chain activities will be the focus of an exhaustive evaluation. The best IT case studies provide real-world instances of cutting-edge technical solutions and best practices in the industry. Other organisations might adopt the empirical ideas provided by the case study evaluation for sustainable supply chain implementation.

4. Secondary Data Analysis:

The policy framework for IT supply chains is shaped by external factors, which will be better understood by evaluating industry reports, sustainability certifications, and government legislation as secondary data. Current operational practices will be evaluated in relation to international sustainability standards.

3.5 Population and Sample

Target population is the larger set of individuals that the researchers want to learn more about. This refers to the population that researchers in clinical trials believe may have an advantage from a specific experimental medication. An indication is the particular medical problem that a medicine is designed to alleviate (Zhao et. al., 2013). The term "target population," which is synonymous with "target audience," describes the whole scope of a company's identified market of prospective consumers. For a small firm, for example, the company's focus can be a certain neighborhood (Kokemuller, 2016).

The target population for this study involved in managing and running supply chains in the Information Technology sector, Individuals in these positions are supply chain managers, sustainability officers, procurement specialists, senior executives, policymakers, members of NGOs, and technology providers. Those taking part will come from organizations engaged in hardware manufacture, software developing, IT service providing, and system integration.

To ensure that a wide range of viewpoints is considered, the sample will have both big multinational firms and small to medium-sized enterprises, because sustainability issues may be different for each type of company. The research team will choose participants for both parts of the study by using purposive sampling.

During the quantitative stage, it is planned to collect 200 survey answers. In this qualitative stage, about 15 to 20 interviews will be carried out with specialists who have learned about sustainable supply chains. This way, the study gathers information on large patterns and detailed experiences to check the adoption of sustainability in IT supply chains.

3.6 Participant Selection

Those who take part in the study will be chosen through purposive sampling so that only those familiar with supply chain management and sustainability in the IT sector are chosen. The study selected this way of sampling experts who are currently involved in sustainable management in the supply chain.

Those who take part in my survey include senior executives, sustainability officers, procurement specialists, supply chain managers, and similar professionals in IT companies. Experts will be searched for using networks, directories, a company's website, and events in their sector. The study will involve researching individuals from both large and small companies to cover different business viewpoints.

The interviewees for qualitative research will also be chosen because they are knowledgeable and active in the area of sustainable supply chains. People who hold important decision-making positions, such as those in charge of sustainability, top supply chain management, and policy, will be invited to the interviews**.** One main goal is that the interviews help to discover ideas and information that are not easily gained from other methods.

Using this selection process fits the study's research plan and makes it possible to work with data that will be helpful for the answers you are seeking.

3.7 Instrumentation

A questionnaire comprises of a list of questions or items designed to get information from respondents about their origins, opinions, and beliefs. Typically, it is composed of a sequence of inquiries intended to get detailed data on a given subject or group of subjects (Taylor-Powell and Marshall, 1998). A research tool called a questionnaire is used to gather information from respondents for an investigation or statistical analysis. It has a set of questions (or other types of cues) (Krosnick, 2018). Open-ended and closed-ended items are both included in research questionnaires. Long, open-ended enquiries allow the reply additional space to expand on their

ideas. Questionnaires offer the following benefits over other survey instruments: In comparison to verbal or telephone surveys, they are less costly, require less work from respondents, and often feature predefined answers that facilitate data collecting (Lietz, 2010).

Research for this study will depend on two main forms of data collection. For the quantitative phase, a formal survey will be made to gather information on sustainability initiatives, use of new technologies, what stops their adoption, and what promotes sustainable supply chain practices in the IT industry. There will be a questionnaire of short-answered questions using a five-point scale, together with demographic details about the participants and their organisations. The research team will form the questionnaire items from the findings of the literature review and match them to the study's main concepts.

The qualitative part of the research will begin with semi-structured interviews based on an interview guide. It will offer open-ended questions to understand the participants' experiences, problems, and certain views on sustainable supply chains. A set of industry experts will test the instruments to make sure they are clear and relevant before the main data collection is done.

Instrument Development

The questionnaire has been separated into two parts i.e., based on personal information and the other being questions based on the objectives/ hypothesis for analysis.

a) **Based on Personal information:** The personal information section has questions about the respondent himself. This section includes questions aimed at understanding the demographics and background characteristics of the individuals participating in the study.

b) **Based on hypothesis/ objectives variables:** This section has questions to analyze the hypothesis and objective of the study where the questions are developed to find the data of respondents to complete the study.

3.8 Data Collection Procedures

This study will use a well-organised approach to gather data, which will guarantee the reliability and validity of the outcomes (Bouma et al., 2004). The research process will be done in two stages: first quantitative and then qualitative. At the beginning, survey research will be used to get data from certain IT professionals. Story and Tait (2019) point out that survey research is used to gather information from a certain group to study important variables.

a) Survey Research

According to Story and Tait (2019), survey research involves collecting data from a pre-selected group of people, such as customers or potential customers, with the aim of gaining insights regarding the goods, services, or brand overall. Researchers using surveys that they send to survey respondents are doing research using survey research. To provide meaningful study findings, survey data is then statistically analyzed. Survey research methodologies can be formed from two important factors: Survey research instrument and the time spent performing study (Bhaskaran, 2024).

b) E-Mail-Based Surveys

Email surveys are among the most popular ways to get information. Market researchers find that email feedback is a more convenient way to provide surveys to their respondents. Researchers might include a statement in email surveys to inform respondents about the purpose of data gathering (Bhat, 2024)

c) Online Survey Method

One of the most common ways to gather information is through an online survey, often known as an internet survey. This method involves sending out a list of questions to a certain group of people and then collecting accurate responses from them via the Internet (Braun et. al., 2021). Many different channels reach respondents with surveys: email, website embeds, social media, etc. Businesses utilize online survey tools to learn more about customers' thoughts and feelings on future offerings, existing features, marketing approaches, the firm itself, and more (Bhat, 2023).

The survey and the interview instruments will both be tried out with a few professionals from the field to make sure no problems arise before we start the main collection of data.

3.9 Data Analysis

Data Collection Source

The process of gathering information about a pre-existing system's characteristics in order to answer pertinent questions and assess outcomes is recognized as "data collection" (Willson and Miller, 2014). Data collection is an important component of research in all academic fields, including the natural and social sciences, as well as the arts and business. Different fields may use

different techniques, but they always have a focus on truthful and reliable data collecting (Johnson and Turner, 2003). Data collection is only useful if it enables analysis to provide credible answers to the queries posed. Research integrity requires accurate data collection regardless of the field or preferred method for defining data ("qualitative or quantitative"). Selecting appropriate data collection technologies (new, modified, or existing) and giving clear instructions on how to use them are two ways to reduce the chance of error (Couper, 2017).

This stage is crucial for all types of research, analysis, and decision-making, including social science, commercial, and medical research (Simplilearn, 2023). This procedure is critical in research because it guarantees that the data obtained is relevant, adequate, and valid for analysis and decision-making. Depending on the study design and aims, data collecting can be accomplished using a variety of methods like surveys, interviews, observations, and experiments. Effective data collecting helps researchers to develop educated conclusions and provide accurate and valid results, so improving the overall quality of the research (Kumar, 2018).

Primary Data: Primary data is information that is originally collected from the original source in order to achieve a certain research objective. Direct encounters with study-relevant individuals or organizations, as well as surveys, interviews, experiments and observations, are some of the main data collection methods used by researchers (Taherdoost, 2021). Raw data, first-hand information, and similar terms all describe it. The data compilation procedure is costly due to the fact that the analysis is carried out by an external organization or agency, necessitating investment and human resources. The investigator is directly involved in managing and supervising the data collection process. Focus groups, case studies, surveys, mail questionnaires, in-person interviews, telephone interviews, physical testing, and observations make up the bulk of the data collection methods (Admin, 2021).

Primary data is sourced from a structured questionnaire. To collect primary data from participants in the study, a questionnaire was used.

Secondary Data: Information or statistics which have already been gathered from other sources are referred to as secondary data. Quantitative and qualitative approaches are also possible in secondary research. In most cases, it draws on information found in meta-analyses, peer-reviewed studies, public and private databases, and datasets (Johnston, 2014). This method of gathering data is accessible to most people, saves money, and requires little effort. One drawback, though, is that

the information gathered may not be accurate or meet the present study's objectives because it was put together for another purpose (Harwood and Vang, 2009).

Secondary data is collected from "research articles, journals, reports, relevant books and websites".

In the present study, "primary and secondary data" are employed.

- **Research Tools**

The study used SPSS and Microsoft Excel as the main research tools. SPSS made it easy to do advanced statistical analysis and develop models, while Excel helped organise, calculate, and check the accuracy of numerical data in a structured spreadsheet format.

Research Techniques

The study used important statistical methods such the Arithmetic Mean, Standard Deviation, Regression, and Correlation. The Arithmetic Mean shows the central tendency, and the Standard Deviation shows how spread out the data is around the mean. Regression analysis looks at how dependent and independent variables are related, while correlation measures how strongly two variables are related without saying that one causes the other. Both of these methods help in understanding and predicting data.

3.10 Research Hypothesis

Formulation of Research Hypotheses

The study has proposed five major hypotheses for defining the testable connections between the main constructs regarding sustainable supply chain management in the IT industry.

Hypothesis 1(H_1): Relationship between Barriers and Sustainability Practices

H_1: It is hypothesized in this study that barriers to perceived sustainability behaviors and sustainability supply practices will have a significant positive association.

Theoretical Foundation: In an institutional perspective, organizations that are driven by the shackles of a "more-is" imperative are generally made to come up with more sophisticated ways to legitimize themselves and earn trust from stakeholders. The resource-based view, on the other hand, argues that companies aware of limitations in resources and competition invest to develop unique capabilities to fight these limitations.

Operationalization: This hypothesis tests the case that companies facing sustainability obstacles (like financial limitations, supplier resistance, technological limitations, regulatory complexities, and expertise lacking) to a higher degree are also more involved with sustainability projects at the same time. The connection is ascertained by means of correlation analysis between the scores of barrier perception and the scores of sustainability practice adoption.

Expected Outcome: It is expected that there will be a positive correlation, meaning that the organizations are likely to react proactively to the challenges presented by sustainability instead of tolerating them or avoiding them.

Statistical Testing: The barriers were treated as the independent variable while sustainability practices were considered as the dependent variable in the Pearson correlation and linear regression analysis.

Hypothesis 2 (H$_2$): Drivers and Sustainability Performance Relationship

H$_2$: The drivers of sustainability such as regulatory measures, market requirements, new technology, and company ethics have a great impact and positive effect on the performance of IT supply chains in terms of sustainability.

Theoretical Foundation: The Triple Bottom Line model states that the sustainability performance of an organization is the result of many factors, which are the economic, environmental, and social dimensions, that press each other up and down. The Theory of Institutions also points out that at the same time, the coercive (regulatory), normative (societal expectations), and mimetic (competitive imitation) forces influence organizational behavior.

Operationalization: The current hypothesis is that higher ratings given to sustainability drivers (such as regulatory compliance, customer sustainability preferences, competitive advantage pursuit, leadership commitment, and CSR culture) will be the reason for better performance results in sustainability (i.e., transparency, efficiency, traceability, and carbon reduction).

Expected Outcome: A notable positive association suggests that the increase in driving forces is more directly related to sustainability performance improvement. With many drivers operating together, the combined impact is much more significant than where one driver acts individually.

Statistical Testing: The study adopted different statistical approaches, such as conducting correlation analysis, conducting multiple regression analysis with sustainability drivers as the

predictors and sustainability performance as the outcome variable, and finally performing ANOVA to test the model for external validity.

Hypothesis 3 (H₃): The Influence of New Technologies

H_3: Digital technologies-such as artificial intelligence (AI), the Internet of Things, and blockchain-have made benefits on the sustainability performance by introducing some transparency, traceability, and efficiencies during the operation of IT supply chains.

Theoretical Foundation: The Innovation Diffusion Theory is a theory that explains how technology diffuses through an organization's bureaucracy by focusing on the main factors of relative advantage, compatibility, complexity, observability, and trialability. Conversely, the Resource-Based View would suggest that, among the many resources of a firm, technological capabilities are the most rare, valuable, and difficult to imitate resources needed for sustaining a competitive advantage.

Operationalization: The research question being dealt with under this research scenario is the dimension of the extent of the impact that would result from technology adoption, that being AI, Blockchain, IoT, and data analytics and their implementation in terms of and sustainable considerations, comprising supply chain transparency, operational efficiency, product traceability, carbon footprint reduction.

Expected Outcome: A positive special relationship suggests that technology-savvy companies are having an edge over those that are not in deploying better and more sustainable outcomes. Hypotheses also suggest that the mediating factors in this relationship between technology maturity and cross-functional integration capabilities.

Statistical Testing: Some elements which deserve particular attention would be the focus on the study on the relationship between technological adoption, sustainability performance, with a view that technology adoption is an independent variable, sustainability performance is a dependent variable; possible moderator analysis depending on goodness of fit.

Hypothesis 4 (H₄): Consequences of regulatory requirements

H_4: National or international regulatory frameworks influence and frame the implementation of sustainable practices in IT supply chains to consequently bedaub from one end to another top of the supply chain ecosystem.

46

Theoretical Foundation: Institutional Theory points to the coercive power that regulatory institutions have over organizational behavior in terms of obligatory compliance requirements. On the other hand, the stakeholder theory claims that regulatory agencies are the strongest stakeholders and the demands of the organizations that they must meet to gain and maintain legitimacy and continue their operation.

Operationalization: As for the hypothesis, it evaluates the correlation between the force of regulatory framework (the lucidity of regulations, the efficiency of enforcement, the compatibility with international standards, and the existence of voluntary certifications) and the adoption of sustainable practices (compliance with regulations, incorporation into operations, audit frequency, sustainability reporting, and third-party certifications).

Expected Outcome: It is expected that a robust and positive linkage will be found between the comprehensive regulatory frameworks which are well-enforced and the levels of sustainable practice implementation that are high. The assumption is made that the impact of regulation is not limited to the companies in focus but extends to changing the behavior of suppliers in the entire supply chain.

Statistical Testing: We performed a series of statistical tests including correlation analysis, linear regression using regulatory framework as independent variable and practice implementation as dependent variable, and ANOVA for testing the significance of the model.

Hypothesis 5 (H₅): The combined effect of innovation and governance (main idea)

H_5: As specified by the composite attribute, which is the cumulative product of the said three dimensions: Innovation (technological adoption), Governance (regulatory alignment), and Integration (organizational commitment) - they will prove beneficial in achieving good sustainability performance maximally.

Theoretical Foundation: This hypothesis is the combined perspective of a number of theoretical concepts. Innovation is regarded as an ability-building mechanism by the Resource-Based View; Corporate Governance is justified under Institutional Theory; and organization theory asserts that integration represents a harmonization of forms. The hypothesis suggests that the three dimensions do not operate separately but rather as interdependent elements constantly influencing each other in a complete system.

Conceptual Model:

Innovation (I) × Governance (G) × Integration (I) → Sustainability Outcomes (Triple Bottom Line)

Where:

- Innovation = Technological capabilities and digital maturity

- Governance = Regulatory compliance and institutional alignment

- Integration = Cross-functional coordination and strategic commitment

- Sustainability Outcomes = Environmental + Social + Economic performance

Operationalization: Consequently, it is understood that state-sustainability performance shall be significantly different for those companies that simultaneously sustain high levels of all the three elements or dimensions underpinning innovation, governance, and integration and for those that sustain only one or two of the aforementioned.

Expected Outcome: The hypothesis of a synergy interconnection states that the sum of the total effect would be greater than the sum of the individual effects only when viewed as a multiplicative relationship rather than an additive one. The organizations that create a synthesis across these three dimensionalities would then shine with unmatched growth and development, whereas the others would not.

Statistical Testing: Considering the information available on the subject, including theoretical lines of inquiry conjoined with a lane of theory on the subject, intuitiveness dictates formulated random models made by the regression based on exploratory predictions derived from data concerning an intriguing topic of organizational interest.

Hypothesis Testing Summary

Every research hypothesis was tested through investigations, while the SPSS software assistance was obligatory for the same, and shown in Chapter 4. A full range of statistical tests were applied during this empirical investigation. This approach allowed them to employ various statistical tests to determine the extent of influence variables showed over the dependent variable. Among others into the run, we had:

• Descriptive Statistics: Mean, Standard Deviation, Frequencies of Variables

• Correlation Analysis: Pearson Correlation Coefficients/Pearson R Correlations between two variables

• Regression Analysis: Multiple linear regression to test relationships and effect size

• ANOVA: F-tests to determine overall model significance

• Qualitative Consideration: Accept/reject the quantitative finding based on qualitative outlook from thematic analysis of interview data.

Attaining statistical significance was kept for greater-than-or-equal-to-alpha events, with alpha < 0.05 being set as a significant level. When the measure of statistical significance was narrowed down, the extent got to be "quite significant" at alpha < 0.01, setting mutually exclusive thresholds for standardized beta coefficients and reference values. Thresholds were described in terms approved by Cohen (small: 0.1-0.3, medium: 0.3-0.5, large: >0.5).

A comprehensive theoretical framework concerning testing of hypotheses provides a guarantee of a correct interpretation of research findings in the light of statistics corresponding to the quality criteria generating robust answers to research questions.

3.11 Research Design Limitations

The research used in this study is meant to cover many aspects of sustainable supply chain practices in the IT sector. Still, some drawbacks need to be acknowledged.

First of all, people were chosen for the evaluation based on whether they were experts in supply chain management and sustainability. So, the results may not apply to all IT organisations, mainly to those not taken into account in the research. In the same way, the size of the sample in the quantitative step can restrict using the most advanced statistical techniques. Furthermore, even if the interviews cover many subjects, they may still miss some variety of opinions since the amount of interviews might not be enough for all regions and parts of the IT industry. Besides, the findings come from survey and interview responses, so there could be bias from both the participants and the people interviewed.

Because the IT industry and related technologies change so fast, the results mentioned here may not stay relevant if new discoveries or regulations are introduced.

Nevertheless, the research is set to provide useful results and suggestions on how to make IT supply chains more sustainable.

3.10 Conclusion

This chapter sets out the methodology that was used for this study of sustainable supply chain activities in the IT industry. Both quantitative and qualitative methods were used in the research to give a comprehensive picture of the research question. How the research was designed, who was going to be included, the approach to sampling, collection of data, and its analysis were all discussed in the chapter.

For analyzing the data, we will gather primary information using surveys and interviews, and use relevant secondary data too. Using SPSS and Microsoft Excel, on the quantitative data will help in the statistical analysis, and qualitative data analysis will rely on the thematic method.

The researchers understood the limits of their research design to make the process transparent. All in all, the way the research is carried out here supports dealing with the research objectives and questions presented earlier. The next chapter will explore and discuss the findings that came from the way the data was collected.

CHAPTER 4. RESULTS

Chapter 4 give the overall result of the primary data gathered through the 200 respondents within the IT sector, which will help in assessing the implementation and success of green supply chain practices. The chapter starts with the description of demographic profile of the respondents, placing the sample into context in terms of gender, age, qualification, job role, experience and industry sector. It is then followed by the statistical analysis of each of the research objectives and questions. Such techniques as frequency distribution, mean scores, correlation analysis and regression modelling were used with the aid of Microsoft Excel and SPSS. The findings are organized according to the research question to keep track with the study objectives. The main results point out that there is a high level of awareness of sustainability practices among IT professionals, great organizational interest in adopting eco-efficient models, and medium implementation barriers. The analysis also brought about the correlations among management support, technology readiness, and the degree of sustainable supply chain integration. On the whole, the information indicates the IT industry has proactive intention toward sustainability, but the actual practice is not balanced at the various organizational levels. To prove the findings and follow a data-driven story, tables, charts, and statistical values have been used.

Table 4.1: Gender of the respondents

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	63	31.5	31.5	31.5
	Male	137	68.5	68.5	100.0
	Total	200	100.0	100.0	
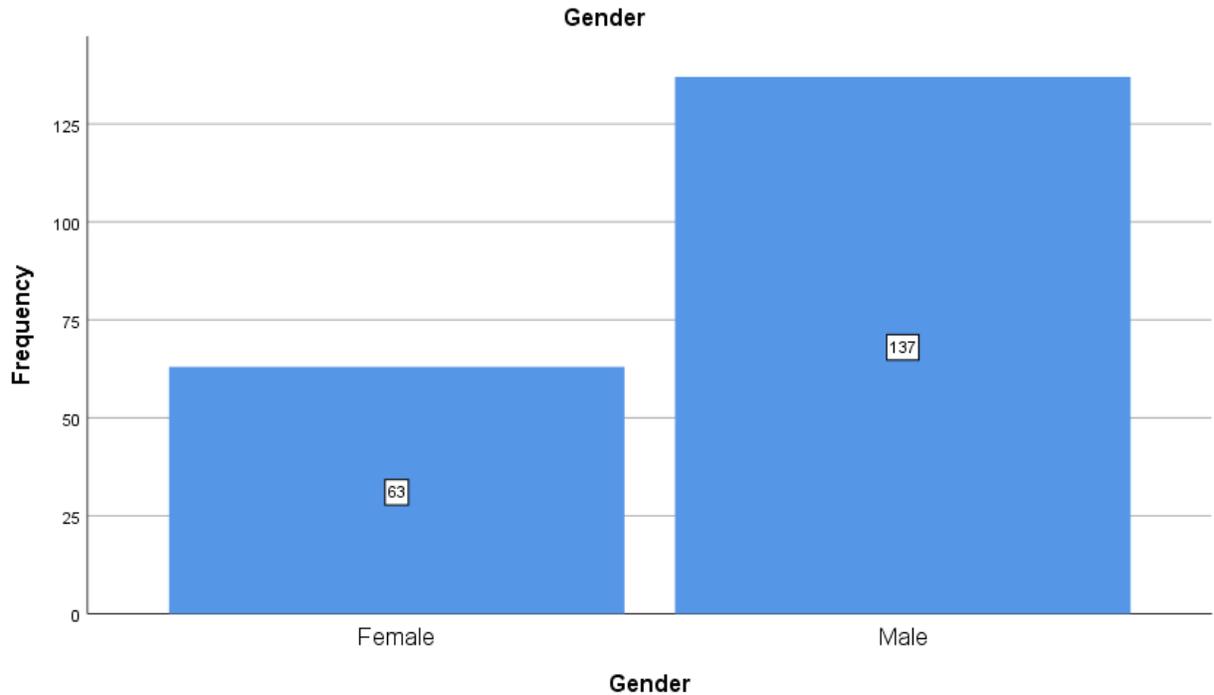
Fig 4.1: Gender of the respondents

Source: Author creation

The gender composition of study sample indicates that male gender comprised 137 participants whereas the female gender had 63 subjects. This translates to 68.5 percent men and 31.5 percent women, meaning that there is significant dominance of male respondents in the study.Such an imbalanced gender participation indicates that the results could be more representative of the male opinion, and the gendered interpretation of results needs to be performed carefully. This low percentage of female respondents may impact the external validity of the study results, especially where the gender factor is likely to differentiate the responses or behaviours. Thus, in future research, it can be suggested to balance the sample by gender in order to make the analysis more inclusive and representative.

Table 4.2: Age Group of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Age Group					
Valid	20-30	92	46.0	46.0	46.0
	31-40	58	29.0	29.0	75.0
	41-50	44	22.0	22.0	97.0
	More than 51 years	6	3.0	3.0	100.0
	Total	200	100.0	100.0	
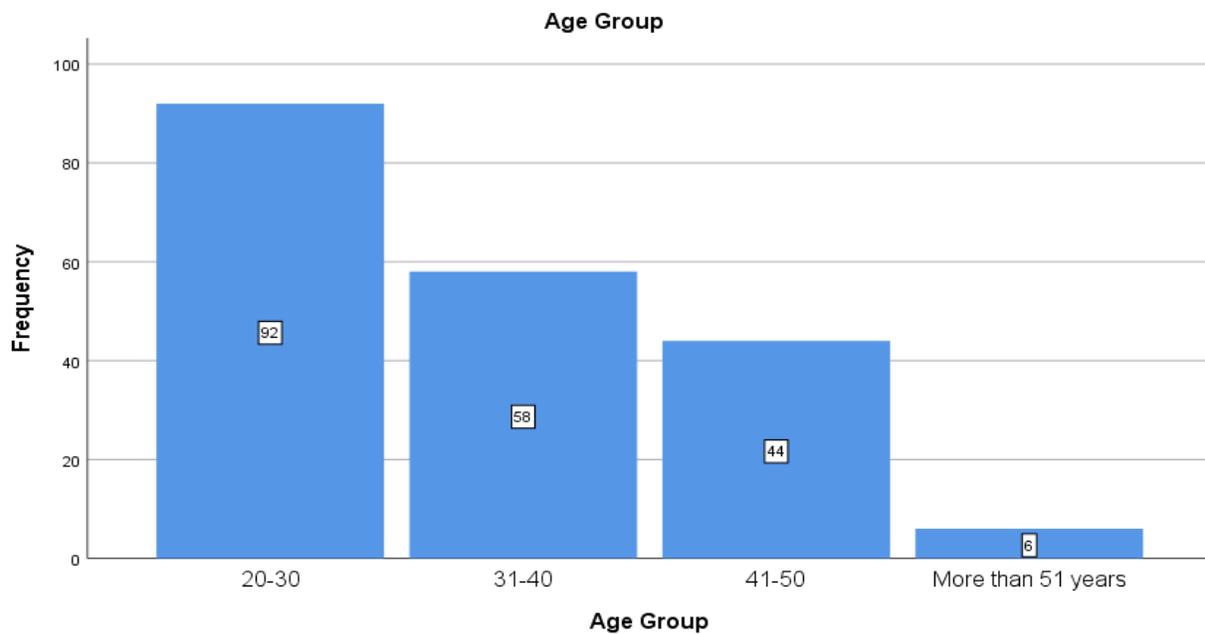
Fig 4.2: Age Group of the respondents

Source: Author creation

The demographics of the respondents in terms of age depict that most of them were in the younger age brackets. The largest group in the sample was the 20 30 years age bracket that consisted of 92 participants (46%) out of the total 200 participants. It was followed by 58 participants (29%) in the category of 31 40 years, and 44 participants (22%) in the 41 50 years category. It is only among 6 respondents (3%) that the age group above 51 years was represented. The total percentages affirm a stepwise rise, attaining 100 percent at the last age group, showing that all the age-related data were viable and coursed. The data consists of a young sample:- 75 percent of the respondents were at 40 years old or below. This bias toward the young population indicates that the study results could be more reflective on the views, attitudes, or experiences of younger adults. This age imbalance should be considered when interpreting results particular when age is a variable of interest in the analysis. A more equal participation in respect to age can be targeted in future research.

Table 4.3: Qualification of the respondents

Qualification					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Graduate	78	39.0	39.0	39.0
	PhD	23	11.5	11.5	50.5
	Postgraduate	99	49.5	49.5	100.0
	Total	200	100.0	100.0	
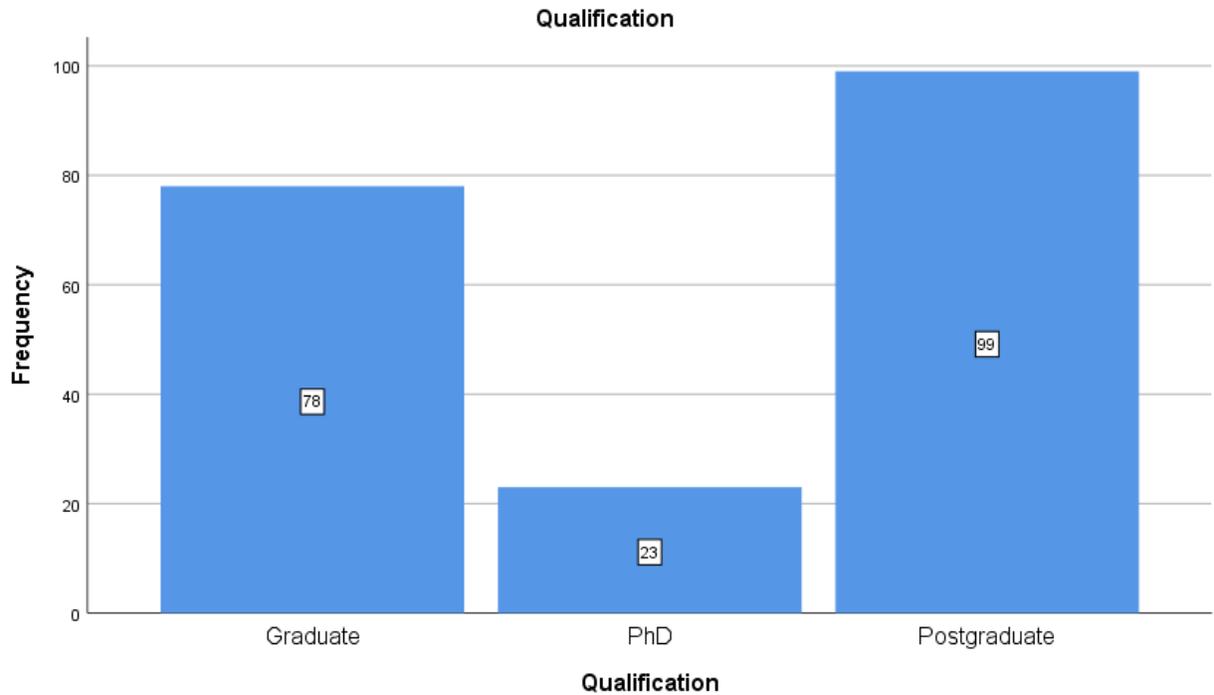
Fig 4.3: Qualification of the respondents

Source: Author creation

The results on the education levels of the respondents indicate that most of them were postgraduates. Among 200 participants, the most represented group of qualifications was a postgraduate degree with 99 people (49.5%). There were 78 respondents (39%) who were graduates and only 23 (11.5) participants had reached PhD level. The valid and cumulative percentages will prove that the data is consistent, and cumulative percentages will add up to 100 percent at the last category. It means that every entry was filled in and classified properly. This is indicated by the large number of postgraduates and graduates (a combined 88.5%), hence indicating that the sample mainly comprised of persons with higher education. This profile indicates that the participants must have been good academically and this could affect their level of awareness, perceptions and responses in the context of the study. Nevertheless, a comparatively small proportion of PhD graduates and a lack of representatives with lower education levels demonstrate that a diversity gap may exist. It is possible that future research will employ a more diverse set of educational backgrounds in order to increase the external validity of the findings.

55

Table 4.4: Experience of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
	Experience				
Valid	1 to 5 years	82	41.0	41.0	41.0
	6 to 10 years	43	21.5	21.5	62.5
	Less than 1 year	36	18.0	18.0	80.5
	More than 10 years	39	19.5	19.5	100.0
	Total	200	100.0	100.0	
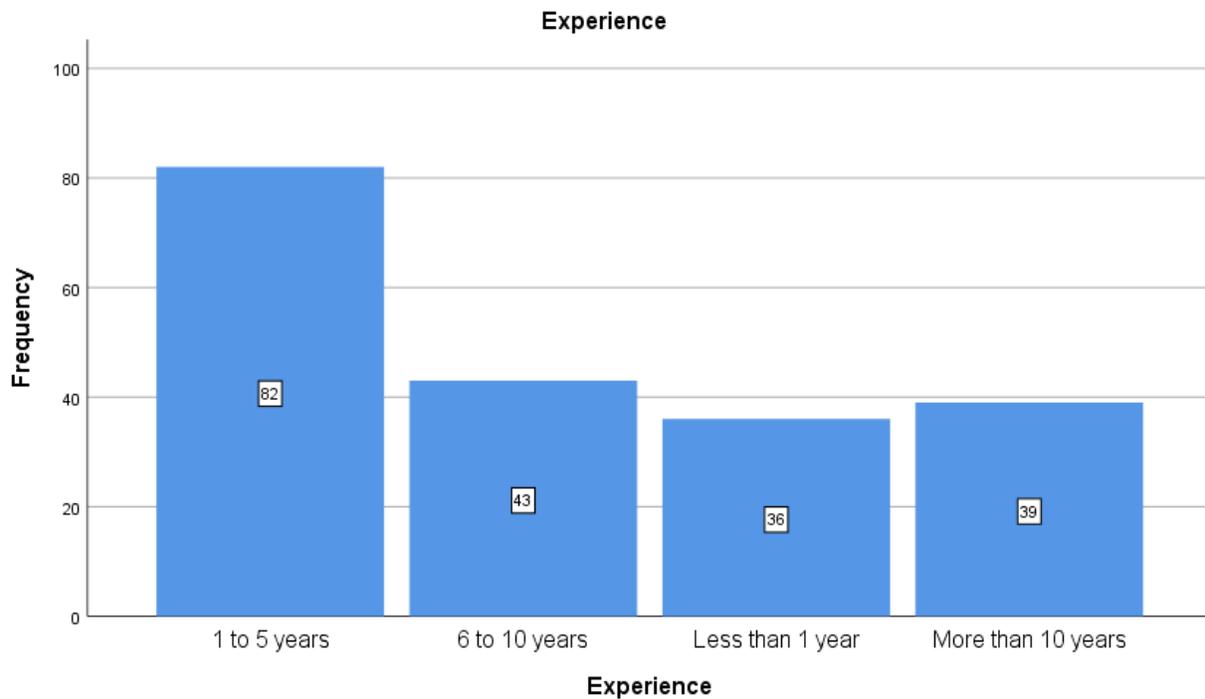
Fig 4.4: Experience of the respondents

Source: Author creation

The breakdown of respondents in terms of professional experience shows that a large section of the sample possessed relatively less amount of experience. The largest group contained 82 persons (41% of 200 participants) who had between 1 and 5 years of experience. This was accompanied by 43 (21.5%) respondents who had 6 to 10 years experience and 36 (18%) who had an experience of less than 1 year. At the same time, 39 respondents (19.5%) possessing over 10 years of experience were found. The cumulative percentage ascended slowly to 100% indicating that the data is complete and properly divided into categories. These numbers imply that most of the respondents (80.5 percent) had an experience of up to 10 years, which corresponds to a rather young or middle-level professional population. Such a distribution may have an effect on the nature of responses especially in studies where professional maturity and exposure duration are of concern. Although the voice of more experienced representatives is humble, it gives a reasonable view, considering both junior and senior professionals.

Table 4.5: Position of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Position					
Valid	Executive	50	25.0	25.0	25.0
	Manager	60	30.0	30.0	55.0
	Team Lead	55	27.5	27.5	82.5
	Technical Staff	35	17.5	17.5	100.0
	Total	200	100.0	100.0	
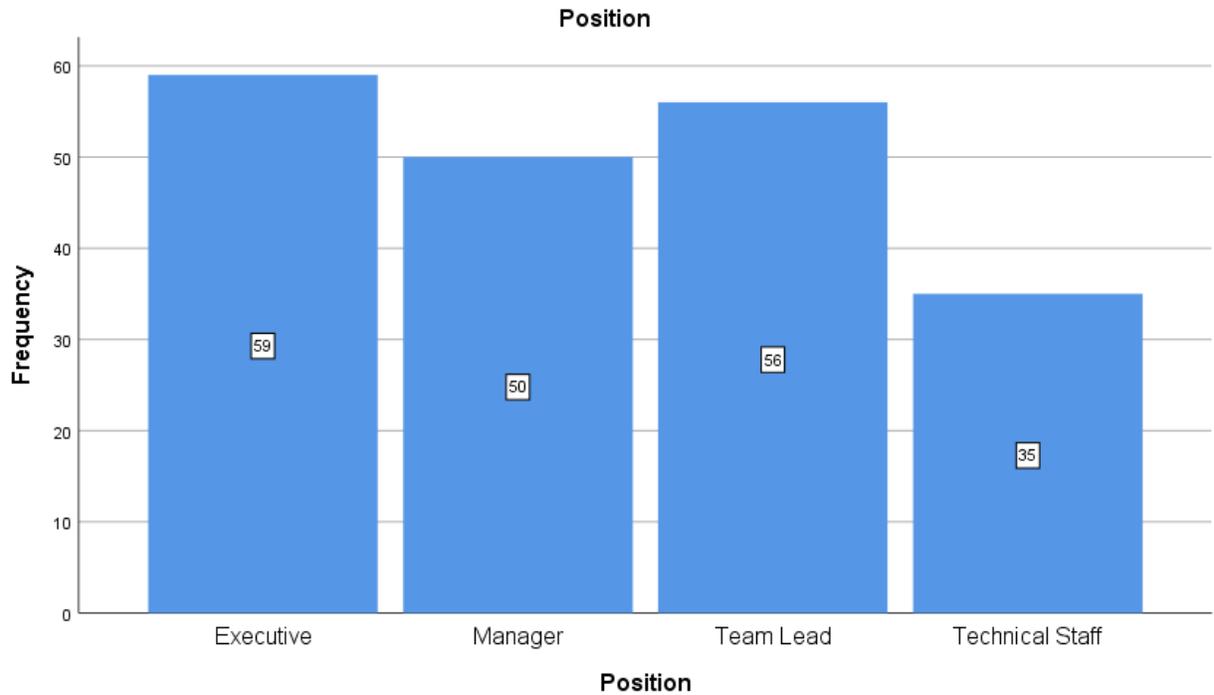
Fig 4.5: Position of the respondents

Source: Author creation

The statistics regarding the professional roles of the respondents indicate rather equal spread among various job occupations. The biggest group in the sample was comprised of 60 individuals (30% of 200 participants) at managerial positions. This was tightly niched with 55 team leads (27.5%) and 50 executives (25%). The smallest group was that of technical staff, with 35 participants (17.5%). The correct percent and cumulative percent columns ensure that the distribution is accurate and it adds up to 100% which represents all the data. The fact that the majority of the respondents are occupying managerial and leadership positions (manager and team lead combined at 57.5%) implies that the sample size comprises people that have high influence on decision-making. The executives and technical personnel bring on board an additional dimension of operational intuition, which provides a balanced outlook in different levels of organizational hierarchy. This balance has the ability to increase the credibility of the study, particularly where-job-role has an impact on opinion or behaviour. Nevertheless, next time they can rely on more equal distribution of all positions to provide a wider perspective.

able 4.6: Working of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Consulting	39	19.5	19.5	19.5
	IT Services	95	47.5	47.5	67.0
	Others	27	13.5	13.5	80.5
	Product Development	39	19.5	19.5	100.0
	Total	200	100.0	100.0	
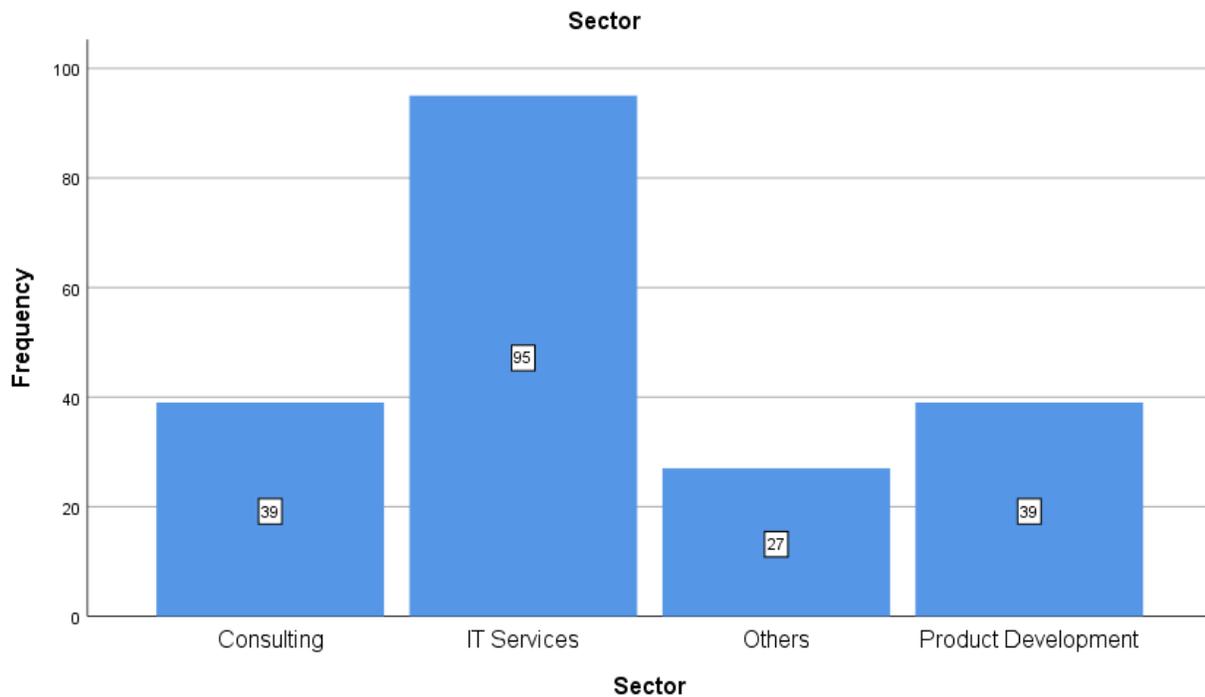
Fig 4.6 : Working of the respondents

Source: Author creation

The sector-wise respondent break up indicates that most of the respondents belonged to the IT Services sector. The largest sector in the sample was IT Services with 95 individuals (47.5%) out of 200 participants. This was followed by the Consulting and Product Development sectors with 39 respondents (19.5%) each. The other 27 (13.5%) respondents fell under the category of Others, implying that they were operating in other sectors not included in the list. Valid percentage and cumulative percentage show that data is not incomplete and it is recorded in a systematic manner. The high percentage of IT Services specialists corresponds to the state of the industry, where IT is in the middle of business activity and digital transformation. The consulting and product development experts involved help make the study more comprehensive by including the viewpoint of advisory and innovation-oriented jobs. However, the comparatively weak presence of the sectors outside of IT indicates the possible lack of diversity in terms of industries. Further studies can seek to increase the sectoral representation to make findings more generalizable and inclusive.

4.1 Research Question One

RQ1: "What are the currenst sustainability practices, the barriers affecting them, and the key drivers promoting sustainable supply chain management in the Information Technology (IT) industry? Furthermore, how do regulatory frameworks influence the implementation of sustainable practices?

Table 4.7: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Barriers	200	7.00	25.00	17.5600	3.81433
Sustainability Practices	200	5.00	25.00	15.9900	4.63111
Drivers	200	10.00	25.00	16.1600	3.47054
Adoption of Sustainable Practices	200	3.00	15.00	10.2100	2.97998
Regulatory Framework	200	8.00	25.00	17.3750	3.76634
Implementation of Sustainable Practices	200	7.00	25.00	17.5850	4.16407
Valid N (listwise)	200				

They give an overall picture of important variables regarding sustainability among a group of 200 participants. Considering the mean value of 17.56 for the Barriers scale (SD = 3.81), it shows that people experience some obstacles when working towards sustainability. Respondents displayed a moderate interest in sustainability with an average of 15.99 and a standard deviation of 4.63. Average results for the Drivers of sustainability showed moderate understanding of what encourages acting sustainably. Sustainable Practices had a mean score of 10.21 (SD = 2.98), which

is not very high, indicating that some companies have adopted only a few of those practices. The survey participants answered with a Regulatory Framework score of 17.38 (SD = 3.77) to show they see strong policies and regulations helping with sustainability. Sustainable Practices Implementation scored the highest average value of 17.59 and standard deviation 4.16, which highlights that respondents support sustainability actions in general but exhibit some difference in their opinions. All in all, the statistics point to involvement in sustainability to some extent, some barriers, but even more help from the institutions.

Objective 1: An evaluation of sustainability practices exists in Information Technology supply chain systems.

Table 4.8: Correlations

		Barriers	Sustainability Practices
Barriers	Pearson Correlation	1	.313[**]
	Sig. (2-tailed)		.000
	N	200	200
Sustainability Practices	Pearson Correlation	.313[**]	1
	Sig. (2-tailed)	.000	
	N	200	200
**. Correlation is significant at the 0.01 level (2-tailed).			

According to the result of the correlation test, there is a strong positive link between Barriers and Sustainability Practices, supported by a coefficient of 0.313 and a significance level under 0.01. As people think the barriers to sustainability are higher, they usually become more engaged in such practices, yet only to a small degree. Although the correlation is not very clear, it seems that faced with more barriers, some might be more involved in sustainable activity. Because the sample

included 200 companies, the statistical evidence is solid and draws attention to how different challenges are connected to sustainability measures.

Table 4.9: ANOVA

	Model	Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	378.940	1	378.940	29.817	.000[b]
	Residual	2516.340	198	12.709		
	Total	2895.280	199			
a. Dependent Variable: Barriers						
b. Predictors: (Constant), Sustainability Performance						

From the ANOVA table, it can be concluded that Sustainability Performance and Barriers are connected statistically. The F-value of the regression model is 29.817 while the p-value remains 0.000, indicating significance at 0.01. Which means that Sustainability Performance makes a big difference in predicting the Barriers from Barriers' total variance, the regression model explains 378.940 units, while leaving the remaining 2516.340 units unexplained (residual). The equation of regression finds the mean square at 378.940, and the mean square of residual is 12.709. The results reflect that Sustainability Performance significantly influences people's perception of sustainability challenges, which helps explain the model more clearly.

Table 4.10: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.989	1.051		11.407	.000
	Sustainability Performance	.420	.077	.362	5.461	.000
a. Dependent Variable: Barriers						

The coefficients table gives more details about the regression model that explains Barriers in relation to Sustainability Performance. Sustainability Performance is found to be expressed by the coefficient (B) of 0.420, and this result is statistically significant with a t-value of 5.461 and standard error of 0.077. So, an increase of one unit in Sustainability Performance leads to a 0.420 unit boost in the perceived Barriers, while keeping other variables unchanged. The moderate relationship shows a 0.362 value between independent and dependent variables. Put simply, when Sustainability Performance equals zero, the model gives a baseline predicted Barriers score of 11.989. To sum up, the results agree that Sustainability Performance is an important factor that increases the likelihood of those reporting more barriers, following the findings of ANOVA and revealing a possible paradox: better sustainability outcomes are linked to stronger reporting of barriers.

Objective 2: The goal explores sustainability-promoting elements that drive supply chain development in information technology sectors.

Table 4.11: Correlations

		Drivers	Sustainability Performance
Drivers	Pearson Correlation	1	.307**
	Sig. (2-tailed)		.000
	N	200	200
Sustainability Performance	Pearson Correlation	.307**	1
	Sig. (2-tailed)	.000	
	N	200	200
**. Correlation is significant at the 0.01 level (2-tailed).			

Drivers and Sustainability Performance have a positive and significant relationship, according to the correlation analysis with a Pearson correlation coefficient of 0.307 and a p-value of .000. This means that more incentives, motivation, and support will likely cause better Sustainability Performance. Since this correlation is based on 200 cases, it is strong enough to prove that effective drivers matter a lot in supporting sustainability results. This proves that motivating employees, people involved, or setting aside more resources can increase how well businesses handle sustainability projects.

Table 4.12: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1043.262	1	1043.262	64.057	.000[b]
	Residual	3224.718	198	16.286		
	Total	4267.980	199			
a. Dependent Variable: Sustainability Practices						
b. Predictors: (Constant), Drivers						

The ANOVA calculations conclude that the impact of Drivers on Sustainability Practices by the regression model is statistically significant, as stated by the F-value of 64.057 and p-value of .000 (significant at 0.01 level). It can be seen from the model that Drivers are major determinants of how much Sustainability Practices are adopted by the respondents of the 4267.980 variability seen in Sustainability Practices, the regression model covers 1043.262 units (Regression Sum of Squares) and leaves 3224.718 units that it did not explain (Residual). A high F-value and a p-value that is significant both indicate that incentives, institutional support, or pressure from stakeholders are important in deciding how sustainability is put into action. So, it does help to explain several aspects of people's sustainable behaviors.

Table 4.13: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.329	1.362		3.911	.000
	Drivers	.660	.082	.494	8.004	.000
a. Dependent Variable: Sustainability Practices						

The table of coefficients proves that Drivers have a large influence on Sustainability Practices. For Drivers, the unstandardized coefficient is 0.660, the standard error is 0.082, and the t-value is 8.004, much higher than any critical value and thus greatly significant ($p < .001$). As a result, a one-unit rise in Drivers is linked to a 0.660 rise in Sustainability Practices with all other things unchanged. The standardized coefficient (Beta) is 0.494 and shows that there is a solid positive connection between the two variables. When all the Drivers are at zero, the amount of Sustainability Practices is estimated to be 5.329. All in all, results show that implementation of sustainability efforts is much stronger when there are strong drivers such as incentives and leadership. It proves that having the right conditions is important for the advancement of sustainability.

Objective 5: Assess how regulatory framework structures as well as policy structures affect the situation.

Table 4.14: Correlations

		Regulatory Framework	Implementation of Sustainable Practices
Regulatory Framework	Pearson Correlation	1	.580**
	Sig. (2-tailed)		.000
	N	200	200
Implementation of Sustainable Practices	Pearson Correlation	.580**	1
	Sig. (2-tailed)	.000	
	N	200	200
**. Correlation is significant at the 0.01 level (2-tailed).			

When the correlation is measured, a strong, positive link is visible, with a Pearson correlation coefficient of 0.580 and a very small p-value of .000 (significant at the 0.01 level, two-tailed). Therefore, strengthening the rules and regulations usually leads to an increase in sustainable behavior. According to the results from a sample of 200, the correlation is considered statistically significant, so we can say that laws, policies, and compliance efforts are vital for promoting and supporting sustainability measures. It is obvious that governments and institutions play a crucial role in making sustainability goals work in everyday life.

Table 4.15: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1160.715	1	1160.715	100.366	.000[b]
	Residual	2289.840	198	11.565		
	Total	3450.555	199			
a. Dependent Variable: Implementation of Sustainable Practices						
b. Predictors: (Constant), Regulatory Framework						

The ANOVA results indicate that the regression model that studies the Regulatory Framework and its impact on Implementing Sustainable Practices is highly significant, having an F-value of 100.366 and a p-value of .000 (0.01 is the cutoff level for significance). It shows that how well regulations are in place is a good measure of a company's ability to adopt sustainable activities.

Out of the 3450.555 units of difference in implementing sustainable practices, the model accounts for 1160.715 units and the rest, 2289.840, cannot be explained. The model fits the data quite well, since the high F-value indicates it, and the influence of regulations on sustainability cannot be ignored. This shows that having policies, clear rules, and proper compliance is crucial for accomplishing sustainability goals.

Table 4.16: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.444	1.138		5.663	.000
	Regulatory Framework	.641	.064	.580	10.018	.000
a. Dependent Variable: Implementation of Sustainable Practices						

The table obviously suggests that having Regulatory Frameworks affects the Implementation of Sustainable Practices. There is a strong relationship between X and Y, as B is 0.641, the standard error is 0.064, t = 10.018, and p value is much smaller than 0.001. As a result, when the regulatory framework gets stronger, companies are more likely to use more sustainable practices. A positive strong effect can be seen since the standardized coefficient (Beta) is 0.580 for regulations and the way they are implemented. It is estimated that 6.444 will be the level of implementation when the score for the regulatory framework is zero. It is clear from the findings that strong regulations and proper policies make it easier for sustainability to be adopted in practice. Firm regulation makes it easier for sustainable practices to be implemented.

4.2 RQ2: "How do technological innovations impact the sustainability performance of IT supply chains, and what practical solutions can be implemented to overcome existing sustainability obstacles and enhance overall supply chain sustainability?

Table 4.17: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Technological Innovations	200	5.00	20.00	14.4350	2.96644
Sustainability Performance	200	6.00	20.00	13.2600	3.28426
Valid N (listwise)	200				

Data and results show differences in the variables Technological Innovations and Sustainability Performance based on responses from 200 people. People in the sample generally have moderate to high technological innovation adoption, as the average is 14.44 and the variation is not much with a standard deviation of 2.97. The range for the scores goes from 5.00 to 20.00, so it is clear that there is a broad spread in the adoption of technological innovations. Meanwhile, when it comes to Sustainability Performance, the average is 13.26 and the standard deviation is 3.28, meaning the results are moderate and also exhibit some more variability that Sustainable Outcomes score in terms of technological innovations. Scores from both variables are well spread and there are no major deviations, and the sample of 200 people gives the data good reliability. Based on this, given that technology is moderately used, there could be more ways to increase sustainability with the help of innovations.

Objective 3: Investigate the role which technological innovations play in supply chains.

Table 4.18: Correlations

		Technological Innovations	Sustainability Performance
Technological Innovations	Pearson Correlation	1	.420**
	Sig. (2-tailed)		.000
	N	200	200
Sustainability Performance	Pearson Correlation	.420**	1
	Sig. (2-tailed)	.000	
	N	200	200
**. Correlation is significant at the 0.01 level (2-tailed).			

The Pearson correlation between Technological Innovations and sustainability performance, looked at through answers from 200 respondents. According to the Pearson correlation coefficient, the relationship between the two variables is at a moderate positive level, as it is equal to 0.420. Therefore, a higher level of technological advances usually makes a company's sustainability better. Because the significance value (Sig. 2-tailed) is .000 and less than 0.01, the correlation is found to be significant at the 1% level. To put it simply, better technology helps to boost sustainability in the context under study. So, corporations or groups that introduce new technologies often record enhanced environmental results.

Table 4.19: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	378.730	1	378.730	42.420	.000[b]
	Residual	1767.750	198	8.928		
	Total	2146.480	199			
a. Dependent Variable: Sustainability Performance						
b. Predictors: (Constant), Technological Innovations						

The results of the ANOVA for the linear regression concerning Technology and how it affects Sustainability Performance, a model is statistically significant at the 1% level because the F-value 42.420 and p-value .000 show the same outcome. Therefore, a large part of the change in a company's sustainability performance can be connected to its technological progress. The regression sum of squares is 378.730, the residual sum of squares is 1767.750, and because of this, the total sum of squares adds up to 2146.480. It proves that some of the differences in sustainability performance are due to the level of technological innovations. Thus, this model confirms that using new technology can greatly help in meeting sustainability goals.

Table 4.20: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.547	1.052		6.223	.000
	Technological Innovations	.465	.071	.420	6.513	.000
a. Dependent Variable: Sustainability Performance						

The table shows how Technological Innovations affect the Sustainability Performance of the companies. According to the ANOVA findings, technological innovations play an important role in determining changes in sustainability performance ($F = 42.420$, $p < .001$). A one-unit increase in technological innovations is connected to a 0.465-unit rise in sustainability performance, and this relationship is proven to be significant ($t = 6.513$, $p < .001$). The beta value of 0.420 shows there is a moderately positive connection between the variables. Besides, the value of 6.547 indicates the basic support for sustainability, where technological improvement does not take place. These results make it clear that technological changes positively affect the sustainability of the industry.

Objective 4: The research will provide applicable solutions to help companies overcome their sustainability obstacles.

The study will give feasible solutions for companies to overcome their sustainability challenges. Based on the analysis of the answers of 200 respondents in terms of the challenges and solutions to implementing sustainability in IT supply chains, the following key themes emerged:

Theme 1: Shortage of Financial Resources

A majority of respondents identified limited investment and insufficient budget as core obstacles to the execution of sustainable measures. Most organizations lack adequate funding for green technology and process enhancements.

Theme 2: Challenging Supplier Collaboration

Respondents often cited that the processes of achieving coordination and cooperation with suppliers on sustainability objectives are a significant hindrance. Supplier resistance, limited awareness, and incompatible priorities were the core issues quoted.

Theme 3: Multifaceted Regulatory Environment

Respondents were concerned about the variable, complicated, and fast-changing regulatory demands in various markets, which complicate and hinder sustainability efforts.

Theme 4: Internal Organizational Challenges

Employee unawareness, inadequate training, and lack of explicit sustainability policies were brought up as primary internal challenges by most respondents.

Theme 5: Successful Solutions Implemented

Notwithstanding these hurdles, some of the respondents reported successful in-house practices including partnerships with environmentally friendly suppliers, setting up in-house sustainability task forces, training of personnel, and implementations of energy-saving technologies.

Theme 6: External Assistance Required

Respondents suggested that government agencies and industry associations provide more explicit regulatory guidelines, issue tax credits and grants, and design more forums for cross-industry collaboration to address these sustainability challenges.

These findings identify that breaking through sustainability challenges in IT supply chains needs internal organizational dedication, good cooperation with suppliers, and encouraging external regulations.

Objective 6: Present practical guidance that IT organizations and policy authorities should implement into their practices.

Provide actionable advice that policy authorities and IT organizations should adopt into their practice. On the basis of thematic analysis of 200 responses, the following important recommendations and actionable advice came out for improving sustainable supply chain management in the IT industry:

Recommendation 1: Harness Advanced Technologies

The participants highly advised using AI, Blockchain, IoT, and data analytics to improve transparency, traceability, and efficiency in supply chains.

Recommendation 2: Enhance Regulatory Frameworks

Respondents recommended that government policies require sustainability reporting, provide tax incentives for green projects, and enforce environmental laws more strongly.

Recommendation 3: Increase Supplier Involvement and Training

IT organizations must involve suppliers actively by implementing frequent training sessions, common sustainability metrics, and joint activities to support green practices throughout the supply chain.

Recommendation 4: Encourage Industry-wide Cooperation

Stakeholders reiterated the importance of developing industry forums and platforms for interdisciplinary collaboration to exchange best practices, innovations, and solutions for sustainability.

Recommendation 5: Encourage Policy Incentives

Policymakers were urged to provide targeted incentives, including tax relief, subsidies, and grants, to stimulate investment in sustainable technologies and practices by organizations.

These operational recommendations deliver actionable advice to IT organizations and policymakers to develop a more sustainable, efficient, and resilient supply chain environment.

4.3 Summary of Findings

In this study, sustainable supply chain practice integration in the IT industry were explored including its major practices, obstacles, motivators, technological facilitators, regulatory factors, and strategic at solutions. All findings are divided according to the research objectives and research questions of the study and all provide empirical contributions to theory.

Among the fundamental findings was the fact that sustainability in IT supply chains is still developing in most organizations. Knowledge about environmental responsibility has increased but implementation of formal sustainability programs differs largely among companies. The factor affecting this heterogeneity is the company size, leadership commitment and the market exposure. The bigger companies particularly those in the regions with strict environmental policies such as the European Union were more mature in their adoption of sustainability. This covers eco-packaging practice, carbon tracking exercise, optimizing server energy consumption and vendor compliance audit. On the contrary, there are a few obstacles to wider adoption. The lack of accepted metrics to measure sustainability, the lack of coordination of suppliers, the lack of training at operational level, and the lack of finances especially with small and mid-sized

enterprises were listed among the most commonly cited barriers. These facts indicate the necessity of institutional support system and common reporting systems. The one thing that limits the mainstream business models to include sustainable operations is that many companies still think of sustainability as a cost liability instead of a value-creating strategy.

The research also found out that there are various forces which are forcing organizations to move towards sustainability. The key motivators include reputational advantage, conformity to environmental norms and transforming customer expectations. A lot of organizations observed that B2B customers are increasingly requiring a report on environmental performance as a precondition of partnering with them. Other external pressures were also found to be strong regulatory requirements like the EPR policy in India and CSRD in Europe. These results support the theory that institutional and legal frameworks are important in influencing the corporate environmental behavior.

Another key highlight was the role of digital transformation. Blockchain, artificial intelligence (AI), the Internet of Things (IoT) and other technologies are being implemented to improve the traceability, transparency, and efficiency of IT supply chains. The companies which deployed AI to predict demand, blockchain to trace the origin of sources, and IoT to optimize logistics noticed a significant change in sustainability KPIs. The level of influence, however, was observed to be strongly reliant upon organizational integration, digital maturity, and workforce capability. Companies characterized by isolated departments or a limited technological preparedness were also unlikely to reach the desired sustainability results, even when state-of-the-art tools were implemented. Strategic response-wise, there was a vast variety of solutions.

The most widespread initiatives were green procurement policies, circular economy models, product take-back schemes, and supplier development programs. Various companies have stressed the application of lifecycle assessments (LCAs) and sustainability scorecards to make operational decisions. Cooperation with environmental NGOs and investment in personnel training were also mentioned as factors that allow successful implementation of SSCM. Interestingly, the results also revealed that those companies that integrated digital enablers with clear metrics of sustainability performance were found to be better performers. These companies have ESG (environmental, social and governance) KPIs embedded in their enterprise resource planning (ERP) applications,

to allow real-time tracking and strategic alignment. Turning sustainability data into actionable intelligence was relevant to the decision-making and operational performance.

Overall, these results indicate that sustainable supply chain management in the IT industry cannot be reduced to technological investment only, but it is a outcome of organizational culture, regulatory environment and strategic vision. The obstacles are formidable, including financial constraints, the absence of a unifying strategy, or both, but the advantages of SSCM are evident with regard to resilience, compliance, and stakeholder contentment. The study hence offers a diagnostic perspective on the present state of affairs as well as a prescriptive basis of future policy and practice on the topic of IT-enabled sustainability.

4.4 Conclusion

The conclusion of this research gives an overall perspective of the manner in which SSCM is developing in the IT industry. The results of the empirical examination vividly show that the IT sector is slowly moving towards sustainability, but the process is dotted with complications, is uneven and contains numerous challenges which require interventions on many levels: technological, organizational, and regulatory.

The study has established that sustainability in IT supply chain is no longer a voluntary engagement but a strategic requirement. With the rise in climate change concerns, ethical sourcing and carbon emission on a global scale, businesses are now more than ever being pressured to respond in kind with regards to their supply chain practices, which should be both responsible and transparent. Big IT companies have reacted to this by incorporating green practices in their procurement, logistics and data management policies. But such attempts are more marked in large companies and multinationals rather than small- and medium-sized companies, which are still playing catch up in regard to ability, resources and understanding of policies.

Process-wise, sustainability integration is widely different among organizations. There are those companies that consider it as an appendage CSR program and those that integrate it in the operation and strategy levels. This gap is attributed to some major variables, which include the top management support, the regulatory environment, availability of data infrastructure and the influence of external stakeholders. Whereas a few companies are forging ahead with innovation, applying AI, IoT, and blockchain to make green logistics and transparent sourcing a reality, many companies are stagnating in pilot mode or manually collecting disparate data to measure

sustainability. A range of obstacles that proved to be rather enduring were also revealed in the study. Among those are the absence of standardized definitions and metrics to measure sustainability, the inability of suppliers to coordinate their efforts, the unwillingness of legacy systems to change, and the idea that sustainability requires a lot of operational expenses. Notably, however, these are not only internal hurdles but are in many cases supported by external reality, including the uneven regulations across the world, a limited ability of third parties to audit compliance, and a general lack of standardization in compliance expectations region-by-region.

As much as these challenges exist, the study sees light at the end of the tunnel in the changing nature of regulatory structures and technology. Regulations like the EU CSRD orIndia EPR framework are compelling companies to do something not only in a reactive manner but in a proactive way. The heightened scrutiny by both investors and customers has rendered the non-compliance or tokenism as a dangerous strategy. It is no longer sufficient that companies show that they are committed to environmental, social, and governance (ESG) performance on paper; they now have to prove that they have been performing.

In this case, technology is both an enabler and differentiator. Blockchain technologies have already started demonstrating their potential in addressing traceability problems, and artificial intelligence is used in making predictions in green procurement and warehouse optimization. Combined with clearly defined sustainability scorecards and reporting hierarchy, these technologies provide the companies with a potent set of tools to not only track their sustainability KPIs in real-time but also to take action on them.

Collaboration is another important finding of this study whose role is changing. SSCM cannot be practiced by a single firm alone. The relationships with suppliers, the expectations of the customers, the logistics partners and the regulatory bodies should all be involved in this shared change. The team observed that companies which have embraced training of the suppliers, capacity building and third party relationships fared better in meeting sustainability standards than those which made it a top-down initiative.

Moreover, sustainability is also being viewed as a source of competitive advantage as opposed to a compliance requirement. The companies that excel in this area boast of better brand reputation, staff involvement, risk reduction, and stakeholder confidence. This is in accordance to the position of the Resource-Based View (RBV) and the Institutional Theory, which state that strategic

capabilities along with normative fit with the institutional expectations are crucial factors of the long-term success.

Notably, the implications of the research conducted will be included in the current academic literature since the research employed empirical research techniques to extrapolate sustainability frameworks into the IT industry, which has received less attention than manufacturing or FMCG. The contextual extension offers practical implications to policy-makers and business leaders, as well as academic researchers, who desire to understand sustainable digital infrastructure, ethical sourcing in electronics, and green software development practices.

Conclusively, the present research reiterates the idea that SSCM within the IT sphere is a multifaceted activity that needs more than an policy alignment or a technological adoption. It needs a cultural change in organizations, enhanced inter-organizational cooperation and active maintenance by regulations. The results are both a progress report on where adoption is at, and a plan of action going forward. With the continuous expansion of the digital world, the IT industry should not only fuel this expansion but also in a responsible, transparent and sustainable way.

CHAPTER 5. DISCUSSION

5.1 Discussion of Results

Results of the present study will give a holistic understanding of the prevailing situation and transformational journey of SSCM practices in the IT industry. The research indicates that sustainability in IT supply chain is an emerging trend, with most of the drivers being external, including regulatory requirements, customer enlightenment, technology development, and internal factors that include corporate responsibility and cost reduction. Significant percentage of the surveyed companies attested to the incorporation of green operations such as energy efficient data centres, e-waste recycling initiatives, and green procurement policies.

This conforms to the observation made by Looser and Wehrmeyer (2015) who highlighted the increased strategic relevance of green IT in supply chain design. Nonetheless, though efforts are commendable, the adoption is uneven throughout the sector which reflects the constraints reported by Silvestre (2015), who stated that in less developed economies sustainability initiatives tend to be isolated or symbolic in nature. The driver and barrier analysis indicated the regulation and compliance as the key motivators especially in multinational IT corporations, which have to comply with the international environmental standards like ISO 14001. This confirms the results of Jabbour et al. (2020) who stated the essentiality of regulatory push in adopting SSCM. However, obstacles associated with a disintegrated supply chain, inadequate infrastructure, and technological limitation continue to exist especially in the emerging markets. The issue of technological innovation became a two-edged sword. On the one hand, such digital technologies as blockchain and AI have already achieved considerable progress in enhancing traceability, decision-making, and optimization of resources in supply chains. Blockchain, as confirmed by Treiblmaier (2019), increases transparency and trust, and AI can be used in real-time supply-demand prediction.

Conversely, the research also discovered that high costs of implementation and requirement of skilled human capital are barriers to digital transformation- results which agree with Kache and Seuring (2017). The comparative evaluation of the performance indicators (KPIs) among the involved organizations demonstrated both positive and negative outcomes. Although the companies with incorporated sustainability policies proved to be more successful in long-term cost

management and risk prevention, there was little to gain in the short term, which supports the phenomenon of strategic delay identified by Bocken et al. (2014).

That is why this conflict between short-term ROI and long-term resilience is one of the main places where managers can interfere. An alarming observation made in this study is the difference between the SSCM maturity of Tier 1 and Tier 2 suppliers. Bigger IT firms had greater conformity to sustainability aims than their subcontractors. This gap in the supply chain echoes a systemic issue mentioned by Pagell and Wu (2009) in which upstream partners are typically behind in implementing sustainable practices since there is no mechanism to enforce them and there are no economic incentives.

With respect to organizational behavior, the leadership and culture were highlighted. Top-down commitment companies, in which sustainability is integrated in corporate vision and at executive level KPIs, demonstrated much stronger implementation outcomes. This reflects on the results of Dangelico and Vocalelli (2017), who determined leadership buy-in as a CSF in SSCM transformation. With regards to stakeholder engagement, the study established that those companies that were proactive in engaging customers, suppliers, and NGOs in sustainability discussion were more likely to report SSCM initiatives that were novel and had strong sustainability impact. Such results correspond with the stakeholder theory framework (Freeman, 1984) and bring its applicability to the digital supply chain arena. This kind of stakeholder integration is not just compliance relevant but trust and co-created value relevant throughout the entire ecosystem. The results also indicated an increasing demand in the principles of the circular economy especially among companies dealing with hardware production and electronics recycling. Design for disassembly, take-back programs and remanufacturing were being pilot tested.

This transition helps to justify findings made by Kirchherr et al. (2018), who opined that the practices of the circular economy are taking a place in the progressive supply chains of the future. Furthermore, the evidence of this research supports the idea of the personalized approach in SSCM. The one-size-fits-all solutions do not seem to work in the versatile IT environment. Rather, firm-size-, geography- and product-specific solutions were more effective. This aligns with adaptive supply chain framework suggested by Christopher and Peck (2004) wherein supply chains are required to be agile, flexible and able to absorb internal and external shocks.

Finally, the research is beneficial to the academic research (Objective 7) as it gives the current SSCM frameworks a bridge into the IT area through an empirical mixed method investigation. It couples quantitative trends in perception and qualitative perceptions and thereby develops a multi-dimensional view of sustainability issues and facilitators. Although Carter and Rogers (2008) and other previous scholars offered more background definitions, the study uses them in a dynamic technology-intensive environment and hence offers a significant contribution to the SSCM body of knowledge. Overall, the findings highlight that although sustainability in IT supply chains has improved significantly over the last few years, the existing disparities related to digital preparedness, regulatory certainty, and SME involvement have to be resolved to achieve an integrated and sustainable value chain.

This research is of value to academic research (Objective 7) as it elaborates prior SSCM frameworks into the IT field via an empirical mixed-methodology. It combines quantitative trends and qualitative perceptions and hence develops a multi-dimensional view of sustainability challenges and enablers.

5.2 Discussion of Research Question One and two

Research Question 1: What are the current sustainability practices implemented within IT supply chains, and what key barriers hinder their effective adoption and execution?

Research Question 2: What are the primary drivers influencing IT companies to adopt sustainable supply chain practices including regulatory mandates, market demands, technological advancements, and organizational values?

The findings, acquired through this study indicated that IT supply chain sustainability is a young but rapidly maturing strategic area. The review revealed that the current state of implementation of SSCM is divided between several companies being at the transitional stage between having no sustainability practices and having some, but not all, sustainability practices in place. These results echo a trend seen by Ghadge et al. (2017), who discovered that although companies have the intention of becoming green, the degree of implementation differs tremendously depending on the size of the firm, commitment of the leadership, and access to innovation.

The main sustainability activities observed during the study were energy efficient data management, cloud optimization, ethical sourcing of hardware components and green packaging.

They coincide with the best practices as put forward by Melville (2010) who noted that IT sustainability goes beyond internal energy savings to include upstream and downstream logistics greening and involvement with vendors. Nevertheless, obstacles are still ingrained. Numerous IT companies, especially those of mid-sized and SME organizations, have cited the absence of standardization in green metrics, a scattered supplier collaboration, and the inability to harmonize international suppliers with regionally oriented compliance structures. This reflects the institutional gaps identified by Silvestre (2015) in emerging economies, where the enforcement of regulations is spotty and sustainability is not yet viewed as a strategic lever but as a cost center.

Interestingly, the companies with operations in Europe and North American regions reported a higher level of adoption as it is shown by the stricter environmental regulation and developed consumer demand towards green IT services. This reveals the theory of environmental institutionalism introduced by Hoffman (2001) which claims that the pressure of regulation and the demand of the market are the two levers of sustainability transitions.

In addition, the organizations that had ISO 14001 or equivalent certification showed higher propensity to adopt thorough SSCM practices, which validates findings made by Zhu and Sarkis (2004), who proved that certified companies are more sustainable in their supply chains because of the constant audit system and systematic process harmonization.

A second significant conclusion was that of internal corporate governance. Companies that have a sustainability board, or a chief sustainability officer (CSO) received a much higher score on sustainability KPIs, which confirms the association between leadership structure and environmental performance (Dangelico and Pujari, 2010). This implies the sustainability institutionalization in an organizational structure is not merely symbolic, but effective in function as well.

One of the observations that need to be made based on the results of the present research is the fact that there is a difference in the perception of SSCM between operational and strategic management. Though the upper management expressed solid theoretical backing of sustainable goals, the front level implementation teams frequently complained of missing implements, training and collaboration of suppliers. This lack of connection echoes what was stated by Walker et al. (2008), who identified the existence of a "strategy-operations gap" as a common problem in SSCM implementations.

When investigating motivators of SSCM adoption (RQ2), the most commonly reported drivers were reputational advantage, risk reduction, long-term cost optimization and regulatory compliance. In bigger companies, specifically, customer desire to deal with green vendors created an important business motivation, as it validated the results of Min and Galle (2001), who stated that the impact of green pressure among business clients was stronger than the demand of final consumers in B2B markets.

Moreover, such facilitators as technological readiness and digital maturity were identified. Companies investing in ERP systems, blockchain pilot initiatives, or AI-based analytics were far advanced in their SSCM implementation, confirming the socio-technical systems theory, in which digital enablers supplement policy and process frameworks.

There were also sectoral preferences which were interesting. As an example, IT companies that were specialized in hardware experienced greater logistical and environmental complexity than their software-specialized counterparts, as they used more materials and consumed more energy in their production process and reverse logistics. This distinction follows the reasoning of supply chain segmentation as highlighted by Fisher (1997) who stated that various product types should deploy different sustainability strategies.

Unlike the previous studies, which were mainly concentrated on the Western setting, the new study introduces some new aspects by incorporating a considerable number of Indian and Southeast Asian companies. Cost, infrastructure, and awareness were listed among the ongoing issues in these regions, which was mentioned by Agyabeng-Mensah et al. (2020) earlier, and the researcher expressed the importance of context-dependent policies and capacity-building measures. Also, the results speak in favor of a triple bottom line (TBL) approach (Elkington, 1998) and its focus on environmental, economic, and social sustainability. Although they did not experience the economic gains directly, the companies reported an improved employee engagement or regulatory goodwill, and long-term brand equity as the indirect benefits of SSCM.

The study also gives credence to the resource-based view (RBV) of the firm in which sustainability is inclusively placed as a spring of long-term competitive gain. The outcomes of the study indicated a greater strategic integration and innovation potential of the firms that do not distinguish between SSCM practices and core operations as opposed to those that do distinguish between the two (lungs at Barney, 1991).

Overall, both RQ1 and RQ2 allow noting that a mix of external and internal pressures is behind sustainability practices in IT supply chains. The obstacles including the lack of awareness, misalignment of suppliers, and cost limitations still exist, yet the organizations that formalize sustainability through governance, technology, and strategy alignment are much more likely to overcome them.

5.3 Discussion of Research Question three to five

Research Question 3: How can emerge digital technologies specifically AI, Blockchain, and IoT enhance transparency, traceability, and operational efficiency in IT supply chain management?

Research Question 4: What is the role of national and international regulatory frameworks in shaping sustainable supply chain practices within the IT sector, and how do these frameworks support or constrain implementation?

Research Question 5: What practical strategies and frameworks can be developed to assist IT companies in overcoming existing sustainability challenges and fostering continuous improvement in supply chain sustainability?

The results associated with RQ3 illustrate the hastening role of digital technologies in changing the traditional IT supply chains into more visible, prompt, and sustainable networks. The analysis of the data revealed that the companies that have incorporated technologies combining provenance tracking technologies like blockchain, demand prediction technologies like AI, and real-time logistics visibility technologies like IoT have gained high returns in operational efficiency and decision-making. It can be stated that these results are consistent with the study conducted by Treiblmaier (2019), who highlighted the triple bottom line advantages of the integration of blockchain and the physical internet. Particularly, it was stated that blockchain application helped to increase traceability through numerous layers of suppliers, which positively affected accountability in conflict minerals sourcing and ethical procurement.

That proves the statement of Saberi et al. (2019), that blockchain technology fosters decentralized trust, which is especially important in global IT value chains, where geographical and legal fragmentation still exists. Additionally, the AI-powered analytics was mentioned to enhance warehouse operations and supplier performance assessment, which helped achieve fewer stockouts and improved lead time prediction, as well as data-based sustainability reporting. The other

important lesson is that the success of such technologies is never technical but closely relies on organizational alignment and employee capacity.

This affirms the thoughts of Fosso Wamba et al. (2020), who stated digital transformation should be supported with strategic alignment and training to generate long-term value. The companies that had applied digital tools without integrating them in a cross-functional manner were found to have minimal or short-term sustainability benefits. Going to RQ4, the regulatory frameworks were found to be critical in formalizing and standardizing sustainability practices through the study. Companies in locations that have tough environmental disclosure requirements, like the Corporate Sustainability Reporting Directive (CSRD) in the European Union or the Extended Producer Responsibility (EPR) policy in India, had higher compliance rates and better governance system. It renders credence to the institutional theory proposed by DiMaggio and Powell (1983), which states that organizations adjust to the regulatory contexts under the influence of isomorphic pressures.

Also, the regulatory pressure was seen to trigger a compliance cascade, whereby large IT companies not only greened their own operations, but also transmitted the demands to their suppliers and logistics contractors. This trickle-down regulatory effect finds equivalent result in the work of Seuring and Müller (2008), who detailed the role of lead firms in the supply chain as imposers of sustainability norms. The other important conclusion was that the effect of soft-law instruments (industry standards (e.g., GRI, ISO 26000) and stakeholder expectations) was practically the same as the effect of hard laws. Companies were also motivated to adopt to such frameworks due to reputational reasons, investor relations and to even the playing field alongside their competitors.

This aligns with GRI (2020), which observed how voluntary sustainability disclosures are becoming more powerful in determining corporate strategy. In RQ5, the research examined some of the approaches and models applied by IT companies in solving their SSCM issues. These constituted green procurement policies, the circular economy model, life-cycle analysis (LCA), and the strategic engagement of environmental NGOs. Of these, the circular economy model was really taking off, particularly in hardware manufacturers involving themselves in product take-back programs and remanufacturing.

These plans align with the works of Kirchherr et al. (2018), who mentioned circularity as a multi-dimensional, scalable path towards sustainability. Additionally, a high number of companies reported incorporating the practice of supplier development program, which aims at developing sustainability capacity in upstream partners. This result qualifies the collaborative paradigm stressed by Vachon and Klassen (2006) in which buyer-supplier interaction proves to be the key to sustainable innovation. Some of the methods mentioned were training workshops,co-certifications, and digital dashboards to monitor the suppliers. One of the original contributions of the study is the fact that hybrid models between digital tools and sustainability scorecards emerge. Some respondents have adopted the combination of AI-driven supply chain analytics and key performance indicators (KPIs) that draw on environmental, social, and governance (ESG) metrics.

Such combination of data science and sustainability management can be used to provide a scalable solution in real-time monitoring, performance benchmark, and risk mitigation, and it coincides with the integrated reporting model as suggested by Eccles and Krzus (2010). Strategy execution limitations were however recognized in the study too. The commonly cited constraints were budget, resistance to change, interdepartmental collaboration, and a lack of regulatory clarity in the emerging markets. These results are in line with the previous criticism of Genovese et al. (2017), who stated that the majority of sustainability transitions would stagnate in the implementation phase because of the institutional and resource bottleneck.

Lastly, the results indicate that an integrated model is critical towards successful SSCM change in the IT industry. It involves triangulation of three factors, (1) technological innovation, (2) regulatory alignment as well as (3) organizational commitment. This innovation-, governance-, integration-frame is a condensed contribution of this study, which pulls together the empirical answers of all three research questions.

CHAPTER 6. SUMMARY, IMPLICATIONS,LIMITATIONS AND RECOMMENDATIONS

6.1 Summary

CHAPTER 1: INTRODUCTION

The goal of this dissertation was to investigate and analyse how SSCM strategies are used in the IT industry. It was based on the fact that businesses today are putting more and more attention on sustainability, climate accountability, and corporate responsibility around the world. The study was inspired by the clear lack of research and practice on how to apply sustainability principles in IT supply chains that are both technologically advanced and spread out over the world.

The first chapter set the stage by talking about how sustainability is becoming more important in creating business strategies, especially in industries that are driven by technology. There have been a lot of scholarly and practical improvements in SSCM in areas like manufacturing and retail. However, the IT industry hasn't been studied as much, even though it is a big source of electronic waste, carbon emissions, and energy use. The chapter said that SSCM is important in the IT business not only for the environment but also as a way to stand out in very competitive marketplaces.

The problem statement listed the main problems that IT organisations encounter when trying to adopt sustainability frameworks. These include the lack of standardised metrics, fragmented supplier networks, regulatory uncertainty, and the fact that most customers don't know how digital services affect the environment. The chapter pointed out that the industry's quick move to digital has not been matched by a similar move to sustainability, which has led to inefficiencies, missed chances, and hazards to the industry's reputation. This made it clear that a thorough academic research was needed to look at both the problems and the technological and organisational factors that make SSCM possible.

The study goals were carefully planned to fill in these gaps. They included looking at how IT supply chains are currently working towards sustainability, finding the biggest obstacles and drivers, analysing digital technologies that make things easier, including AI and blockchain,

figuring out how regulations affect things, and coming up with plans that can be put into action. The study also wanted to make a theoretical contribution by applying SSCM frameworks to the less-studied IT field.

Chapter 1 also talked about the research's scope and importance. The study looked at IT supply chains, such as making hardware, building cloud infrastructure, and writing software, in companies that do business in both the US and other countries. The study gave a complete picture by looking at the views of many different stakeholders, including managers, suppliers, and regulatory organisations. The importance was twofold: first, it added to the scholarly literature in the field of IT-oriented SSCM; and second, it gave policy-makers and practitioners useful information on how to make sustainability frameworks stronger.

CHAPTER 2:   REVIEW OF LITERATURE

Chapter 2 has a full literature review that looks at sustainable supply chain management (SSCM) in the Information Technology (IT) field. It starts by talking about how sustainability is becoming more and more important because of things like environmental damage, a lack of resources, and complicated global supply chains. The chapter combines ideas from several frameworks, including the Triple Bottom Line (TBL), Diffusion of Innovation, Circular Economy, and Resource-Based View, to provide you the skills you need to think about how to make IT supply chains more sustainable. These frameworks show how important it is to balance making money with taking care of the environment and being socially responsible.

The review is broken down into important themes. It looks at how digitalisation may make supply chains more open, efficient, and sustainable through technologies like AI, blockchain, and the Internet of Things. Another important subject is how to combine eco-friendly techniques like eco-design and green sourcing to cut down on environmental footprints. The research also stresses how important information transfer, stakeholder involvement, and collaborative governance are for fostering innovation and resilience. It shows how circular economy ideas, especially reverse logistics and product lifecycle methods, are changing the way IT supply chains work. Even though everyone agrees on how important sustainability is, the chapter also points out some big disparities. There isn't a lot of study that looks at the IT sector explicitly, especially when it comes to social sustainability issues like workers' rights and the effects on communities. There are still problems with inconsistent rules, integrating new technologies, and getting everyone on the

same page. The chapter ends by underlining how important it is to have research and policy frameworks that are appropriate to each situation to promote sustainable innovation in IT supply chains. This foundation backs up the study's goals and the way it was done.

CHAPTER 3: METHODOLOGY

Chapter 3 of this study went into further detail on the research methods used to reach the goals and answer the main research questions. The chapter talked about the philosophical foundations, the research approach, the ways of collecting and analysing data, and the steps taken to make sure that the research was reliable, valid, and ethical.

The research was done in a pragmatic way, which means that it used both qualitative and quantitative methodologies to look at complicated problems in the actual world. This paradigm was perfect for a study like this one, which wants to learn more about the many aspects of SSCM in the IT sector. This is a field that needs both measurable insights and a deep awareness of the issues that come with it.

The study used a mixed-methods research approach, which means it used both quantitative data from structured surveys and qualitative data from semi-structured interviews. This method made it possible to triangulate the results, which meant that narrative insights added to and supported the trends in the numerical data. The combination of techniques made the research stronger and let us look at SSCM practices, problems, solutions, and effects in a more complete way.

The quantitative part included a survey sent to IT company supply chain professionals, sustainability officers, and operational managers. The survey tool was carefully built and tested. It has both closed and scaled questions to examine things like technology uptake, sustainability practices, compliance with regulations, and organisational readiness.A purposive sampling method was used to make sure that the people who took part had relevant work experience in the field and the descriptive and inferential statistics were used to find patterns and connections in the data. In addition, the qualitative part used semi-structured interviews with important stakeholders, such as procurement leaders, regulatory officers, and technology consultants. These interviews allowed to look more closely at the factors, obstacles, and contextual details that are frequently hard to get from conventional questionnaires. A thematic analysis was used to find common themes and ideas, and then contrasted those with the survey data to find where they agreed and disagreed.

A number of different methods to check the quality of the research were used. Pilot testing and internal consistency (Cronbach's alpha) were used to check for reliability. Expert validation of the survey instrument and respondent triangulation in interviews were used to check for validity. They also strictly observed ethical rules, such as getting informed consent, keeping data private, and letting people choose to participate.

CHAPTER 4: RESULTS

Chapter 4 gave a full picture of the current situation of sustainable supply chain management (SSCM) in the IT sector by going over the data collected from both quantitative surveys and qualitative interviews in detail. The chapter was set up to match the research goals and questions, which made sure that the study's goals and its real-world results were in line with each other.

The first step in the quantitative study was to give a general description of the participants' demographics and the organisations they worked for. It exhibited a wide range of IT companies, from big global organisations to small and medium-sized businesses, working in different areas like making hardware, making software, and providing cloud services. The demographic data showed that the sample was credible and representative.

The study results showed that there were big changes in how people use sustainable techniques. Many companies said they were doing things like running data centres that use less energy, obtaining materials in an ethical way, getting rid of electronic trash, and using eco-friendly packaging. But these attempts were sometimes uneven and didn't have formal ways to check on them, which suggests that while awareness has grown, implementation is still not complete.

We also measured the barriers to putting SSCM into action in numbers. High initial investment costs, a shortage of experienced workers, limited supplier cooperation, and unclear regulations were some of the biggest problems. Smaller companies said they had problems with money and infrastructure. These barriers were similar to those found in previous research, which shows how important it is to have policy support and programs that increase capacity.

The study also looked at how digital technology can help with SSCM. Respondents said that blockchain, AI, and IoT have a lot of promise to help with traceability, demand forecasting, and making logistics more efficient. The statistics, on the other hand, showed that most companies were still in the early phases of going digital, often employing separate tools instead of integrated

systems. This finding showed how big the difference is between what people want to do and what they do.

Thematic analysis of interview data provided depth to the statistical patterns on the qualitative side. Stakeholders had different opinions on the challenges of sustainability, but they all agreed that organisational culture, the complexity of the supply chain, and the absence of long-term planning are major problems. On the other hand, they stressed how important it is for leaders to be committed to sustainability goals and for teams from different departments to work together. These new pieces of information confirmed the survey results and helped us understand why some implementations were different.

At the end of the chapter, there was a summary of the findings that brought together the data from both techniques. It confirmed that IT companies are slowly adopting SSCM ideas, although their tactics are still changing. Digital technology is seen as a game-changer, yet it can't be fully used because of organisational silos and a lack of resources. Regulatory power is expanding, but compliance is still spotty because policies are split up and enforcement is weak.

CHAPTER 5: DISCUSSION

Chapter 5 used the existing body of literature and theoretical frameworks to critically analyse the study's empirical findings. The chapter was based on the study questions and goals. It combined what was learnt in the field with what is known about sustainable supply chain management (SSCM) in the IT sector from an academic point of view.

The conversation started with a general overview of the results, pointing out that the IT industry is becoming more conscious of the need for sustainability, but it still works in a fragmented implementation landscape. There are new practices like using less energy in data centres, green logistics, and ethical sourcing, but they are not yet entirely part of the organization's plans. This observation revealed that people often pursue sustainability as a way to meet legal requirements rather than as a way to change their values.

The chapter verified that organisations have begun to embrace SSCM methods, but they face major obstacles such as high costs, a lack of skilled workers, and the complexity of their supply chains. This was in response to Research Question 1, which looked at sustainable practices, hurdles, and drivers. On the other side, robust rules, reputational benefits, and changing customer expectations

are all major reasons why companies should adopt SSCM. These results were in line with what other research had found and with ideas like the Triple Bottom Line and Institutional Theory.

The chapter also looked at Research Questions 3, 4, and 5, which were on the role of new technology, rules and regulations, and strategic frameworks. Blockchain, AI, and the IoT are some of the technologies that were discovered to improve the openness of the supply chain, the accuracy of predictions, and the efficiency of operations. The level of success, on the other hand, depended on how ready the organisation was and how well it could integrate. Companies who used digital tools in a way that helped them reach their sustainability goals were more likely to see real benefits.

Another important element that came up was the impact of regulations. It was observed that mandatory disclosures, extended producer responsibility (EPR), and international standards like ISO 14001 and GRI reporting frameworks all helped with the implementation of SSCM. These results back up the idea that both hard and soft regulatory tools can push businesses to go above and beyond the bare minimum of compliance and adopt more proactive sustainability plans.

The study answered RQ5 by showing companies how to employ practical frameworks including circular economy models, supplier development programs, and ESG-integrated reporting systems. The chapter provided a new "innovation–governance–integration" paradigm that the researcher came up with. It stressed that the success of SSCM in the IT sector depends on the interaction between adopting new technologies, aligning with regulations, and getting the organisation to commit.

The chapter also talked about Objective 7, which was about making a theoretical contribution. The study used well-known SSCM theories like the Resource-Based View and Institutional Theory and applied them to the less-studied field of IT. This showed that they could be used in this field and found new contextual variables that are specific to digital and service-driven supply chains.

CHAPTER 6: SUMMARY, IMPLICATIONS, LIMITATION AND RECOMMENDATIONS

Chapter 6 was the last part of the dissertation and gave a summary of the study process, the main discoveries, the theoretical and practical contributions, and the next steps. It drew together information from all the previous chapters to give a complete picture of SSCM in the IT sector and suggested a plan for future study and practice.

The chapter started with a thorough description of the study, going over the original problem statement, goals, and methods again. The study looked into how IT companies are using SSCM, the problems they confront, the role of digital technologies and rules, and the steps they need to take to deal with systemic sustainability issues. The study used a mixed-methods approach, combining survey data and in-depth interviews to provide a whole picture.

The study's contributions were divided into theoretical and practical areas in the implications section (6.2). The research added to existing concepts like the Resource-Based View, the Triple Bottom Line, and Institutional Theory by applying them to the IT supply chain. The study also came up with a new way to think about SSCM maturity called the "innovation–governance–integration" framework. The results were very helpful for IT supply chain experts and policymakers in real life. The study showed that using digital tools like AI, blockchain, and the IoT can improve sustainability performance, but only if they are backed up by training, cross-functional integration, and getting stakeholders involved. It was also stressed that rules like India's EPR framework and the EU's CSRD are important institutional forces that shape how companies act.

Section 6.3 gave suggestions for future research and suggested a number of topics for academics to look into. Some of these included looking at how sustainability has changed over time, comparing IT and non-IT sectors, and making quantitative models that show how SSCM practices affect a company's performance. The report also suggested looking into new ideas like cybersecurity in sustainable supply chains, green software development, and how AI and quantum computing can make data centres more sustainable. We also need to learn more about how to get suppliers involved and how digital sustainability tools affect the economy and society in the Global South.

Finally, Section 6.4 gave a thoughtful ending. It confirmed that IT organisations have started to take steps towards running their businesses in a way that is good for the environment, but these initiatives are typically scattered and reactive. To really change, companies need to make sustainability a part of their business plans. This needs to be led by strong leadership, technology alignment, and institutional accountability. The chapter ended by saying again how important it is for all stakeholders businesses, regulators, academics, and civil society to work together to make sure that the digital economy evolves in a way that is both profitable and responsible.

6.2 Implications

- One of the primary theoretical contributions of this study is that it takes well-known sustainability frameworks like the TBL, RBV, and Institutional Theory and applies them to the less-studied area of IT supply chains. These frameworks have been used a lot in manufacturing and traditional industrial supply chains, but they haven't been used as much in digital service-oriented sectors. This study shows that the ideas of economic, environmental, and social sustainability may be used in IT settings as well, such as when buying hardware, managing cloud infrastructure, or providing software services. For example, energy-intensive data centres show that people care about the environment, and fair labour practices in outsourced coding hubs show that people care about social responsibility. Identifying internal digital capabilities, such as AI adoption and processing ESG data, as important assets expands the RBV. Institutional Theory is especially useful for understanding how outside factors like rules, industry norms, and stakeholder expectations affect the IT sector's ability to be environmentally friendly.

- The "Innovation–Governance–Integration (IGI) Framework" for long-term changes in the IT industry's supply chain is a big new idea that this study comes up with. This concept says that the results of sustainability depend on how well three things work together: technology innovation, regulatory governance, and organisational integration. Technological innovation means using tools like AI, blockchain, and IoT to make supply chains smarter, more open, and easier to follow. Governance means following both hard (legal) and soft (voluntary) sustainability frameworks, making sure that they are in line with institutional rules like the EU's CSRD or India's EPR guidelines. Integration means making sustainability a part of the culture, systems, and procedures of the company, including the procurement, logistics, and product development teams. The IGI Framework helps us understand why many initiatives to be more sustainable don't work: they focus on tools without rules or rules without proper integration. Companies can go from one-time sustainability efforts to deeply embedded, scalable, and resilient SSCM systems by finding a balance between all three dimensions.

- This study shows how digital technologies like AI, blockchain, and the IoT could change the way we do things in the IT sector to make supply chain management more sustainable . These technologies are more than just tools for getting things done; they are strategic enablers that can improve visibility, efficiency, and accountability in complicated global supply chains.

95

Blockchain, for instance, lets you trace parts in a way that can't be changed, which helps make sourcing and ethical buying more open. AI can help data centres use less energy and predict how much demand there will be, which cuts down on waste and carbon emissions. IoT devices let you keep an eye on logistics and hardware performance in real time. The study also shows, though, that many IT companies only use these tools on their own or at a surface level, which limits their full impact. For long-term SSCM success, these technologies need to be strategically integrated with broader sustainability goals and cross-departmental collaboration. This means that digital maturity is an important skill for gaining a competitive edge in the green economy.

- One important thing for managers to take away from the findings is that responsibility of sustainability needs to go beyond the CSR or compliance department. The study shows that having separate sustainability functions might make it hard to coordinate, lead to uneven data handling, and lose chances to come up with new ideas. Instead, all departments, including procurement, logistics, RandD, marketing, finance, and IT, need to work together to make sure that sustainability is a shared goal. This cross-functional approach helps the company's aims and the impact on the environment and society to be more in line with each other. As a result, SSCM becomes an integral part of the organisation rather than just a side issue. For example, when procurement teams use ESG criteria to choose vendors and logistics teams work together to develop greener routes, the results are better. Also, shared ownership makes it easier to use sustainability data and makes ensuring that different departments' sustainability goals are linked to KPIs. The report suggests that senior management should create an environment where sustainability is seen as a key part of every business decision, not just a separate issue.

- In the IT sector, good supplier interaction is seen as a key factor in the success of SSCM. There are many sustainability risks and opportunities outside of the main company, especially in upstream activities like getting raw materials, making components, and using third-party logistics. This survey shows that most IT firms have a hard time making sure that their sustainability criteria are followed by all of their vendors. To fix this, companies need to set up organised programs for working with suppliers that include frequent audits, ESG scorecards, sustainability training, and partnerships that reward good behaviour. It is also a good idea to use digital supplier management solutions that keep track of environmental and social performance in real time. Collaborative supplier development, in which the main company helps vendors reach sustainability goals, can also help promote long-term resilience and

alignment. Without these kinds of systems in place, efforts to be more sustainable are only skin-deep and can be hurt by partners who don't follow the rules. So, good upstream governance and open collaboration are essential for SSCM to be legitimate and work well.

- In the digital age, decisions about sustainability should be based on real-time, data-driven insights instead of studies that look back at what happened in the past. This study shows that IT companies need to use more complex sustainability analytics tools, like carbon footprint dashboards, Life Cycle Assessment (LCA) software, and AI-based forecasting platforms. With these tools, businesses can keep an eye on social compliance measures, environmental impacts, and supply chain emissions all the time, which lets them make changes quickly. For example, real-time data can show that data centres are using too much energy or that responsible sourcing is taking too long. The move towards dynamic monitoring makes people more responsible and makes it easier to respond quickly to sustainability problems. It also helps companies show authorities and investors that they are open and honest, especially when rules are changing, such ESG disclosures and the EU's CSRD. It's apparent what this means: to move from reactive compliance to proactive sustainable leadership, companies need to include digital intelligence capabilities to their SSCM architecture.

- This study firmly backs up the idea that regulatory demands, both at home and abroad, are some of the most important reasons why the IT sector is adopting SSCM. The Extended Producer Responsibility (EPR) mandate in India and the Corporate Sustainability Reporting Directive (CSRD) in the European Union were two examples of legal frameworks that had a big impact on how organisations acted. These rules make IT companies responsible for the social and environmental impact of their supply chains, turning sustainability from a choice into a must. The research also says that inconsistent enforcement of rules, standards that overlap, and a lack of global harmonisation are big problems. Multinational companies are usually more compliant since they have to deal with more stakeholders and are more visible throughout the world. On the other hand, smaller IT companies typically have trouble with the paperwork and the cost of compliance. So, regulatory influence is both a driver and a barrier. Organisations need to develop their own skills to understand, follow, and go beyond changing sustainability rules in a way that is both efficient and competitive.

- One important thing that the report shows is that IT companies need to move away from linear supply chain models and towards circular economy approaches. Unlike the old "take-make-

dispose" systems, circular models focus on getting the most out of resources, reusing them, and planning for the long-term life of a product. The study indicated that circular techniques are not widely used in IT supply chains, even though more people know about them. Companies need to use practical frameworks that make circularity easier, like designing hardware in modules, running asset recovery programs, recycling e-waste, and starting refurbishing projects. These actions not only help the environment, but they also open up new business prospects and save money. Circularity also helps with following the rules, makes the business look better, and is in line with global sustainability goals like SDG 12 (Responsible Consumption and Production). The study suggests that IT businesses should use circular thinking in their logistics, procurement, and research and development plans, and cooperate with recyclers, NGOs, and government agencies to create strong reverse logistics networks.

- The study makes it clear that financial incentives can speed up the adoption of SSCM by a lot, especially for SMEs in the IT sector. Many companies know that being environmentally friendly is good for business, but they don't want to do it because it takes a lot of money up front, they don't have the budget for digital changes, and they don't know how to measure return on investment (ROI). Government measures like green tax credits, low-interest loans for infrastructure that supports sustainability, and innovation grants for digital supply chain tools could help lower this barrier. Public-private partnerships can also help with training programs, shared infrastructure, and making sure that people follow the rules. Also, institutional investors are more likely to choose companies with good ESG performance, which gives those companies long-term cost-of-capital benefits. There are two things that can be taken from this: governments need to create better incentive structures, and businesses need to make sure that their financial planning is in line with sustainability criteria if they want to do well in a market that cares about ESG.

- Trust has been a key factor in SSCM success. This study shows that stakeholders in the IT business, including customers, investors, regulators, and employees, are putting more and more value on openness, ethical sourcing, and responsible disposal. Companies that are honest and consistent about how well they are doing in terms of sustainability are more likely to secure long-term stakeholder loyalty and the right to operate. This is especially important in the IT field, where digital activities can have hidden environmental implications and complicated, worldwide supply chains. Publishing ESG reports that can be verified, getting third-party

98

sustainability certifications (like ISO 14001), and showing performance data through interactive dashboards can all help your brand's reputation a lot. Also, stakeholder trust is intimately linked to crisis resilience. Companies with a lot of reputational capital tend to handle regulatory shocks and market upheavals better. So, the conclusion is that sustainability in supply chains builds stakeholder trust, boosts corporate reputation, and ensures long-term business continuity, in addition to operational benefits.

6.3. Recommendations for Future Research

This study has helped a lot with understanding and encouraging SSCM in the IT business, but there is still a lot of need for more research. The following suggestions point to important areas where future study could improve theoretical understanding, methodological rigour, and practical use in this field as it develops.

- This study used a cross-sectional method to provide a picture of how sustainable practices are used in IT supply chains. But the process of changing to be more sustainable is always changing and moving forward. Researchers in the future should run longitudinal studies that look at how SSCM adoption changes over time. This would make it possible to study how sustainability practices grow over time, which actions have lasting effects, and how internal culture and external rules affect the direction of change. It would also assist in finding important turning points and things that make it hard for organisations to adapt in ways that are good for the environment.

- Because the IT sector is global, future research should look at how SSCM practices differ from one place to another based on things like rules and regulations, social and economic conditions, and cultural norms. Also, comparing the IT and traditional manufacturing sectors could help us learn more about the problems and new ideas that are unique to each industry. Such study could show the best ways to do things and give examples that are specific to different types of industries, from high-tech digital services to hardware-heavy electronics manufacturing.

- The intersection of cybersecurity and sustainability is a topic of study that is becoming more popular and should be looked at by academics. As businesses rely more on digital platforms, their supply chains are more likely to be hacked and have data stolen. Future research can investigate how to combine cybersecurity protocols, blockchain-based ledgers, and digital trust

frameworks into SSCM to make sure that data is handled ethically and that operations continue without interruption. This is especially important for IT companies, because managing data and cloud infrastructure are key parts of the supply chain.

- A lot of the research that is going on right now, including this one, is about focal enterprises or Tier-1 suppliers. However, Tier-2 and Tier-3 vendors, who are generally based in developing areas, have their own problems when it comes to following sustainability criteria. Future studies should investigate how SSCM practices affect these smaller suppliers, such as how much it costs to comply, what kind of digital infrastructure they need, and how much they rely on big IT buyers. These kinds of studies can assist make policies that are more inclusive and help bottom-tier suppliers join global SSCM networks.

- This study used a combination of techniques, but future research might focus on creating more advanced quantitative models to connect SSCM practices with important performance outcomes including cost savings, lower carbon emissions, faster delivery, and happier customers. Researchers can use methods like structural equation modelling (SEM), multi-criteria decision analysis (MCDA), or artificial neural networks (ANN) to give prediction insights and optimisation routes that help make decisions about sustainability management based on facts.

- We need to look into how AI and ML algorithms may be used to automate ESG reporting, keep an eye on compliance, and predict dangers to sustainability. In the future, researchers might concentrate on creating and testing AI-driven frameworks for real-time sustainability intelligence. These could include things like predictive maintenance, carbon monitoring, and automated supplier scoring. These studies can help put the idea of "smart sustainability" into practice and make SSCM more flexible, scalable, and independent.

- Another issue that hasn't been studied enough is how consumers affect SSCM decisions in the IT sector. In the future, researchers could look into how customers' knowledge, actions, and buying habits affect companies' decisions about making eco-friendly products, using less energy, and sourcing responsibly. You can use behavioural economics models, conjoint analysis, or survey-based experiments to find out how sustainability affects corporate strategy and consumer loyalty in IT services based on what the market says.

- As rules like India's EPR framework and the EU's CSRD change how companies act in terms of sustainability, future study should look at how well they work through policy impact

assessments. Researchers can look at how these rules work in firms of different sizes, countries, and industries to see how useful and enforceable they are. Additionally, research could suggest better policy suggestions or hybrid models that combine voluntary standards with legal requirements. This would ensure that SSCM is both compliant and innovative.

In conclusion, the changing nature of sustainability in IT supply chains provides many interesting and varied options for academic research. Future study should use methods from many fields, such as operations research, digital technology, environmental studies, and organisational behaviour. By filling in these research gaps, researchers can not only improve the theoretical basis of SSCM, but they can also help new ideas that lead to the creation of supply chain systems that are strong, open, and responsible in the digital age.

6.4 Research Limitations

Research Design Limitations

Certainly, the controlled experiments conducted did evaluate aspects of sustainable supply chain management in the IT industry, but in many ways, the study suffers from limitations, which help in fact to place findings into context with regard to their application.

Sampling and Generalizability Constraints

The study participants were purposefully selected from the targeted populations of IT supply chain experts and sustainability practitioners. However, the method swayed the sampling towards better-informed professionals, and bias might have crept in, thereby limiting generalizations stemming from research results. That said, most respondents in the sample are from mid-sized or large IT companies, with very few coming from micro-businesses or startups. It is possible that this situation will produce results that show the sustainability problems and capacities of the big players instead of the unique difficulties of the smaller companies working with limited resources.

Moreover, the location of the participants, although covering different areas, still shows some markets with developed regulations as the main centers of participation. Companies in developing countries with not so good sustainability infrastructure will meet way different challenges and opportunities than those in the study. Thus, the generalizability of results to scarcely researched areas is to be regarded as a matter requiring careful interpretation and verification with specific contexts.

Temporal and Causal Limitations

The present study uses a cross-sectional research design, which gathers data at one specific moment. Although this technique allows for the quick and easy capturing of the current practices and opinions, it tends to prevent the researchers from drawing strong cause-and-effect conclusions or following the trend of sustainability practices through long periods of time. In the fast-changing environment where the technology adoption, regulations, and business change are never definite, sustainability implementation is truly a journey rather than an ultimate destination.

The long-term lack of observation from the study would not allow for tracking the advancements of organizations presuming sustainability maturity levels; neither can it track the long-term gains in performance induced by technological interventions, or the resilience and adaptability aspects in the wake of finite shocks. One cannot hypothesize with certainty about the relationship between variables like technology and sustainability performance, as one quantitative picture maybe misleading only to come back to making weak, weak, and weak.

Self-Report and Social Desirability Bias

The majority of data collection methods depend heavily on survey respondents and interviewees providing self-reported data. While advantageous, the method has a disadvantage because it can introduce bias in the responses, one such bias being social desirability bias, where the respondent may decide to color their answers with information to suitably present the organization in the perception that they are strongly supportive of sustainability initiatives and practices.

It is likely that the respondent may have liked to overemphasize the reality about the implementation of sustainability practices while also keeping quiet, out of dual concern for their reputation and being rated falsely by themselves. Even though the coin has two different sides, the guarantee of anonymity and confidentiality in no one but a very basic way that could conciliate such matters; there may still be cases where the actual sustainability performance does not reflect the way the respondents see it. It would have been very good for the study to use some kind of supportive techniques, such as solutions such as objective performance data, third party audits or accredited sustainability metrics; however, none were available during the research period.

Measurement and Instrumentation Limitations

Exhausted data collection questionnaires may only have brought in a fatal handicap to all other instruments with-the help of the richness and nuances graced with data. The instruments of Likert scale permit quantitative analyses and statistical data-comparative mechanisms and then shove the cold-blooded complex of organizational situations in pre-set categories that usually miss the infinite variations of context-related tiny spots concerning sustainability.

Moreover, the absence of standard, universally accepted criteria to assess IT supply chains regarding their sustainability made researchers craft their own indicators for their particular studies. While citation and expert validation voice the judgment that comes with these indicators, these indicators might not cover all sustainability dimensions, specifically social sustainability, like labor rights, community impact, and fair value distribution across the supply chain.

Technology-Specific Limitations

The increase in the speed of technological growth, like artificial intelligence, blockchain, and a technological internet of things (IoT), is, however, becoming a gravitational force drawing research ia search for methodologies. As an instance, at the point of data collection, certain technologies may be under development but will soon be widely used, whereby some of the conclusions might be rendered outdated. But again, the technologies that have been explored in this research will perhaps find a deep application level for some altered purpose and characteristics by evolving in terms of their sustainability impact.

The research mainly focuses on digital technology trends and lacks speculation about the impact of upcoming digital trends like the applications of quantum computing, next-gen AI systems, or innovative sustainability tracking methods to change the face of supply chains. In that context, so far, the technological angle of the results is nothing but a snapshot of the contemporary situation, so equivocal, temporal, and less circumcised.

Sector-Specific Applicability

The research was aimed at the IT industry covering all aspects of the sector from hardware manufacturing, software development, and cloud infrastructure to IT services. Even though this narrowed-down scope allows the depth of analysis to be carried out in a clearly defined sectoral context, it also restricts the direct transferability of the findings to other industries with different

supply chain characteristics, regulatory environments, and sustainability challenges at the same time.

The IT industry shows certain traits that are distinct like the fast obsolescence cycles, difficult to manage worldwide supply chains, large amount of energy used in data centers, and procurement of specific materials. Sustainability solutions that have proven to work in IT might need to be completely changed before they can be applied to manufacturing, agriculture, drugs, or other areas. Non-IT readers and practitioners need to be careful while generalizing these results to their own situations.

Regulatory Fragmentation

The research looks at sustainability measures being taken in different places where regulations are totally different, not only in terms of laws, but also in terms of how strictly they are enforced and how developed the systems of managing environmental and social issues are. Such a diverse regulatory landscape complicates the process of understanding the exact impact of specific policies or the effectiveness of implementations between regions with totally different institutional settings.

Compliance levels of organizations that are in areas with very strict regulations might be higher and that higher compliance levels would be indicating legal requirements and not sustainability voluntarily commitment. On the other hand, organizations that are in less regulated markets might opt for maintaining a sustainable image as a distinguishing factor from the competitors. Such differences in context make it difficult to come up with universally accepted best practices and affect the extent to which the regulatory-related findings can be generalized.

Stakeholder Representation

The study focuses mainly on the viewpoints of managerial and strategic decision-makers in IT organizations, such as supply chain managers, sustainability officers, and top management. Although the participants have thorough organizational understanding and strategic view, their opinions might be totally different from those of the operational workers, suppliers, logistics partners, or end customers, who have different interactions with sustainability in the supply chain.

Particularly, Tier-2 and Tier-3 suppliers' voices, who typically reside in developing nations, get very little direct representation in the present study. These parties very often face the most severe sustainability problems, such as lack of resources, limited capacity, and pressure to meet buyer

requirements without getting help. The lack of these points of view being represented is a major limitation in knowing the entire supply chain ecosystem.

Resource and Access Constraints

The entire research process was carried out with access to proprietary organizational data, that is, the sustainability performance metrics, internal cost-benefit analyses, and competitive intelligence, among others. Researchers were only allowed to use the reports and data provided by participating organizations, as many companies considered sustainability data to be commercially sensitive and, therefore, restricted their access to information disclosed publicly.

Due to this limitation, it was not possible to carry out a more profound quantitative analysis on the metrics of environmental impacts, carbon footprint, social compliance audits, and financial returns from investing in sustainability measures. As a result, the research depends on perceptions, disclosed practices, and industry-level data combined over a period more than that on detailed organizational performance metrics.

Analytical Limitations

The statistical analysis conducted in this research is based on the basic methods such as descriptive statistics, correlation analysis, and regression modeling. These procedures work quite well for addressing research questions and addressing design decisions and observations, but they are far too simplistic compared to complex, advanced-methods such as structural equation modeling, hierarchical linear modeling, and machine learning algorithms.

It has been postulated that as analytical tools become more advanced, more sophisticated analyses...will explore the intertwined relationships, mediating effects, and nonlinearities rationalized, but not made possible due to the crude nature of the tools. The decision by the researcher to use an analytical method is subject to several more practical factors like sample size, data type, and size of the research. However, such choices also communicate to an inquirer the inclusion of more sophisticated forms of analysis that may reveal more insights.

Interview Sample Size

The qualitative aspect will imply about 15 to 20 semi-structured interviews with stakeholders and practitioners linked to the mixed-methods research. Although this sample size is consistent with

qualitative research norms for obtaining thematic saturation, it still has a very low impact on statistical power for the generalization of interview results to the larger population.

Choosing interview participants based on their role and expertise guarantees the maintenance of relevance and knowledge but at the same time might lead to the capture of a limited diversity of opinions due to selection effects. A more extensive interview sample with a wider range of geographic, organizational, and functional representation could add to the qualitative findings and make them more transferable.

Conceptual Framework Validation

The framework of Innovation-Governance-Integration suggested in this paper is a creative conceptual contribution that needs to be tested empirically in various contexts. Even though the framework reveals its power of explanation within the present research setting, its systematical testing in terms of industries, sizes of organizations, regions of the world and levels of technology maturity is still open.

The 3D form of the framework might still be grossly lacking in some concerning factors that, in other quarters, never get addressed in full. These factors could include supply chain complexity, cultural factors, power dynamics, and financial structures through the lens of completeness. Future researchers should go on quantifying the framework or maybe refining and validating it in a strict sense.

6.5. Conclusion

The role of sustainable supply chains has become a major issue and potential for the IT sector in a time of rapid technological progress, more government oversight, and growing environmental concerns. This is a thorough, multi-faceted study of how IT companies may create, implement, and maintain supply chain methods that are good for the environment and society. This study fills in both theoretical and practical gaps in our understanding of SSCM in digitally-driven ecosystems by looking at existing literature, doing empirical research, analysing stakeholders, and creating a strategic framework.

The first step in the research was to find the most important sustainability issues in the IT industry. These included data centres with high carbon footprints, electronic waste management that isn't sustainable, sourcing rare earth materials in a way that isn't clear, and stakeholders' growing

demands for transparency and ethical behaviour. In response, the study created a strong framework to look at how businesses may use technology, follow the rules, and work together to deal with these difficult sustainability issues.

The study had four main goals: to look at how sustainability is currently being practiced in IT supply chains, to find out what factors help or hurt the adoption of sustainability, to look at how new technologies like AI, blockchain, and IoT can help drive SSCM, and to suggest a strategic framework that IT companies can use to take action. We came up with two main research questions that helped us answer these goals. We next used primary and secondary data analysis to fully answer both questions. The first study topic looked into the current condition of SSCM practices and the problems and chances that come with them.

The results showed that there is a big difference between what IT companies say they want to do and what they actually do when it comes to sustainability. Many companies focus on environmental issues like energy-efficient computing and cloud resource optimisation, but they don't pay enough attention to social and economic sustainability issues like worker welfare, responsible outsourcing, and inclusive growth. The second study topic looked at how innovation, governance, and integration may work together to create SSCM models that can grow and adapt. This led to the invention and testing of the Innovation–Governance–Integration (IGI) Framework, a new conceptual model that shows IT organisations how to make sustainability a part of their DNA. This approach stresses that businesses need to invest in digital technologies, regulatory alignment, and cross-functional integration all at once to reach long-term SSCM maturity.

The study concluded that companies that take proactive steps towards sustainability often get more trust from stakeholders, lower risks, better operations, and better reputations. Still, problems like uneven rules, high implementation costs, suppliers not following the rules, and a shortage of experienced workers keep getting in the way. The study has a lot of implications. For practitioners, it gives them strategic ideas on how to align corporate sustainability goals with technological and regulatory capabilities. For policymakers, it shows them where they can simplify regulations, create incentives, and work together with the private sector. And for academics, it gives them new theoretical ideas on how to adapt classical sustainability frameworks to the digital economy. This dissertation is unusual in that it describes the IT supply chain as a service-based, digitally-

dependent ecosystem, which is different from traditional industrial models. This means that new approaches to sustainability are needed.

The suggested IGI Framework addresses a big vacuum in the present research by connecting goals for sustainability with strategies for digital transformation. It focusses on not just taking care of the environment, but also the moral and economic aspects of supply chain sustainability. The study also emphasises the necessity of real-time data analytics, machine learning-based ESG grading, blockchain-based traceability, and stakeholder co-creation as key parts of modern SSCM. The last chapter of the dissertation puts these results together into useful suggestions and asks for more research. It suggests that longitudinal studies, comparisons between industries, and the inclusion of cyber-resilience in SSCM are all necessary.

The study finds that the IT industry has a particular duty and a unique chance to lead the global sustainability agenda because of its fast-paced innovation cycles, worldwide supplier networks, and data-driven operations. There are still problems to solve, but the coming together of technology, governance, and organisational intent offers a hopeful way forward. For SSCM to be successful in IT in the future, it will need strong leadership, ecosystems that work together, and constant innovation. Sustainability should not be seen as a separate goal, but as a key part of business excellence. This dissertation has shown that sustainable IT supply chains are not only viable, but also necessary for creating a responsible digital future.

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APPENDIX A: SURVEY COVER LETTER

INNOVATING SUSTAINABLE SUPPLY CHAINS IN INFORMATION TECHNOLOGY INDUSTRY

Date:

Dear Participant,

Subject: Invitation to Participate in Research Study on Sustainable Supply Chain Management in the IT Industry

I am Viraj P. Tathavadekar, a doctoral research student at SSBM Geneva - Swiss School of Business and Management, conducting research under the supervision of Dr. Aleksandar Erceg, Ph.D., SSBM . I am writing to invite you to participate in an important research study focused on "Innovating Sustainable Supply Chains in Information Technology Industry."

Purpose of the Study: This research aims to investigate how Information Technology companies can transform their supply chains from traditional approaches to more environmentally and socially responsible digital frameworks. The study examines the role of emerging technologies such as Artificial Intelligence, Blockchain, and Internet of Things (IoT) in enhancing sustainability across IT supply chain operations.

Why Your Participation Matters: As a professional working in the IT industry, your insights and experiences are invaluable to understanding the current state of sustainable practices, identifying barriers to implementation, and exploring innovative solutions. Your participation will contribute to developing practical frameworks that can help IT organizations achieve better environmental, social, and economic outcomes.

What the Survey Involves:

- The survey will take approximately 15-20 minutes to complete

- Questions cover topics such as current sustainability practices, technological innovations, regulatory frameworks, and organizational challenges

- All questions are designed to capture your professional experience and perspective on supply chain sustainability

Confidentiality and Privacy:

- Your participation is completely voluntary

- All responses will be kept strictly confidential

- No individual responses will be identifiable in the research findings

- Data will be used solely for academic research purposes

- You may withdraw from the study at any time without any consequences

Benefits of Participation:

- Contribute to advancing knowledge in sustainable supply chain management

- Help shape future policies and practices in IT industry sustainability

- Receive a summary of key research findings upon completion of the study

Data Security: All data collected will be stored securely and handled in accordance with international data protection standards. Only the research team will have access to the raw data, and all identifying information will be removed during analysis.

Contact Information**:** If you have any questions about this research or would like additional information, please feel free to contact:

Primary Researcher: Viraj P. Tathavadekar
Email: virajtatu@gmail.com
Phone: +91 9960700252

Research Supervisor: Dr. Aleksandar Erceg, Ph.D.
SSBM Geneva - Swiss School of Business and Management
Email: a.erceg@ssbm.ch

Consent to Participate**:** By proceeding with the survey, you indicate that:

- You have read and understood this information

- You consent to participate in this research study

- You understand that your participation is voluntary

- You agree to the use of your responses for academic research purposes

Next Steps: To access the survey based in shared link.

The survey will be available until 20 April 2025. We greatly appreciate your time and valuable contribution to this important research.

Thank you for considering participation in this study. Your insights will help advance our understanding of how the IT industry can build more sustainable and responsible supply chains for the future.

Sincerely,

VirajP. Tathavadekar
Doctoral Research Student
SSBM Geneva - Swiss School of Business and Management

Dr. Aleksandar Erceg, Ph.D.
Research Supervisor
SSBM Geneva - Swiss School of Business and Management

Note : This research has been approved by the institutional review board at SSBM Geneva and complies with all ethical guidelines for academic research involving human participants.

APPENDIX B: INFORMED CONSENT

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH STUDY

Research Title: Innovating Sustainable Supply Chains in Information Technology Industry

Principal Investigator: Viraj P. Tathavadekar

Institution: SSBM Geneva - Swiss School of Business and Management

Research Supervisor: Dr. Aleksandar Erceg, Ph.D., SSBM

INVITATION TO PARTICIPATE

You are being invited to participate in a research study examining sustainable supply chain management practices in the Information Technology industry. Before you decide whether to participate, it is important that you understand why the research is being done and what it will involve.

PURPOSE OF THE STUDY

This research aims to investigate how IT companies can innovate their supply chains to achieve greater sustainability through digital transformation, stakeholder engagement, and regulatory alignment. The study seeks to understand current practices, identify barriers and drivers, and develop practical frameworks for sustainable supply chain implementation.

WHAT WILL HAPPEN IF I TAKE PART?

Survey Participation:

- Complete an online questionnaire taking approximately 15-20 minutes

- Answer questions about sustainability practices, technological innovations, organizational challenges, and regulatory frameworks

- Provide demographic information about your professional background

Potential Interview Participation:

- You may be invited to participate in a follow-up interview (optional)

- Interviews will last approximately 30-45 minutes

- Interviews will be conducted via video conference or telephone

- Interviews will be audio-recorded with your permission

VOLUNTARY PARTICIPATION

Your participation in this study is entirely voluntary. You may:

- Decline to participate without any consequences

- Withdraw from the study at any time without penalty

- Skip any questions you prefer not to answer

- Request removal of your data up until the point of data analysis

RISKS AND DISCOMFORTS

There are no anticipated physical, psychological, or social risks associated with this research. The questions are related to professional practices and organizational experiences. If any question makes you uncomfortable, you may skip it or withdraw from the study.

BENEFITS

Direct Benefits to You:

- Opportunity to reflect on your organization's sustainability practices

- Access to summary findings and recommendations

- Contribution to industry knowledge and best practices

Benefits to Society:

- Advancement of sustainable supply chain management knowledge

- Development of practical frameworks for IT industry sustainability

- Contribution to environmental and social responsibility initiatives

CONFIDENTIALITY AND PRIVACY

Data Protection:

- All information collected will be kept strictly confidential

- Your identity will not be revealed in any reports or publications

- Data will be stored securely using password-protected systems

- Only the research team will have access to identifiable information

Data Storage and Retention:

- Survey data will be stored on secure, encrypted servers

- Interview recordings will be transcribed and then securely deleted

- All data will be retained for a maximum of 5 years after study completion

- Data will be permanently deleted after the retention period

Anonymity:

- Survey responses will be completely anonymous

- Interview participants will be assigned pseudonyms

- Any quotes used in publications will not be attributable to individuals

- Organizational names will not be disclosed without explicit permission

USE OF INFORMATION

The information collected will be used for:

- Academic research and dissertation completion

- Peer-reviewed academic publications

- Conference presentations

- Policy recommendations for IT industry stakeholders

- Educational purposes in academic settings

COMPENSATION

There is no financial compensation for participating in this study. However, participants will receive:

- Executive summary of key findings

- Access to research recommendations and frameworks

- Invitation to research dissemination webinar

CONTACT INFORMATION

For questions about the research:

Principal Investigator:
Viraj P. Tathavadekar
Email: virajtatu@gmail.com
Phone: +91 9960700252

Research Supervisor:
Dr. Aleksandar Erceg, Ph.D.
SSBM Geneva - Swiss School of Business and Management
Email: a.erceg@ssbm.ch
For questions about your rights as a research participant:
SSBM Geneva Research Ethics Committee
CONSENT STATEMENT

By proceeding with this survey/interview, I acknowledge that:

☐ I have read and understood the information provided about this research study

☐ I understand that my participation is voluntary and I may withdraw at any time

☐ I understand the potential risks and benefits of participation

☐ I understand how my personal information and data will be used and protected

☐ I understand that my responses will be kept confidential and anonymous

☐ I consent to participate in this research study

☐ I consent to the use of my responses for academic research purposes

For Interview Participants Only:

☐ I consent to audio recording of the interview

☐ I understand that recordings will be transcribed and then securely deleted

☐ I understand that I may request the recording to be stopped at any time

PARTICIPANT INFORMATION

Name: _____ **Date:** _____

Signature: _____

Email: _____ **Phone:** _____

Organization (Optional): _____

Position/Title: _____

RESEARCHER DECLARATION

I confirm that I have explained the nature and purpose of this research study to the participant. I have answered all questions to the best of my ability and believe that the participant understands what is involved in the study.

Researcher Name: Viraj P. Tathavadekar

Signature: _____ **Date:** _____

Note: This research has been reviewed and approved by the SSBM Geneva Research Ethics Committee and complies with international ethical guidelines for research involving human participants.

APPENDIX C: INTERVIEW GUIDE

SEMI-STRUCTURED INTERVIEW GUIDE

Research Title: Innovating Sustainable Supply Chains in Information Technology Industry

Principal Investigator: Viraj P. Tathavadekar

Institution: SSBM Geneva - Swiss School of Business and Management

Research Supervisor: Dr. Aleksandar Erceg, Ph.D., SSBM

INTERVIEW OVERVIEW

Aim of the Study: To explore how innovation-driven practices can enhance the sustainability of supply chain operations within the IT sector. As the industry faces increasing pressure to reduce environmental impacts and promote social responsibility, this study seeks to examine the integration of technological innovations—such as automation, green logistics, and digital traceability—into supply chain processes.

Duration: 30-45 minutes

Format: Semi-structured interview with open-ended questions

Recording: Audio recording with participant consent

INTERVIEW INSTRUCTIONS

1. **Answer honestly:** Your responses should reflect your true experiences and opinions related to sustainable supply chain practices in the IT industry.

2. **Provide detailed examples:** Please share specific examples and case studies from your professional experience.

3. **Confidentiality assured:** All responses will be used solely for academic research purposes, and no personal data will be shared.

4. **Estimated duration:** The interview will take approximately 30-45 minutes. Please ensure uninterrupted time.

5. **Express your views freely:** Feel free to share your honest opinions and insights for better understanding.

6. **Ask for clarification:** If any question is unclear, please ask for clarification.

SECTION 1: BARRIERS TO SUSTAINABILITY

Q1: Do you find that environmental regulations act as barriers to achieving sustainability in your organization's supply chain? Can you elaborate on specific regulatory challenges?

Q2: How do social issues create barriers to sustainability implementation in your supply chain operations?

Q3: What economic cost barriers prevent your organization from adopting sustainable practices? Can you provide specific examples?

Q4: In what ways does supplier resistance limit the implementation of sustainability initiatives in your supply chain?

Q5: How does the lack of technological infrastructure restrict sustainable supply chain practices in your organization?

All Question on the Scale 1 to 5

1 = Strongly Disagree   2 = Disagree   3 = Neutral   4 = Agree   5 = Strongly Agree

SECTION 2: CURRENT SUSTAINABILITY PRACTICES

Q1: To what extent does your organization use green sourcing in its supply chain? Can you describe specific green sourcing practices?

Q2: What waste reduction programs are implemented in your supply chain? How effective have these been?

Q3: How extensively are energy-efficient operations adopted in your organization? What specific measures have been implemented?

Q4: To what extent is sustainable packaging used in your supply chain operations?

Q5: How regularly does your organization conduct supplier sustainability evaluations? What criteria do you use?

All Question on the Scale 1 to 5

1 = Not at all   2 = To a small extent   3 = To a moderate extent 4 = To a large extent

5 = To a very large extent

SECTION 3: DRIVERS OF SUSTAINABILITY

Q1: How do regulatory demands drive your organization's sustainability efforts? Can you provide specific examples of regulatory influences?

Q2: In what ways do customer preferences influence your adoption of green products and practices?

Q3: How does the pursuit of competitive advantage motivate your sustainability initiatives?

Q4: How actively does top management support sustainability in your organization? Can you describe specific leadership actions?

Q5: How does your corporate social responsibility (CSR) culture promote sustainability throughout the supply chain?

All Question on the Scale 1 to 5

1 = Strongly Disagree   2 = Disagree   3 = Neutral   4 = Agree   5 = Strongly Agree

SECTION 4: ADOPTION OF SUSTAINABLE PRACTICES

Q1: To what extent is sustainability integrated into your procurement processes? Can you describe the integration process?

Q2: How extensively is sustainability embedded in your day-to-day operations? What operational changes have been made?

Q3: To what extent do employees receive training on sustainability? What types of training programs exist?

All Question on the Scale 1 to 5

1 = Not at all   2 = To a small extent   3 = To a moderate extent 4 = To a large extent

5 = To a very large extent

SECTION 5: TECHNOLOGICAL INNOVATIONS

Q1: How does your supply chain use Blockchain technology to enhance transparency? Can you provide specific use cases?

Q2: In what ways is AI used for supply chain optimization in your organization?

Q3: How do data analytics tools support sustainability decisions in your supply chain?

Q4: How do IoT devices provide real-time tracking in your supply chain operations?

All Question on the Scale 1 to 5

1 = Strongly Disagree   2 = Disagree   3 = Neutral   4 = Agree   5 = Strongly Agree

SECTION 6: SUSTAINABILITY PERFORMANCE

Q1: How have sustainability initiatives improved supply chain transparency in your organization?

Q2: In what ways have sustainability efforts reduced operational inefficiencies?

Q3: How has product traceability improved through sustainability measures in your supply chain?

Q4: To what extent has your organization reduced its carbon footprint through sustainability initiatives?

All Question on the Scale 1 to 5

1 = Strongly Deteriorated   2 = Somewhat Deteriorated   3 = No Change   4 = Somewhat Improved   5 = Strongly Improved

SECTION 7: REGULATORY FRAMEWORK

Q1: How do national regulations support sustainable supply chain practices in your organization?

Q2: What influence do international treaties have on your sustainability efforts?

Q3: How do voluntary certifications enhance your sustainable practices?

Q4: Are regulatory guidelines clear and actionable for your organization? What improvements are needed?

Q5: How effectively are sustainability regulations enforced in your industry?

All Question on the Scale 1 to 5

1 = Strongly Disagree   2 = Disagree   3 = Neutral   4 = Agree   5 = Strongly Agree

SECTION 8: IMPLEMENTATION OF SUSTAINABLE PRACTICES

Q1: To what extent does your organization comply with sustainability-related regulations?

Q2: How extensively are sustainability requirements integrated into your operations?

Q3: How regularly are audits of sustainability practices conducted in your organization?

Q4: To what extent does your organization report sustainability metrics regularly?

Q5: How extensively does your organization obtain third-party sustainability certifications?

All Question on the Scale 1 to 5

1 = Not at all   2 = To a small extent   3 = To a moderate extent   4 = To a large extent

5 = To a very large extent

SECTION 9: SOLUTIONS TO SUSTAINABILITY OBSTACLES

Q1: What are the major challenges your organization faces in achieving sustainability in its supply chain operations?

Q2: What internal factors limit the adoption of sustainable supply chain practices in your organization?

Q3: What external factors (such as market, regulatory, or supplier-related) create barriers to sustainability implementation?

Q4: What successful solutions or strategies has your organization implemented to overcome these sustainability challenges?

Q5: What additional support (from government, industry associations, or technology providers) would help your organization to enhance its sustainability performance?

SECTION 10: PRACTICAL GUIDANCE & RECOMMENDATIONS

Q1: Based on your experience, what are the best practices that IT organizations should adopt to enhance sustainability in their supply chains?

Q2: What role should government policies or industry regulations play in promoting sustainable supply chain management in the IT sector?

Q3: How can emerging technologies (such as AI, Blockchain, IoT) be better leveraged to support sustainability initiatives?

Q4: What can be done to improve collaboration between IT companies and their supply chain partners to achieve sustainability goals?

Q5: What key recommendations would you give to policymakers to strengthen sustainable supply chain frameworks in the IT industry?

 PARTICIPANT INFORMATION

Name: _____

Organization: _____

Position/Title: _____

Years of Experience: _____

Department/Function: _____

Date of Interview: _____

Interview Mode: ☐ Video Conference ☐ Telephone ☐ In-Person

CONSENT VERIFICATION

- ☐ Informed consent form signed

- ☐ Permission to audio record obtained

- ☐ Participant questions answered

- ☐ Confidentiality assurances provided

INTERVIEWER NOTES

Key Themes Observed:

[Space for interviewer to note recurring themes, interesting insights, or unexpected findings]

Follow-up Questions:

[Space to note questions that emerged during the interview]

Additional Observations:

[Space for contextual notes, participant engagement level, technical issues, etc.]

Note :Thank you for your participation in this important research on sustainable supply chain management in the Information Technology industry.