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“Assessing the Impact of Green Supply Chain Initiatives on
Environmental Performance and Regulatory Compliance”

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Patras, Greece, June 2024

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“Assessing the Impact of Green Supply Chain Initiatives on Environmental Performance and Regulatory Compliance”

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“Acknowledgments and / or Dedication”

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Abstract

This thesis examines the impact of Green Supply Chain Initiatives (GSCIs) on environmental performance and regulatory compliance. With the increasing global awareness of environmental issues, businesses are under pressure to adopt sustainable practices. This research explores how GSCIs can enhance environmental performance by reducing waste, emissions, and resource consumption. The study also investigates the role of GSCIs in helping companies comply with strict environmental regulations, thereby avoiding legal penalties and enhancing their market reputation.

The research employs a comprehensive literature review methodology, analyzing data from academic databases like Scopus and Google Scholar. It categorizes GSCIs into key areas such as green purchasing, eco-design, reverse logistics, green manufacturing, and green distribution. By examining these categories, the study identifies the benefits and challenges associated with implementing GSCIs.

Key findings highlight that companies adopting GSCIs experience improved operational efficiency, cost savings, and enhanced brand reputation. Furthermore, GSCIs contribute to regulatory compliance by aligning company practices with international and national environmental standards. The study also discusses future trends, emphasizing the role of technological innovations like blockchain and IoT in advancing GSCIs and promoting transparency and traceability in supply chains.

The thesis concludes that while GSCIs present initial implementation challenges, their long-term benefits in terms of environmental performance, regulatory compliance, and competitive advantage are substantial. The research provides valuable insights for businesses aiming to integrate sustainability into their supply chains, suggesting that ongoing innovation and adherence to environmental regulations are crucial for future success.

Keywords

Green Supply Chain Management, Environmental Performance, Regulatory Compliance, Environmental Regulations, Sustainability Metrics, Sustainable Practices, Carbon Footprint, Supply Chain Sustainability, Green Procurement, Environmental Management Systems

“Αξιολόγηση του Αντικτύπου των Πρακτικών της Πράσινης Εφοδιαστικής Αλυσίδας στις Περιβαλλοντικές Επιδόσεις και τη Συμμόρφωση με τους Κανονισμούς”

Δήμητρα Κωστοπούλου

Περίληψη

Αυτή η έρευνα εξετάζει τον αντίκτυπο των Πρωτοβουλιών Πράσινης Εφοδιαστικής Αλυσίδας στην περιβαλλοντική απόδοση και τη συμμόρφωση με τους κανονισμούς. Με την αυξανόμενη παγκόσμια ευαισθητοποίηση για τα περιβαλλοντικά ζητήματα, οι επιχειρήσεις βρίσκονται υπό πίεση να υιοθετήσουν βιώσιμες πρακτικές. Αυτή η μελέτη διερευνά τον τρόπο με τον οποίο οι πράσινες πρακτικές μπορούν να βελτιώσουν την περιβαλλοντική απόδοση μειώνοντας τα απόβλητα, τις εκπομπές και την κατανάλωση πόρων. Η μελέτη διερευνά επίσης τον ρόλο των πράσινων πρακτικών στο τρόπο που βοηθούν τις εταιρείες να συμμορφώνονται με αυστηρούς περιβαλλοντικούς κανονισμούς, αποφεύγοντας έτσι τις νομικές κυρώσεις και ενισχύοντας τη φήμη τους στην αγορά.

Η έρευνα χρησιμοποιεί μια ολοκληρωμένη μεθοδολογία ανασκόπησης βιβλιογραφίας, αναλύοντας δεδομένα από ακαδημαϊκές βάσεις δεδομένων όπως το Scopus και το Google Scholar. Κατηγοριοποιεί τις πράσινες πρακτικές σε βασικούς τομείς όπως οι πράσινες διαδικασίες αγοράς προμηθειών, ο ανάπτυξη πράσινων υπηρεσιών, η αντίστροφη εφοδιαστικής αλυσίδας, εισαγωγή οικολογικών διαδικασιών στην παραγωγή και τη διανομή. Εξετάζοντας αυτές τις κατηγορίες, η μελέτη προσδιορίζει τα οφέλη και τις προκλήσεις που σχετίζονται με την εφαρμογή των πράσινων πρακτικών.

Τα βασικά ευρήματα υπογραμμίζουν ότι οι εταιρείες που υιοθετούν πράσινες πρακτικές έχουν βελτιωμένη λειτουργική αποτελεσματικότητα, εξοικονόμηση κόστους και βελτιωμένη φήμη της επωνυμίας τους. Επιπλέον, οι πράσινες πρακτικές συμβάλλουν στη

συμμόρφωση με τους κανονισμούς ευθυγραμμίζοντας τις εταιρικές πρακτικές με τα διεθνή και εθνικά περιβαλλοντικά πρότυπα. Η μελέτη εξετάζει επίσης τις μελλοντικές τάσεις, δίνοντας έμφαση στο ρόλο των τεχνολογικών καινοτομιών όπως το blockchain και το IoT και στην προώθηση της διαφάνειας και της ιχνηλασιμότητας στις αλυσίδες εφοδιασμού.

Η έρευνα καταλήγει στο συμπέρασμα ότι ενώ οι πράσινες πρακτικές παρουσιάζουν αρχικές προκλήσεις εφαρμογής, τα μακροπρόθεσμα οφέλη τους όσον αφορά τις περιβαλλοντικές επιδόσεις, τη συμμόρφωση με τους κανονισμούς και το ανταγωνιστικό πλεονέκτημα είναι σημαντικά. Η έρευνα παρέχει πολύτιμες γνώσεις για τις επιχειρήσεις που στοχεύουν να ενσωματώσουν τη βιωσιμότητα στις αλυσίδες εφοδιασμού τους, υποδηλώνοντας ότι η συνεχής καινοτομία και η τήρηση των περιβαλλοντικών κανονισμών είναι ζωτικής σημασίας για τη μελλοντική επιτυχία.

Λέξεις – Κλειδιά

Διαχείριση Πράσινης Εφοδιαστικής Αλυσίδας, Περιβαλλοντική Απόδοση, Κανονιστική Συμμόρφωση, Περιβαλλοντικοί Κανονισμοί, Μετρήσεις Αειφορίας, Βιώσιμες Πρακτικές, Αποτύπωμα άνθρακα, Αειφορία Εφοδιαστικής Αλυσίδας, Πράσινες Προμήθειες, Συστήματα Περιβαλλοντικής Διαχείρισης

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List of Abbreviations & Acronyms

- CSR - Corporate Social Responsibility
- CSR - Corporate Social Responsibility
- EMS - Environmental Management Systems
- GHG - Greenhouse Gas
- GSC - Green Supply Chain
- GSCI - Green Supply Chain Initiative
- GSCM - Green Supply Chain Management
- GSCP - Green Supply Chain Practices
- IoT - Internet of Things
- ISO - International Organization for Standardization
- ISO 14001 - A set of standards put forward by the International Organization for Standardization (ISO). Its purpose is to clarify the best practices for organizations that wish to reduce their environmental footprint by adopting an effective environmental management system (EMS).
- LCA - Life Cycle Assessment
- ROHS - Restriction of Hazardous Substances
- SCM - Supply Chain Management
- SMEs - Small-and Medium-sized enterprises
- UK - United Kingdom
- US - United States
- WEEE - Waste Electrical and Electronic Equipment

1. Introduction

Organizations and researchers are actively seeking new ways to mitigate their impact on the environment while maintaining profitability, as the significance of sustainability keeps increasing. Implementing Green Supply Chain Management (GSCM) is a viable approach to achieve this goal. Environmental considerations are included during the execution of regular supply chain management activities. The thesis titled "Assessing the Impact of Green Supply Chain Initiatives on Environmental Performance and Regulatory Compliance" examines the effectiveness of such initiatives and their effects for organizations.

Global environmental problems like climate change, pollution, and resource loss are getting worse, making it more important than ever for all areas of life to use sustainable practices. An increasing number of companies are becoming aware of the significant effect that their actions are having worldwide and are recognizing the need to take measures to reduce these consequences. Given the circumstances, adopting Green Supply Chain Management (GSCM) appears as an essential approach for firms to operate in a way that is more ecologically sustainable.

Green Supply Chain Initiatives (GSCIs) include a wide range of actions aimed at protecting the environment and promoting sustainable growth throughout the supply chain. Some examples are eco-design, reverse logistics, green manufacturing, green distribution, and green buying. Companies that adhere to these procedures can not only comply with environmental regulations, but also achieve cost savings, enhance their brand reputation, and fulfill the increasing customer demand for environmentally friendly products.

This thesis comprehensively examines the numerous elements of GSCIs and provides a view of their impact on environmental performance and compliance with regulations. This analysis examines prior studies to demonstrate the evolution of these programs over time and categorizes them according to their objectives and goals. Furthermore, the study examines the effectiveness of different types of GSCIs in improving environmental outcomes and ensuring compliance with regulations.

Having a thorough understanding of the advantages and disadvantages of GSCIs is crucial for businesses that are considering their implementation. Possible advantages encompass enhanced adherence to environmental regulations, reduced wastage, and better operational

efficiency. However, there are essential issues that require attention and must be considered. Implementing green technology entails significant initial expenses. Monitoring environmentally sustainable practices throughout the entire supply chain is challenging and assessing and validating the outcomes of Green Supply Chain Initiatives (GSCIs) necessitates accurate metrics.

The thesis aims to provide businesses with insights into sustainable supply chain management, a significant subject. It accomplishes this by conducting a comprehensive evaluation and analysis of the existing literature. This study demonstrates the impact of GSCIs on environmental performance and compliance to legal requirements, highlighting the significance of integrating sustainability into supply chain operations and the potential advantages it can offer.

The findings of this study will assist companies in enhancing their ecological performance and contribute to the implementation of sustainable business practices. The main focus of this thesis is to assess the effectiveness of various Green Supply Chain Initiatives (GSCIs). The goal is to promote sustainable practices among companies and make a positive contribution to global environmental issues.

The primary objective of this thesis is to assess the impact of Green Supply Chain Initiatives on the environment and ensure compliance to regulatory requirements. To analyze the environmental sustainability of corporate processes, a comprehensive overview of these methodologies will be provided, including all advantages and disadvantages.

1.1 Research question

This thesis aims to investigate the effect of green supply chain initiatives on environmental performance and regulatory compliance and assess their potential consequences for the future of supply chain management.

The main research question of the thesis is:

- How do Green Supply Chain Initiatives influence environmental performance and regulatory compliance within organizations?

To improve its accuracy, the research question is accompanied by below sub-questions:

1. How have green supply chain initiatives influenced the environmental performance of companies?
2. What is the impact of green supply chain initiatives on regulatory compliance?

1.2 Purpose of this study

The purpose of this study is to examine how green supply chain initiatives have impacted environmental performance and regulatory compliance by reviewing existing literature. This involves:

1. Historical Overview

This study aims to trace the history of green supply chain initiatives to see how they have evolved and how these changes have shaped supply chain practices. Understanding the key milestones will give context for the current state and future trends in Green Supply Chain Management (GSCM).

2. Analyzing the Impact

Looking at the ways green supply chain initiatives have influenced environmental performance and regulatory compliance, including their effects on company practices, market behavior, and adherence to environmental regulations. This analysis aims to provide a clear picture of both the positive and negative effects of these initiatives.

1.3 Methodology

The study aims to present a historical overview, analyze green supply chain initiatives based on numerous factors, and examine their impact on environmental performance and regulatory compliance. The focus of this thesis provides a comprehensive literature review based on sources in academic databases.

The approach selected for this thesis is a literature review. This allows for an in-depth examination of existing academic literature. A literature review was chosen because it provides a broad understanding of the existing research on green supply chain initiatives.

Data collection involved systematic searches in academic databases such as Scopus and Google Scholar. The search terms included "green supply chain", "environmental performance", "regulatory compliance", "overview of green supply chain initiatives", and related keywords. Inclusion criteria were set to focus on journal articles, books, and authoritative reports mostly published in the last decade, ensuring relevance and currency of the information. The analysis involved organizing the collected literature into different topics based on the research questions. Each topic was reviewed to identify key points, trends, and insights, which were then combined into a coherent narrative.

One obstacle encountered during the research was the vast and rapidly evolving nature of literature on green supply chain initiatives. To address this, a plan was made to collect data by selecting relevant studies based on specific criteria, such as focusing on recent studies and articles from validated sources. Additionally, the large volume of information required careful organization and categorization to ensure all relevant points were included. This was managed by using detailed notes and summaries for each source, which helped to keep the research focused and manageable.

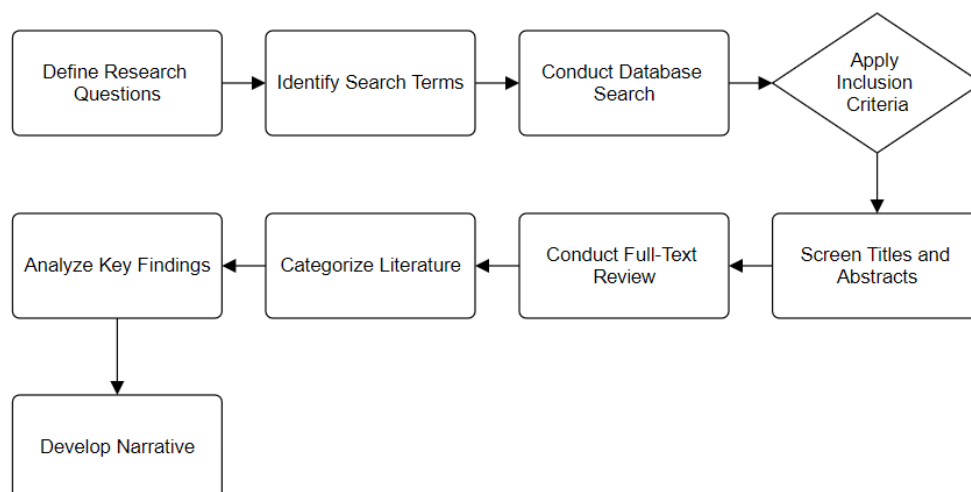


Figure 1: Methodology flowchart describing this research.

1.4 Structure of thesis

This study is organized as follows:

The first chapter introduces the importance of environmental sustainability in supply chain management, presenting the research questions and the purpose of the study. The second chapter traces the historical evolution of GSCIs, discussing the emergence of green supply chains, key milestones, regulatory influences, and case studies. The third chapter offers an overview of GSCM initiatives, discussing green purchasing, eco-design, reverse logistics, green manufacturing, and sustainable distribution, including their adoption by small and medium-sized enterprises (SMEs). The fourth chapter examines regulatory frameworks governing supply chain operations, providing a historical overview, the emergence of environmental regulations, and current compliance frameworks. In the fifth chapter, a bibliometric analysis of Green Supply Chain Management (GSCM) research is conducted, identifying key themes, contributing countries, and leading authors. The sixth chapter provides a comprehensive literature review of Green Supply Chain Initiatives (GSCIs) of the existing literature. The seventh chapter summarizes the key findings, discussing the impact of GSCIs on environmental performance and regulatory compliance, and provides recommendations for future research. The eighth chapter interprets the findings, discussing implications for businesses, policymakers, and researchers, addressing limitations, and suggesting areas for future research.

2. History of Green Supply Chain (GSC) Initiatives

2.1 Background of GSC Initiatives

The implementation of green supply chain initiatives presents both opportunities and challenges. As global awareness of environmental issues grows, businesses are increasingly pressured to adopt sustainable practices. Green supply chain management (GSCM) is crucial as it integrates environmental considerations into supply chain operations, aiming to reduce ecological impact while maintaining economic viability.

Green supply chain initiatives are essential for several reasons. Firstly, they address the urgent need to mitigate environmental degradation caused by industrial activities. Traditional supply chains often contribute significantly to pollution, resource depletion, and greenhouse gas emissions. By adopting GSCM, companies can reduce their environmental footprint and contribute to global sustainability goals. This is particularly important as international agreements and national policies are increasingly mandating reductions in carbon emissions and other pollutants. The environmental benefits of GSCM include improved air and water quality, reduced waste, and conservation of natural resources (Sarkis, 2012; Zhu, Sarkis, & Lai, 2013).

Moreover, consumer awareness and demand for sustainable products are rising. Consumers are increasingly willing to support companies that demonstrate environmental responsibility. This shift in consumer behavior drives companies to implement green practices to enhance their market competitiveness and brand reputation. Companies that adopt GSCM practices can leverage their commitment to sustainability as a unique selling proposition, differentiating themselves from competitors. This can lead to increased customer loyalty, higher sales, and the ability to charge premium prices for sustainable products (Rao & Holt, 2005).

While adopting environmentally friendly practices can lead to increased production costs, these investments are essential for ensuring efficient and responsible supply chain operations. Costs may arise from expanding manufacturing facilities, integrating green technologies, and adhering to strict emission guidelines. For instance, transitioning to renewable energy sources, upgrading equipment to more energy-efficient models, and investing in recycling and waste management systems can require substantial capital outlays. However, these initial investments often result in long-term cost savings through

improved resource efficiency and reduced waste. For example, energy-efficient technologies can significantly lower utility bills, while waste reduction strategies can decrease disposal costs. Over time, these savings can offset the initial expenditures and contribute to a company's bottom line (Zhu, Sarkis, & Lai, 2008).

Green procurement, which involves sourcing greener products and components, plays a crucial role in enhancing the sustainability of supply chains. This approach has led to significant positive outcomes, such as reduced carbon footprints and improved energy efficiency. By prioritizing suppliers who use sustainable practices, companies can create a ripple effect throughout the supply chain, encouraging broader adoption of green practices. Additionally, green procurement can lead to innovation in product design and materials, fostering the development of more sustainable products. Furthermore, green practices have proven to be financially beneficial, generating increased revenues and contributing to job creation. Companies that implement GSCM can attract environmentally conscious consumers and enter new markets that prioritize sustainability. This can result in revenue growth and diversification of the customer base (Walker, Di Sisto, & McBain, 2008).

Effectively coordinating the implementation costs while addressing environmental issues poses a significant challenge. Balancing these aspects is crucial for the long-term success of green initiatives. Companies must develop comprehensive strategies that integrate environmental objectives with business goals. This involves careful planning, resource allocation, and continuous monitoring and evaluation of progress. Additionally, organizations need to foster a culture of sustainability among employees and stakeholders to ensure widespread commitment to green practices. Implementing training programs and incentive schemes can help achieve this goal (Seuring & Müller, 2008).

Compliance with environmental regulations and enhancing brand reputation through green marketing strategies are also critical components. Regulatory compliance is becoming increasingly strict as governments worldwide create policies to protect the environment. Companies that fail to comply with these regulations risk facing high costly fines, legal actions, and damage to their reputation. On the other hand, proactive compliance can enhance a company's image and build trust with consumers, investors, and other stakeholders. Green marketing strategies can communicate a company's commitment to sustainability, attracting environmentally conscious consumers and improving market positioning (Darnall, Jolley, & Handfield, 2008).

Green supply chain initiatives contribute to reducing harmful emissions, conserving energy, and creating job opportunities, thereby fostering innovation in eco-friendly technologies. This supports sustainability in the business sector and advances environmental protection. Companies that invest in green technologies can drive technological advancements and set industry standards for sustainability. Moreover, these practices enhance brand reputation and customer loyalty, as consumers increasingly prefer companies committed to sustainability. Adopting green supply chain practices also helps businesses adapt to regulatory changes and mitigate risks associated with climate change, ensuring compliance with environmental legislation and preparing for future challenges. For instance, companies that reduce their carbon footprint are better positioned to meet future regulatory requirements and avoid potential carbon taxes or trade restrictions (Carter & Rogers, 2008). In conclusion, while there are costs and challenges associated with green supply chain initiatives, the long-term benefits far outweigh the initial investments. Green supply chain practices offer a comprehensive approach to sustainable business operations, enabling companies to protect the environment, support economic growth, and create positive social impacts. By integrating environmental considerations into their supply chains, companies can achieve significant ecological, economic, and social benefits, positioning themselves for success in an increasingly sustainability-focused market.

2.2 Historical Overview of GSC Initiatives

The implementation of green supply chain initiatives presents both opportunities and challenges. As global awareness of environmental issues grows, businesses are increasingly pressured to adopt sustainable practices. Green supply chain management (GSCM) is crucial as it integrates environmental considerations into supply chain operations, aiming to reduce ecological impact while maintaining economic viability.

2.2.1 Early Concepts and Origins

The origins of green supply chain management (GSCM) can be traced back to the environmental movements of the 1960s and 1970s, which emphasized pollution control and resource conservation. However, the formal integration of environmental concerns into supply chain management practices began to gain traction in the late 1980s and early 1990s.

The initial focus was primarily on waste reduction and recycling efforts within manufacturing processes. During this period, businesses started to recognize the environmental and economic benefits of reducing waste and improving resource efficiency.

2.2.2 Evolution Through the Decades

- **1990s: The Emergence of Green Supply Chains**

In the 1990s, the concept of reverse logistics emerged, emphasizing the importance of reclaiming products and materials for reuse and recycling. Reverse logistics involves the process of moving goods from their final destination for the purpose of capturing value or proper disposal. This period also saw the rise of eco-design, which integrates environmental considerations into product design to minimize negative impacts throughout the product lifecycle. Companies began to adopt green supply chain practices as a means to comply with increasing environmental regulations and to meet the growing consumer demand for eco-friendly products (Eltayeb & Zailani, 2014).

- **2000s: Regulatory Pressures and Consumer Demand**

The 2000s marked significant advancements in GSCM practices, driven by increased regulatory pressures and consumer demand for sustainable products. Companies began adopting comprehensive green purchasing policies, which involved selecting suppliers based on their environmental performance and sustainability practices. This era also witnessed the rise of green marketing, as companies sought to leverage their environmental initiatives as a competitive advantage. Green procurement became a key focus, with businesses prioritizing suppliers that demonstrated strong environmental stewardship (Dube & Gawande, 2012).

- **2010s: Integration and Innovation**

The 2010s saw further integration of GSCM practices into corporate strategies, with a focus on innovation and technological advancements. Companies began to implement advanced technologies such as Internet of Things (IoT), blockchain, and big data analytics to enhance transparency and traceability in their supply chains. These technologies enabled businesses to monitor and manage their environmental impact more effectively. Additionally, the concept of the circular economy gained prominence, emphasizing the need to create closed-loop supply chains that minimize waste and maximize resource efficiency (Chalotra, 2012).

2.2.3 Categories of Green Supply Chain Initiatives

Green supply chain initiatives can be broadly categorized into several key areas:

1. Green Purchasing and Procurement

Green purchasing involves selecting suppliers and products based on environmental criteria, encouraging sustainable practices across the supply chain. This approach ensures that companies reduce their overall environmental footprint while promoting sustainability among their suppliers. By prioritizing suppliers who use renewable energy, minimize waste, or have certifications like ISO 14001, companies can significantly enhance their environmental performance (Zhu, Sarkis, & Lai, 2013).

Moreover, green procurement often leads to innovative product designs and materials. For instance, companies may work with suppliers to develop biodegradable packaging or components made from recycled materials. This not only benefits the environment but also aligns with increasing consumer demand for sustainable products. Furthermore, by engaging in green procurement, companies can achieve cost savings through improved resource efficiency and reduced waste, ultimately enhancing their competitive advantage (Walker, Di Sisto, & McBain, 2008).

2. Eco-Design

Eco-design integrates environmental considerations into the product development process to minimize the environmental impact throughout a product's lifecycle. This includes selecting sustainable materials, designing for energy efficiency, and ensuring products are easy to recycle or dispose of responsibly. For example, using biodegradable materials or designing products that consume less energy during their use phase can significantly reduce the environmental footprint (Zhang, 2017).

By incorporating eco-design principles, companies can not only meet regulatory requirements but also cater to the growing market for green products. This practice helps in reducing costs related to material and energy use while enhancing the company's reputation as a leader in sustainability. Eco-design thus plays a crucial role in both environmental stewardship and business strategy, positioning companies to better respond to environmental challenges and consumer preferences (Zhang, 2017).

3. Green Manufacturing

Green manufacturing involves adopting environmentally friendly practices in production processes, such as reducing emissions, conserving energy, and minimizing waste. Companies might invest in energy-efficient machinery, implement waste-to-energy programs, or use renewable energy sources like solar or wind power (Chalotra, 2012).

By implementing green manufacturing practices, companies can improve their environmental performance and achieve cost savings over time. These practices not only reduce operating costs but also enhance the company's reputation among stakeholders, offering a competitive edge. Green manufacturing is essential for compliance with environmental regulations and contributes significantly to long-term sustainability objectives (Chalotra, 2012).

4. Green Distribution and Logistics

Green logistics focuses on optimizing transportation and distribution to minimize environmental impacts. Strategies include route optimization, using fuel-efficient vehicles, and adopting alternative fuels. For instance, logistics companies might use advanced software to optimize delivery routes, reducing fuel consumption and emissions. Additionally, investing in electric or hybrid vehicles can significantly lower the environmental footprint (Mingqiang & Yabo, 2009).

Green logistics also encompasses practices like consolidating shipments to reduce the number of trips required and using biodegradable packaging materials. These efforts enhance environmental sustainability, improve operational efficiency, and reduce costs. Companies that adopt green logistics can achieve significant cost savings and improve customer satisfaction by delivering products in a more sustainable manner (Mingqiang & Yabo, 2009).

5. Reverse Logistics

Reverse logistics focuses on the recovery and recycling of products and materials, promoting the circular economy by reclaiming valuable resources. This process includes product returns, refurbishing, remanufacturing, and recycling. For example, an electronics company might collect old devices, refurbish them, and resell them as refurbished products, reducing waste and providing a cost-effective option for consumers (Eltayeb & Zailani, 2014).

Implementing reverse logistics allows companies to reduce their environmental impact significantly. It also lowers costs associated with waste disposal and generates new revenue streams from reclaimed materials. Additionally, this practice supports sustainability goals by reducing the need for virgin materials and conserving natural resources, thus mitigating environmental degradation (Eltayeb & Zailani, 2014).

2.2.4 Regulatory Influence and Global Adoption

The adoption of GSCM practices has been significantly influenced by regulatory frameworks and international agreements. The Kyoto Protocol (1997) and the Paris Agreement (2015) are notable examples of global efforts to reduce greenhouse gas emissions, which have spurred businesses to adopt greener practices. National regulations, such as the European Union's Waste Electrical and Electronic Equipment (WEEE) Directive and the Restriction of Hazardous Substances (RoHS) Directive, have also played crucial roles in promoting GSCM. These regulations mandate companies to manage their environmental impact and encourage the adoption of sustainable practices across supply chains (Xu, 2011).

2.2.5 Impact on Business Practices and Performance

Adopting Green Supply Chain Management (GSCM) practices has led to numerous benefits for businesses, including enhanced brand reputation, regulatory compliance, and improved operational efficiency. Companies that integrate environmental considerations into their supply chains often experience cost savings through waste reduction and energy efficiency. For example, implementing energy-efficient technologies and waste reduction strategies can significantly lower operating costs. Additionally, these practices open new market opportunities by attracting environmentally conscious consumers and fostering innovation. Businesses that demonstrate strong environmental performance can gain a competitive edge, attract investors, and enhance their market value (Li, 2022).

Moreover, GSCM practices support the creation of a sustainable business model, which is increasingly demanded by stakeholders. Customers, investors, and regulatory bodies are placing more emphasis on sustainability, urging companies to adopt greener practices. For instance, studies have shown that companies with robust GSCM strategies are better

positioned to manage risks and improve their long-term profitability (Carter & Rogers, 2008). By aligning their operations with environmental standards and focusing on sustainability, companies not only avoid potential legal penalties but also build stronger relationships with stakeholders, enhancing their overall market performance.

2.2.6 Case Studies and Examples

Several companies have successfully implemented GSCM practices, serving as benchmarks for others. For instance, Toyota's adoption of the Toyota Production System (TPS) includes principles of lean manufacturing and waste reduction, which align with GSCM goals. Similarly, Walmart's sustainability index assesses the environmental impact of its products, encouraging suppliers to adopt greener practices. These companies have demonstrated that integrating sustainability into supply chain management can lead to significant environmental and economic benefits (Borhanudin & Abdullah, 2012).

- **Toyota's Adoption of the Toyota Production System (TPS)**

Toyota has long been recognized for its pioneering efforts in lean manufacturing through the Toyota Production System (TPS). TPS integrates principles of lean manufacturing and waste reduction, which align closely with the goals of green supply chain management. One of the core components of TPS is the concept of "Just-In-Time" (JIT) production, which minimizes inventory levels and reduces waste by producing only what is needed, when it is needed.

In addition to JIT, Toyota has implemented several green initiatives to enhance its environmental performance. For instance, Toyota has focused on reducing emissions from its manufacturing processes by adopting renewable energy sources and improving energy efficiency. The company has also invested in developing hybrid and electric vehicles, significantly reducing the carbon footprint of its products. These efforts have not only improved Toyota's environmental performance but also strengthened its market position as a leader in sustainable automotive manufacturing.

Moreover, Toyota's commitment to sustainability extends to its supplier relationships. The company works closely with its suppliers to ensure they adhere to environmental standards and continuously improve their own sustainability practices. This collaborative approach

helps to extend the benefits of GSCM throughout the entire supply chain, creating a network of environmentally responsible partners.

- Walmart's Sustainability Index

Walmart, one of the world's largest retailers, has implemented a comprehensive sustainability index to assess the environmental impact of its products. This initiative encourages suppliers to adopt greener practices by evaluating their performance on various sustainability metrics, including energy use, waste management, and resource efficiency.

The sustainability index is part of Walmart's broader sustainability strategy, which aims to create a more sustainable supply chain. Walmart has set ambitious goals to reduce greenhouse gas emissions, increase the use of renewable energy, and minimize waste. For example, the company aims to achieve zero waste in its operations by diverting waste from landfills through recycling and composting programs.

One of the key elements of Walmart's sustainability efforts is its focus on improving the efficiency of its logistics network. The company has invested in advanced logistics technologies and optimized its transportation routes to reduce fuel consumption and emissions. Additionally, Walmart has implemented sustainable packaging solutions to reduce the environmental impact of its products.

Walmart's sustainability initiatives have resulted in significant environmental and economic benefits. The company has reported substantial cost savings from improved energy efficiency and waste reduction efforts. Furthermore, by promoting sustainability throughout its supply chain, Walmart has enhanced its brand reputation and attracted environmentally conscious consumers.

2.2.7 Future Trends and Developments

The future of Green Supply Chain Management (GSCM) will be shaped by modern technologies, stricter regulations, and changing consumer demands. Emerging technologies like blockchain can improve transparency and traceability in supply chains, ensuring environmental standards are met consistently. Blockchain technology helps create reliable records, verifying the authenticity of sustainable practices and reducing the risk of false green claims (Tedesco, 2022).

The shift towards a circular economy will also drive innovations in recycling and resource recovery. The circular economy model emphasizes reusing, remanufacturing, and recycling products and materials instead of disposing of them. This approach aims to reduce waste and conserve natural resources, encouraging companies to design products that last longer and are easier to recycle (Tedesco, 2022).

Consumer expectations are increasingly leaning towards environmentally friendly and ethically produced products. Companies need to adapt by improving their GSCM practices, such as adopting sustainable sourcing strategies, increasing energy efficiency, and reducing carbon footprints. Meeting these expectations can improve brand loyalty and provide a competitive advantage (Tedesco, 2022).

Additionally, regulatory pressures are expected to intensify, with governments introducing more laws to reduce carbon emissions, enhance resource efficiency, and promote sustainable practices in supply chains. Companies must stay ahead of these regulations by integrating sustainability into their operations and maintaining transparent reporting and documentation (Tedesco, 2022).

In summary, the future of GSCM requires companies to be proactive and innovative. By using advanced technologies, embracing the circular economy, and responding to regulatory and consumer demands, companies can achieve significant environmental and economic benefits.

2.2.8 Technological Innovations

Technological innovations are expected to play a significant role in the future of GSCM. Blockchain technology, for example, can provide a transparent and immutable record of transactions throughout the supply chain, enhancing traceability and accountability. This can help ensure that products are sourced, manufactured, and distributed in compliance with environmental standards. Similarly, IoT devices can provide real-time monitoring of environmental conditions, enabling companies to optimize their operations and reduce their environmental impact (Xu, 2011).

2.2.9 Circular Economy

The circular economy is a concept that emphasizes the need to create closed-loop systems where waste is minimized, and resources are continually reused and recycled. This approach contrasts with the traditional linear economy, which follows a "take, make, dispose" model. The circular economy promotes sustainable production and consumption patterns, encouraging companies to design products for longevity, repairability, and recyclability. As the circular economy gains momentum, companies will need to adopt GSCM practices that support resource efficiency and waste reduction (Chalotra, 2012).

2.2.10 Summary

The historical evolution of green supply chain initiatives highlights the growing importance of integrating environmental considerations into business practices. From early concepts of waste reduction to comprehensive GSCM frameworks, these initiatives have significantly shaped how companies operate and compete in the global market. As regulatory pressures and consumer demands continue to evolve, the adoption of GSCM practices will remain crucial for achieving sustainability goals and maintaining competitive advantage.

Green supply chain initiatives not only help businesses comply with regulations but also enhance their reputation, reduce costs, and drive innovation. By integrating environmental considerations into their supply chains, companies can achieve significant ecological, economic, and social benefits, positioning themselves for success in an increasingly sustainability-focused market.

3. Green Supply Chain Management & Initiatives – The Overview

3.1 GSCM & GSC Initiatives

Green Supply Chain Management (GSCM) integrates environmental considerations into various stages of the supply chain, including production techniques, material sourcing and selection, product design, distribution to consumers, and end-of-life management. GSCM is considered an integrated approach including various stages of the supply chain, such as green procurement, integrated supply chain management, and reverse logistics. It involves all stakeholders, from providers and manufacturers to clients, and is sometimes referred to as "closing the loop" (Ahi & Searcy, 2013).

The literature on GSCM presents several definitions. According to Ahi and Searcy (2013), Green Supply Chain Management is the integration of environmental considerations into supply chain management. Bai, Kusi-Sarpong, and Sarkis (2017) extend this definition to cover the entire life cycle of a product, including design, manufacturing, distribution, end-user usage, and disposal at the end of the product life. GSCM aims to increase process and product efficiency in compliance with environmental regulations. In the context of Green Supply Chain Management, the various entities involved in the supply chain, operate in a manner that satisfies legal and consumer needs. National and international authorities, as well as government agencies, can enforce ecologically conscious behavior. Rivera (2004) found that companies adopt environmental practices due to both internal and external pressures and rising awareness of the adverse effects of not meeting environmental criteria. Companies that genuinely care about the environment and have societal support, often implement environmental initiatives early in the supply chain (Carter et al., 2000). Studies in developed countries have shown how institutional standards influence businesses to enhance their competitive advantage through the adoption of environmental policies. These companies implement GSCM techniques such as training, sharing environmental data, and group research. According to Heras-Saizarbitoria et al. (2011), the application of ISO 14001 depends significantly on external motivators, particularly customer demand. The literature covers several aspects of green purchasing, including the encouragement of recycling, reuse, and resource reduction. Green supply chain practices (GSCP) often encompass investment

recovery, ecological design, green procurement, customer collaboration, and internal environmental management.

The implementation of GSCP is particularly relevant in developing countries, where pollution is more noticeable and leads to health problems, mortality, and disabilities among the population (Lee, 2008). Adoption of green purchasing is one of the commonly accepted dimensions of GSCM practices. According to Lee (2008), enterprises, especially small and medium-sized enterprises that have implemented a green supply chain strategy, pay more attention to the green practices of their suppliers to ensure alignment with their environmental goals.

Furthermore, the importance of eco-design was highlighted by Buyukozkan and Cifci (2011), who found that about eighty percent (80%) of the environmental impacts associated with products can be modified during the design phase. Eco-design practices fall into two main categories: product-related design and packaging-related design. Regarding product design, Min and Galle (2011) suggested significant cost-saving opportunities at the beginning of the supply chain, recommending that companies actively seek opportunities to incorporate recycled and reused parts.

In conclusion, Green Supply Chain Management (GSCM) represents a transformative approach that integrates environmental sustainability into every stage of the supply chain. By adopting GSCM practices, companies can not only comply with environmental regulations but also enhance their competitive advantage and corporate reputation. The adoption of green initiatives, from eco-design to green procurement, demonstrates a commitment to sustainability that agrees with stakeholders and consumers alike. As global awareness of environmental issues continues to rise, the implementation of GSCM will become increasingly vital for businesses striving to achieve long-term sustainability and success. The ongoing research and development in this field will undoubtedly lead to more innovative and effective strategies, fostering a more sustainable future for industries worldwide.

3.2 The Role of Green Supply Chain Management Practices – Findings of various studies

Organizations are becoming more alert of the environmental consequences of their actions. This has led to a rise in interest in green supply chain management as a way to improve operational performance, minimize waste, enhance product quality, and conserve natural resources, all while providing better customer service. GSCM serves as a potent strategy for organizations to differentiate their business from competitors (Azadi, Moghaddas, Saen, Mardani, & Azadi, 2023).

GSCM encompasses green purchasing, green manufacturing, materials management, green distribution, and reverse logistics. It involves integrating environmental considerations into supply chain management practices and is essential for organizations that seek to achieve environmental sustainability and enhance their market reputation (Azadi, Moghaddas, Saen, Mardani, & Azadi, 2023). In their study, Dzikriansyah et al. (2023) examined how the implementation of GSCM practices influenced the environmental performance of eighty-nine small- and medium-sized firms (SMEs) in Indonesia. The findings demonstrate that the use of GSCM methods led to a notable enhancement in the environmental performance of the organizations. In their study, Fu, Yang, Liu, and Mei (2022) conducted an empirical investigation to examine how GSCM affects company environmental performance, and how market setting, regional culture, and industry type affect this relationship. The findings demonstrated that the implementation of GSCM had a positive impact on the environmental performance of the examined organizations. Moreover, Vanalle et al. (2017) conducted an analysis of the demands, practices, and effectiveness of GSCM among Brazilian suppliers in an automotive supply chain. The research found that adopting GSCM methods is definitely linked to the sustainability and economic well-being of the supply chain that was looked into.

Yildiz Çankaya and Sezen (2019) examined the influence of eight aspects of GSCM (green purchasing, green manufacturing, green distribution, green packaging, green marketing, environmental education, internal environmental management, and investment recovery) on economic, environmental, and social performance. The findings indicate that every aspect of the GSCM is connected to at least one performance factor, highlighting the significance of this topic in enhancing environmental performance.

Shaikh, Shahbaz, and Odhano (2020) conducted research to examine the influence of GSCM on both environmental and operational performance. The study demonstrates that organizations implementing Green Supply Chain Management enhance their environmental performance. Furthermore, the implementation of ecological practices leads to higher levels of consumer satisfaction and attraction. In their study, Amjad et al. (2022) examined the characteristics of GSCM and its impact on the environmental, social, and economic performance of 190 respondents from manufacturing enterprises in Pakistan. The findings indicate that every aspect of GSCM has a favorable impact on environmental, social, and economic performance.

3.3 SMEs and Green Supply Chain Adoption

Developing nations are prioritizing industrialization as a means to transition from small-scale agriculture to manufacturing, with the aim of achieving economic growth and reducing poverty. Nevertheless, industrial enterprises, particularly during their initial stages, require significant amounts of energy resources that inevitably contribute to pollution and environmental deterioration. In order to address the issues, three objectives were set with a main emphasis on the influence of five GSCPs (Green Supply Chain Practices) - green purchasing, eco-design, investment recovery, internal environmental management, and customer collaboration - on environmental performance. (Azadi, Moghaddas, Saen, Mardani & Azadi, 2023).

Vijayvargy et al. (2017) found that medium-sized firms have adopted Green Supply Chain Management practices that resemble those of large-scale enterprises. However, there are three distinctions: the presence of established environmental management systems, support from mid-level and top management, and the evaluation of suppliers based on their environmental practices. The study found that the adoption of GSCM results in comparable enhancements in operational performance for both small and medium-sized organizations. Kim (2011) conducted a comparative analysis of project management maturity levels in Korea, specifically focusing on the differences between small and medium-sized firms (SMEs) and large enterprises. The results of his study uncovered discrepancies in project management skills among companies of varied sizes and scopes. SMEs face challenges in achieving satisfactory project performance, such as implementing quality management

(QMS) or Supply Chain Management (SCM) systems, due to limited human resources and lack of internal innovation capability. Many small and medium-sized businesses have trouble meeting the new needs of the companies that buy from them because they do not have enough knowledge, experience, money, or people. Small and medium-sized businesses (SMEs) often lack sufficient proactive environmental strategy, environmental awareness, and environmental management procedures. They are generally ineffective in tackling difficulties related to environmental management. Thus, the presence of these small and medium-sized firm suppliers, may hinder the progress of customer-businesses efforts to implement green supply chain management practices (Kannan, Jabbour, & Jabbour, 2014).

3.4 Environmental Metrics & Performance

In recent decades, the challenges of air pollution, climate change, and the increase in solid waste generation have been worsened by population growth and urbanization. As a result, concerns about sustainability have significantly grown, drawing more attention from researchers, business leaders, and government agencies (Ansari & Kant, 2017).

In addition to these challenges, organizations are recognized as the primary carriers of these challenges. They are compelled to adopt a new environmental stance due to the influence of stakeholders, such as public awareness and the realization that embracing environmental issues can lead to competitive advantages. Consequently, organizations are progressively implementing environmental management practices. According to Pane Haden, Oyler, and Humphreys (2009), environmental management is viewed as a systematic approach involving invention, implementation, and development of environmental strategies. The goal is to gain a competitive advantage, ensure the company's long-term viability, minimize waste production, and foster social responsibility. According to Montabon, Sroufe, and Narasimhan (2007), environmental management refers to the specific tools, policies, and procedures that firms employ to monitor and control the effects of their operations on the natural environment.

Thus, environmental management arises as a method for enterprises to work together in mitigating the negative environmental impacts they produce, ultimately leading to improved environmental performance. Environmental performance is the outcome of environmental management, which demonstrates a company's dedication to the environment through

actions and attitudes. Companies can improve their environmental performance by using an environmental management system (Boiral, Guillaumie, Heras-Saizarbitoria, & Tayo Tene, 2017). Environmental performance refers to an organization's capacity to decrease emissions, waste, and the use of hazardous and toxic materials, as well as the occurrence of environmental accidents. It also involves reducing operating costs, enhancing resource utilization, and accessing additional market opportunities (Jin, Lei, & Wu, 2023).

Various academic studies have examined the environmental performance (EP) of companies from diverse angles and perspectives. For instance, Cho, Cho, and Lee (2018) investigated the influence of managerial traits on a company's EP. In their study, Bakhsh Magsi et al. (2018) examined the impact of organizational culture on environmental performance. Furthermore, in his study, Ramanathan (2018) stated that a strong environmental performance not only creates a competitive advantage but also has a favorable influence on the financial performance of the organization. Hartmann and Vachon (2017) suggested that there is a direct correlation between the implementation of environmental management practices and the resulting environmental performance. Moreover, in their study, Russo, Pogutz, and Misani (2021) discovered that organizations exhibiting robust environmental performance experience cost reductions, leading to enhanced financial performance and increased market value in the short, medium, and long term. Finally, according to Benkraiem et al. (2023), there is a favorable relationship between improved environmental performance, increased green innovation, and the financial performance of organizations. Examining the environmental performance of organizations and identifying factors that contribute to their enhancement is widely recognized as crucial for achieving environmental sustainability.

3.5 Green Supply Chain Planning

Implementing sustainable practices, such as incorporating supply chain planning activities, has a beneficial impact on operational performance, resulting in enhanced efficiency and ecological sustainability. Gao et al. (2022) investigate the assessment of sustainable performance in the electronics sector through the application of green supply chain techniques. Research indicates that implementing green supply chain planning and other environmentally friendly methods have a positive impact on sustainability, particularly in

the areas of environment, finance, and society. Research also indicates that participating in GSC Planning activities has a positive effect on the efficiency and productivity of manufacturing companies. The paper highlights the potential benefits of integrating sustainable approaches into supply chain planning processes, including enhanced operational efficiency, organizational performance, and increased sustainability. These examples demonstrate the potential benefits of incorporating sustainable methods into supply chain planning, such as enhanced operational efficiency and long-term sustainability. A study was also conducted by Asghar (2023) to examine the relationship between GSCP and environmental performance in the manufacturing industry. The study found that businesses that implemented GSC Planning practices experienced significant enhancements in environmental performance indicators, including reduced energy consumption, waste generation, and emissions. The study conducted by Lee et al. (2016) examined the impact of GSC Planning on the operational efficiency and cost reduction in the electronics industry. Luthra et al. (2017) examined how GSC Planning can improve stakeholder integration and collaboration in the manufacturing industry. Chen, Zhu, and Sarkis (2022) examined the impact of the GSC Planning on regulatory compliance and risk management within the industrial sector.

3.6 Green Procurement and Firms Environmental Performance

Green procurement, also known as sustainable procurement, is the process of purchasing goods and services with minimal environmental impact throughout their lifecycle. This means considering environmental factors alongside cost and quality when making procurement decisions. The main goal of green procurement is to reduce the environmental footprint of the products and services an organization buys. This approach can be applied in various sectors and industries, promoting practices that meet today's needs while protecting the environment for future generations. It involves integrating environmental concerns into policies and procurement processes to encourage practices like recycling, reuse, and resource reduction (Thahir et al., 2022).

For managers, incorporating green supply chain practices is crucial. It helps reduce environmental impact, comply with regulations, enhance brand reputation, improve customer satisfaction, and potentially cut costs. The first step is to assess current supply

chain operations to identify areas with significant environmental impact. After this audit, managers should set clear goals for reducing environmental impact. Klassen and Vereecke's 2012 study highlights the important role of green supply chain management in the manufacturing and industrial sectors. They point out that adopting green practices can improve environmental performance and support sustainable economic growth. Supply chain managers can use green supply strategies to boost social responsibility, reduce waste, mitigate reputational risks, and adapt more easily to new environmental regulations.

Life cycle costing is an important part of green procurement. It involves looking at the total cost of ownership, including purchase price, operating costs, maintenance, and disposal costs. Environmentally friendly products can often be more cost-effective over their entire lifecycle, even if they have higher initial costs. Another key aspect of green procurement is assessing the environmental impact of a product or service at every stage, from production to disposal. This includes factors like energy consumption, resource use, emissions, waste generation, and the potential for recycling or reuse. By understanding these impacts, organizations can make better decisions that support environmental sustainability. By implementing green procurement, organizations contribute to broader sustainability goals and reduce their environmental footprint. Zhou et al. (2023) conducted a thorough analysis of green supply chain management strategies in the high-tech industry, particularly in manufacturing. They emphasized the importance of adopting sustainable practices such as green production, packaging, and design. Shin and Cho (2022) found that green innovation positively impacts cost-effectiveness, suggesting that manufacturers can achieve cost savings by reducing energy use, minimizing waste, and optimizing raw resource use. Sustainable materials are also crucial in green procurement. Organizations prioritize products made from renewable, recyclable, or biodegradable materials to reduce dependence on non-renewable resources and minimize waste. Choosing energy-efficient products and services can significantly cut greenhouse gas emissions and operational costs over time. Reducing the use of hazardous substances is also a priority. Organizations aim to avoid products with harmful chemicals, opting for alternatives that are safer for human health and the environment. Calza et al. (2021) examined how companies' environmental policies, like green procurement, influence their efforts to create eco-friendly products. The study found that companies practicing green buying are more likely to invest in and develop environmentally better products. Similarly, Sant (2022) noted that companies began seeking environmentally friendly materials, suppliers, and processes, leading to a broader search for

greener products and methods. The study showed a positive link between adopting green procurement strategies and increased rates of green innovation. Collaborating with suppliers who adhere to environmentally friendly practices and are committed to sustainability is essential in green procurement. Organizations seek suppliers who meet certain environmental standards and certifications, ensuring that their supply chain supports their sustainability goals. This can involve regularly auditing suppliers to ensure compliance with environmental standards and prioritizing sourcing from suppliers with strong environmental practices through green procurement policies. Additionally, encouraging suppliers to use recycled, renewable, or low-impact resources and materials can further enhance the positive environmental impact.

Studies indicate that businesses are more likely to offer innovative solutions and products that have minimal negative effects on the environment when they adopt environmentally conscious procurement strategies, such as selecting suppliers based on their environmental record or procuring eco-friendly materials (Karim et al., 2023). Kannan et al. (2014) discovered that companies showed a greater tendency to engage in eco-friendly innovations when they employed Green Supply Chain and Circular Economy approaches to select their suppliers. It has also been proven that green innovation fosters collaboration in the supply chain and promotes efficiency enhancements. Mehta et al. (2019) found that cooperative relationships between manufacturers and suppliers facilitated the exchange of environmental best practices, resources, and knowledge. These collaborations fostered the development of new ideas, improvements in productivity, and a strategic edge over competitors.

Green procurement plays a crucial role in enhancing the environmental performance of manufacturing firms. This approach involves integrating environmentally friendly practices into the procurement process, focusing on the use of green products, processes, and suppliers. Studies have shown that these practices lead to significant improvements in environmental performance across various manufacturing sectors. Shevchenko et al. (2023) investigated the correlation between operational efficiency in the manufacturing industry and green supply chain methods. Their research indicates that implementing green supply chain execution strategies, such as effective waste management and energy conservation, can enhance operational efficiency by lowering expenses, improving quality, and reducing lead time. These studies demonstrate that adopting sustainable procurement methods has a

beneficial impact on the performance of the industrial sector. Additionally, the adoption of green procurement practices not only enhances environmental actions but also boosts a firm's market performance and competitiveness. Green, Zelbst, Meacham, and Bhadauria (2012) examined the influence of environmentally friendly procurement practices on the competitive advantage of companies in the Chinese manufacturing sector. The study's findings revealed that green procurement positively impacted corporate performance. Implementing Green Procurement (GP) practices enhances the operational effectiveness of the manufacturing industry.

The implementation of green supply chain management practices, which includes green procurement, green manufacturing, and green recycling, has been found to positively impact both environmental and economic performance. These practices help firms reduce their environmental footprint while also enhancing operational sustainability and customer satisfaction. Shang et al. (2019) conducted research to analyze the impact of Green Supply Chain Practices (GSCP) on environmental performance in the manufacturing industry. Their survey indicated that organizations implementing GSCP had significant improvements in their environmental performance. Luthra, Govindan, Kannan, Mangla, and Garg (2017) examined the factors that influence the implementation of ecologically sustainable supply chain practices in the manufacturing industry. They identified multiple factors impacting the adoption of sustainable practices in the supply chain, such as stakeholder influence, regulatory environmental policies, and supplier engagement.

Pagell et al. (2010) analyzed how adopting an environmentally friendly supply chain affects the financial performance of industrial companies. Their findings established a direct relationship between adopting environmentally friendly supply chain practices and improved financial performance for companies, confirming the advantages of sustainable sourcing. Zhu et al. (2008) introduced several metrics to evaluate the performance of Green Supply Chain Management (GSCM) in terms of benchmarking, implementation, and continuous improvement. They suggested that implementing sustainable practices in a company's supply chain can yield several advantages, such as reducing expenses, involving suppliers in collaborative decision-making, and fostering environmental innovation. Furthermore, the implementation of environmental initiatives throughout the company and the procurement of ecologically sustainable products from global markets are commonly observed business practices.

4. Regulatory Compliance Frameworks

4.1 Definition and Importance of Regulatory Compliance in Supply Chains

Regulatory compliance in supply chains means following all the laws, regulations, guidelines, and specifications relevant to supply chain operations. These rules can be set by governments, international organizations, or industry groups and cover areas like environmental protection, labor rights, product safety, and trade practices (European Commission, 2020).

In practical terms, regulatory compliance involves putting policies and procedures in place to meet these standards, conducting regular audits, and keeping records to prove compliance (ISO, 2021). It ensures that supply chain activities stay within the legal frameworks set by various authorities, protecting companies from potential legal issues. Staying compliant with regulations in supply chains is crucial for several reasons:

1. **Legal Protection:** Following the rules helps companies avoid legal trouble, fines, and lawsuits. Breaking environmental laws, for example, can lead to costly fines and legal actions (Bisetti, She, & Zaldokas, 2023).
2. **Risk Management:** Compliance helps manage risks in supply chain operations, such as accidents, product recalls, and environmental incidents. This is vital for keeping supply chains running smoothly and ensuring business continuity (Lafrogne-Joussier, Martin, & Mejean, 2022).
3. **Reputation and Trust:** Companies that stick to regulations build trust with stakeholders, including customers, investors, and partners. A good reputation for compliance can boost brand value and customer loyalty, as people prefer to do business with companies that act ethically (Villena & Gioia, 2020).
4. **Market Access:** Meeting specific regulations is often necessary to enter certain markets. For instance, the European Union has strict rules on product safety and environmental standards, and companies must comply to do business there (European Commission, 2020).

5. **Sustainable Practices:** Compliance often promotes sustainable and ethical practices. Environmental regulations push companies to adopt greener technologies, reduce waste, and lower emissions (Baldwin & Freeman, 2022). Labor regulations ensure fair treatment of workers and respect for human rights (Cherel-Bonnemaison, Erlandsson, Ibach, & Spiller, 2021).
6. **Operational Efficiency:** Implementing compliance measures can improve operational efficiency. Regular audits and standardized processes help identify inefficiencies and areas for improvement, leading to better resource management and cost savings (Cherel-Bonnemaison, Erlandsson, Ibach, & Spiller, 2021).

4.2 Brief Historical Overview of Supply Chain Regulations

The history of supply chain regulations began with a focus on consumer protection and fair-trade practices. In the early 20th century, laws like the Pure Food and Drug Act of 1906 in the United States aimed to eliminate the sale of contaminated food and drugs, laying the foundation for future regulatory measures (Young, 2018). Similarly, the UK's Factory Acts, starting in 1833, sought to improve working conditions in factories, setting a precedent for labor regulations (Wagner, 2009). A significant milestone in global trade regulation was the General Agreement on Tariffs and Trade (GATT) established in 1947. GATT played a crucial role in reducing trade barriers and promoting international trade, significantly impacting supply chain operations by encouraging global cooperation and standardization (Hoekman, 2002). Another landmark regulation was the Clean Air Act of 1970 in the United States, which set strict standards to control air pollution. This law required industries to adopt cleaner technologies, influencing manufacturing and logistics practices worldwide (Rao, 2000).

As globalization and technological advancements progressed, supply chain regulations evolved to address new challenges. The formation of the World Trade Organization (WTO) in 1995, which succeeded GATT, provided a structured framework for global trade regulations, promoting smoother international transactions (WTO, 2021). Technological advancements, particularly in digital technologies, brought about new regulatory needs. For instance, the rise of e-commerce led to the creation of data protection laws like the General

Data Protection Regulation (GDPR) by the European Union in 2018, setting strict standards for data privacy and security (European Union, 2018).

The introduction of international standards such as ISO 9001 has been transformative for supply chain management. First published in 1987, ISO 9001 provides a framework for quality management systems, focusing on principles like customer satisfaction, leadership, and continuous improvement (ISO, 2015). Companies adopting ISO 9001 can streamline their processes, enhance efficiency, and ensure consistent product quality. This standard has become a benchmark for quality management, facilitating international trade by providing a common language and set of expectations across different industries and regions (Tsim, Yeung, & Leung, 2002).

In recent years, there has been a growing emphasis on sustainability, leading to the development of green supply chain initiatives. These initiatives aim to reduce the environmental impact of supply chain operations. For example, the European Union's REACH regulation, which focuses on the safe use of chemicals to protect human health and the environment, has played a significant role in this area. Environmental standards like ISO 14001, which provides guidelines for environmental management systems, have been integrated into supply chains to promote sustainable practices. This standard helps organizations minimize their environmental footprint and comply with environmental regulations, fostering sustainability throughout the supply chain (ISO, 2015). Implementing green supply chain initiatives not only helps companies comply with environmental regulations but also improves their overall environmental performance. By adopting sustainable practices, companies can reduce waste, enhance resource efficiency, and lower emissions. These improvements contribute to better regulatory compliance and a positive environmental impact (Zhu, Sarkis, & Lai, 2008).

4.3 Emergence of Environmental Regulations

The gradual appearance of environmental regulations has been driven by growing awareness of environmental issues and the need to address them through regulatory frameworks. Early environmental concerns led to various regulatory responses aimed at mitigating the negative impacts of industrial activities on the environment.

In the mid-20th century, rising pollution levels and environmental degradation became significant concerns. Events such as the publication of Rachel Carson's "Silent Spring" in 1962 highlighted the major effects of pesticides, leading to increased public awareness and demand for environmental protection. This period saw the establishment of foundational environmental laws and agencies, such as the United States Environmental Protection Agency (EPA) in 1970, tasked with regulating and enforcing environmental protection standards (EPA, 2021).

Two major international agreements mark significant milestones in environmental regulation: the Kyoto Protocol and the Paris Agreement.

The Kyoto Protocol, adopted in 1997, was the first major international treaty aimed at reducing greenhouse gas emissions. It set binding emission reduction targets for developed countries, recognizing their significant contribution to global emissions (UNFCCC, 1998).

The Paris Agreement, adopted in 2015, built on the foundations laid by the Kyoto Protocol. Unlike its predecessor, the Paris Agreement includes commitments from all participating countries to limit global warming to well below 2 degrees Celsius above pre-industrial levels, with efforts to limit the increase to 1.5 degrees Celsius (UNFCCC, 2015).

Environmental regulations have prompted a significant shift towards sustainable practices within supply chains. Companies are now more focused on reducing their environmental footprint by adopting greener technologies, improving energy efficiency, and minimizing waste. This shift is not only driven by regulatory compliance but also by the increasing demand from consumers and stakeholders for sustainable products and practices (Gimenez & Sierra, 2013).

Several companies have been early adopters of sustainable practices, often going beyond regulatory requirements to achieve environmental excellence. One notable example is Patagonia, the outdoor clothing company, which has been a pioneer in environmental sustainability. Patagonia's commitment to using recycled materials, reducing energy consumption, and ensuring fair labor practices has set a benchmark for the industry. Their proactive approach has not only helped them comply with environmental regulations but has also strengthened their brand and customer loyalty (Patagonia, 2021).

Another example is the multinational corporation Unilever, which launched its Sustainable Living Plan in 2010. The plan focuses on reducing the environmental impact of its products,

sourcing sustainably, and improving health and well-being for consumers. Unilever's initiatives have led to significant reductions in greenhouse gas emissions, water usage, and waste generation across its supply chain, demonstrating the positive impact of integrating sustainability into business operations (Unilever, 2020).

4.4 Current Regulatory Compliance Frameworks

The landscape of regulatory compliance frameworks is essential for understanding the impact of green supply chain initiatives on environmental performance and regulatory compliance. Major regulatory bodies and standards, as well as key legislation, play a critical role in shaping the practices and policies of supply chains worldwide.

4.4.1 Major Regulatory Bodies and Standards

- European Union Regulations

The European Union (EU) has established comprehensive regulatory frameworks to promote environmental sustainability and economic efficiency. The EU Green Deal is a strategic initiative aimed at transforming the EU into a modern, resource-efficient, and competitive economy. It focuses on turning climate and environmental challenges into opportunities, ensuring a just and inclusive transition (European Commission, 2019).

Additionally, the Circular Economy Action Plan, part of the EU Green Deal, emphasizes sustainable resource use, recycling, and waste reduction. This plan aims to decouple economic growth from resource use, fostering long-term sustainability (European Commission, 2020).

- United Nations Initiatives

The United Nations (UN) has been instrumental in promoting global sustainability through initiatives like the Sustainable Development Goals (SDGs) and the UN Global Compact. The SDGs consist of seventeen global goals designed to achieve a better and more sustainable future by addressing global challenges such as poverty, inequality, climate change, and environmental degradation (United Nations, 2015).

The UN Global Compact encourages businesses worldwide to adopt sustainable and socially responsible policies. It provides a framework based on ten principles covering human rights, labor, environment, and anti-corruption, thereby promoting sustainable development (United Nations Global Compact, 2021).

4.4.2 Industry-Specific Standards and Certifications

Industry-specific standards and certifications are also crucial in promoting sustainability. LEED (Leadership in Energy and Environmental Design) is a widely recognized green building certification system that provides a framework for creating healthy, efficient, and cost-saving green buildings (U.S. Green Building Council, 2021).

BREEAM (Building Research Establishment Environmental Assessment Method) is another leading sustainability assessment method for master planning projects, infrastructure, and buildings. BREEAM reflects the value in higher-performing assets across the built environment lifecycle (BREEAM, 2021).

4.4.3 Key Legislation Impacting Supply Chains

Key legislation such as REACH, RoHS, and WEEE significantly impacts supply chain management by enforcing environmental and safety standards, and by adhering to these regulations, companies can enhance their environmental performance and achieve regulatory compliance, thereby contributing to the overall sustainability of their supply chains.

- REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals)

REACH is an EU regulation that addresses the production and use of chemical substances, aiming to protect human health and the environment. Companies must register chemicals with the European Chemicals Agency (ECHA), ensuring that they manage the risks associated with these substances (European Chemicals Agency, 2021).

1. **Supplier Compliance:** Companies need to ensure that their suppliers comply with REACH regulations by verifying safety data sheets and other documentation. This

process enhances transparency and ensures that chemicals used in products meet safety standards.

2. **Transparency and Communication:** REACH mandates that information about chemical substances be communicated throughout the supply chain, allowing companies to make informed decisions about materials and ensuring safety requirements are met.
3. **Innovation and Substitution:** REACH encourages the use of safer alternatives to hazardous chemicals, driving innovation and the development of greener products, thereby contributing to more sustainable supply chains.

- **RoHS (Restriction of Hazardous Substances)**

RoHS aims to reduce the environmental impact of electronic products by restricting the use of specific hazardous materials. This regulation ensures safer material sourcing and drives sustainable product design (European Commission, 2011).

1. **Material Sourcing:** Companies must source components and materials that comply with RoHS requirements, ensuring the exclusion of restricted hazardous substances.
2. **Design and Manufacturing:** RoHS influences product design and manufacturing processes, promoting the use of safer materials and sustainable practices.
3. **End-of-Life Management:** By reducing hazardous substances in electronics, RoHS facilitates safer recycling and disposal processes, minimizing environmental impact.

- **WEEE (Waste Electrical and Electronic Equipment Directive)**

WEEE focuses on reducing electronic waste by promoting the reuse, recycling, and recovery of electrical and electronic equipment. It sets targets for the collection and recycling of e-waste, encouraging manufacturers to take responsibility for the entire lifecycle of their products (European Commission, 2012).

1. **Product Take-Back Programs:** WEEE requires manufacturers to implement take-back programs, ensuring that end-of-life products are returned for proper recycling and disposal.
2. **Recycling Partnerships:** Companies must partner with certified recycling facilities to handle electronic waste, impacting logistics and supply chain planning.

3. **Design for Recycling:** WEEE promotes the design of products that are easier to disassemble and recycle, supporting a circular economy and reducing waste.

4.4.4 Analysis of Their Requirements and Implications for Supply Chain Management

The implementation of REACH, RoHS, and WEEE regulations requires companies to adapt their supply chain practices ensuring compliance. This adaptation involves several key aspects:

1. **Supplier Management:** Companies must collaborate closely with suppliers to ensure all materials and components comply with relevant regulations. This includes conducting regular audits, obtaining necessary documentation, and fostering transparent communication throughout the supply chain (Kogg & Mont, 2012).
2. **Product Design and Development:** Compliance often necessitates changes in product design and development. Companies must innovate and develop products that meet regulatory standards, using safer materials and sustainable manufacturing processes (Dalhammar, 2007).
3. **Logistics and Reverse Logistics:** Effective management of logistics and reverse logistics is crucial for complying with WEEE regulations. Companies need to establish efficient systems for collecting and recycling e-waste, ensuring that end-of-life products are processed responsibly (Gimenez & Sierra, 2013).

4.5 Impact of Green Initiatives on Regulatory Compliance

The integration of green supply chain initiatives (GSCM) with regulatory compliance frameworks can significantly enhance a company's environmental performance while ensuring adherence to regulatory standards. This section explores how green initiatives align with regulatory requirements, as well as the challenges and solutions associated with this integration.

4.5.1 Integration of Green Initiatives with Regulatory Requirements

Green initiatives often align with regulatory requirements by promoting practices that reduce environmental impact and enhance sustainability. These initiatives typically focus on reducing waste, minimizing resource use, and improving energy efficiency, all of which are central to many regulatory frameworks. For example, companies that adopt green practices such as recycling and using eco-friendly materials can more easily comply with regulations like the EU's Waste Electrical and Electronic Equipment (WEEE) Directive and the Restriction of Hazardous Substances (RoHS) Directive (European Commission, 2012; European Commission, 2011).

One example of the alignment between green supply chain initiatives and regulatory compliance is the implementation of the REACH (Registration, Evaluation, Authorisation, and Restriction of Chemicals) regulation. Companies that prioritize the use of safer, non-toxic materials in their products inherently comply with REACH standards, which aim to protect human health and the environment from hazardous chemicals (European Chemicals Agency, 2021).

Another example is the integration of sustainable design principles that adhere to the guidelines set forth by the Leadership in Energy and Environmental Design (LEED) certification. LEED promotes the use of energy-efficient and sustainable building materials, which can help companies meet environmental regulations and standards (U.S. Green Building Council, 2021). According to Cherel-Bonnemaison et al. (2021), adopting sustainable practices within the supply chain can significantly enhance compliance with environmental regulations and improve overall operational efficiency.

4.5.2 Challenges and Solutions

Integrating green initiatives with regulatory compliance can present several challenges for companies. One common challenge is the initial cost of implementing green technologies and practices. These upfront costs can be significant and may deter companies from adopting sustainable practices despite long-term benefits (Zhu, Sarkis, & Lai, 2008).

Another challenge is the complexity of regulatory requirements, which can vary significantly across regions and industries. This complexity can make it difficult for

companies to understand and comply with all relevant regulations, especially when trying to integrate new green initiatives (Kogg & Mont, 2012).

To overcome these challenges, companies can adopt several best practices. One effective approach is to leverage technology and data analytics to track and manage compliance with regulatory standards. By using software solutions that provide real-time data on environmental performance, companies can more easily identify areas for improvement and ensure compliance with regulations (Gimenez & Sierra, 2013).

Another solution is to invest in employee training and development to build a culture of sustainability within the organization. Training programs can help employees understand the importance of green initiatives and how they contribute to regulatory compliance. This cultural shift can encourage the adoption of sustainable practices throughout the company (Cherel-Bonnemaison et al., 2021).

Additionally, companies can seek partnerships and collaborations with other organizations, industry groups, and regulatory bodies. These partnerships can provide valuable insights into best practices for integrating green initiatives and achieving compliance, as well as offer support and resources for overcoming challenges (Kogg & Mont, 2012). For instance, the UN Global Compact provides a platform for companies to align their operations with universal principles on human rights, labor, environment, and anti-corruption, thereby fostering a collaborative approach to sustainability and regulatory compliance (United Nations Global Compact, 2021).

4.6 Future Trends and Predictions

The future of green supply chain initiatives and regulatory compliance is shaped by emerging regulations, technological advancements, and increased emphasis on sustainability reporting and transparency. These trends will play a pivotal role in how companies adapt to new requirements and improve their environmental performance.

4.6.1 Emerging Regulations and Their Potential Impact

As global awareness of environmental issues continues to grow, it is anticipated that regulatory frameworks will become stricter. Governments and international bodies are

likely to introduce new regulations aimed at reducing carbon footprints, enhancing resource efficiency, and promoting sustainable practices across supply chains. For instance, the European Union is expected to expand its regulatory reach with initiatives like the EU Taxonomy Regulation, which aims to provide a clear definition of what constitutes a sustainable activity (European Commission, 2020).

In addition to regional regulations, global frameworks such as the United Nations Sustainable Development Goals (SDGs) will continue to influence national policies, pushing for more rigorous environmental standards (United Nations, 2015). Companies will need to stay informed of these changes to ensure compliance and maintain their competitive edge.

Emerging technologies such as blockchain and the Internet of Things (IoT) are poised to revolutionize regulatory compliance in supply chains. Blockchain technology can enhance transparency and traceability by providing an immutable record of transactions and material flows. This capability is particularly useful for ensuring compliance with regulations like REACH and RoHS, as it allows for real-time tracking of hazardous substances and verification of supplier certifications (Bisetti, She, & Zaldokas, 2023).

IoT devices can monitor environmental conditions and resource usage in real-time, providing critical data that companies can use to ensure compliance with environmental standards. For example, IoT sensors can track emissions and energy consumption, helping companies to identify inefficiencies and take corrective actions promptly (Baldwin, Freeman, & Theodorakopoulos, 2023). These technologies not only facilitate compliance but also drive improvements in environmental performance.

4.6.2 Sustainability Reporting and Transparency

Sustainability reporting has become an essential aspect of corporate responsibility, as stakeholders increasingly demand transparency regarding environmental practices. Sustainability reports provide insights into a company's efforts to reduce its environmental impact, improve resource efficiency, and contribute to social and economic development. These reports are crucial for building trust with investors, customers, and regulatory bodies. Furthermore, sustainability reporting helps companies to identify areas for improvement and track progress towards their environmental goals. By disclosing their environmental

performance, companies can benchmark themselves against industry standards and peers, fostering a culture of continuous improvement and accountability (Villena & Gioia, 2020).

Regulatory requirements for sustainability reporting are becoming stricter. In the European Union, the Non-Financial Reporting Directive (NFRD) requires large companies to disclose information on environmental matters, social and employee-related aspects, human rights, and anti-corruption (European Commission, 2019). This directive is expected to be replaced by the Corporate Sustainability Reporting Directive (CSRD), which will extend the scope of reporting requirements to include more companies and ensure more rigorous auditing and enforcement (European Commission, 2021).

Similarly, other regions are adopting similar frameworks to ensure that companies are transparent about their environmental impact. For example, the United Nations Global Compact encourages companies to report on their progress in implementing sustainable practices and aligning with the SDGs (United Nations Global Compact, 2021). These regulatory requirements force companies to integrate sustainability into their core operations and enhance their transparency, thereby improving overall environmental performance and compliance.

4.7 Summary

The evolution of regulatory frameworks in supply chains has been significant, reflecting growing environmental awareness and the need for sustainable practices. Historically, initial regulations focused on basic consumer protection and fair trade, evolving to include comprehensive environmental standards. Key regulations such as the EU's REACH, RoHS, and WEEE directives have set severe requirements for managing chemical substances, restricting hazardous materials, and promoting the recycling of electronic waste. These regulations ensure that companies operate responsibly, minimizing their environmental impact (European Chemicals Agency, 2021; European Commission, 2011, 2012).

Green supply chain initiatives (GSCM) play a pivotal role in enhancing regulatory compliance. By integrating sustainable practices, such as using eco-friendly materials, reducing waste, and improving energy efficiency, companies can align with these regulations more effectively. Initiatives like adopting LEED certification or adhering to sustainable development goals (SDGs) not only help companies meet regulatory standards

but also foster innovation and improve overall environmental performance (U.S. Green Building Council, 2021; United Nations, 2015).

Looking ahead, the future of regulatory compliance in supply chains will be shaped by emerging regulations and technological advancements. As global environmental concerns continue to escalate, regulatory bodies are expected to introduce stricter and comprehensive frameworks. Anticipated changes include the expansion of the EU's regulatory scope with initiatives like the Corporate Sustainability Reporting Directive (CSRD), which will require more detailed and rigorous sustainability reporting from companies (European Commission, 2021).

Technological advancements, particularly in blockchain and the Internet of Things (IoT), will also significantly impact regulatory compliance. Blockchain technology offers enhanced transparency and traceability, providing immutable records of transactions and material flows that ensure compliance with regulations like REACH and RoHS. Similarly, IoT devices can monitor environmental conditions in real-time, helping companies track emissions and energy usage, thereby facilitating compliance and driving improvements in environmental performance (Bisetti, She, & Zaldokas, 2023, Baldwin, Freeman, & Theodorakopoulos, 2023).

Sustainability reporting and transparency will become increasingly important. Regulatory requirements for detailed disclosures on environmental impact and resource usage will compel companies to integrate sustainability into their core operations. Enhanced transparency will build trust with stakeholders, improve accountability, and foster a culture of continuous improvement (European Commission, 2019, United Nations Global Compact, 2021).

The continuing evolution of green supply chain management will focus on integrating sustainable practices throughout the supply chain, from sourcing to end-of-life management. Companies will need to innovate and collaborate to meet new regulatory demands and achieve their sustainability goals. By doing so, they will not only comply with regulations but also contribute to global efforts to mitigate climate change and promote sustainable development.

5. Bibliometric analysis

This chapter provides a bibliometric analysis of GSCM research, utilizing data extracted from Scopus and analyzed with VOSviewer¹. The focus is on identifying key themes, important countries, and leading authors in the field. By examining the most frequently occurring keywords, top contributing countries, and influential authors, this analysis aims to give a comprehensive overview of the current state and trends in GSCM research.

5.1 Methodology

The methodology for this bibliometric analysis involved several key steps. Data was retrieved from the Scopus database by searching keywords such as "supply chain," "green supply chain," and "green logistics". The data was then processed using VOSviewer, a tool for constructing and visualizing bibliometric networks. Four main analyses were conducted: keyword co-occurrence analysis, co-authorship of countries, bibliographic coupling of countries, and author co-authorship analysis. For the keyword analysis, a minimum occurrence threshold was set to filter the most relevant terms. For the country analyses, a minimum of one hundred citations and at least one document was required for the co-authorship analysis, and a minimum of five hundred citations for the bibliographic coupling analysis. For the author analysis, the top fifty authors were selected based on their document count, citations (minimum of 1,000 citations), and total link strength to identify the most influential contributors.

5.2 Data analysis

5.2.1 Keywords

This analysis uses data from Scopus, analyzed with VOSviewer, to highlight the most frequently occurring keywords related to GSCM research. By examining the top ninety keywords from the extracted documents, the aim is to understand the key themes and trends in this field.

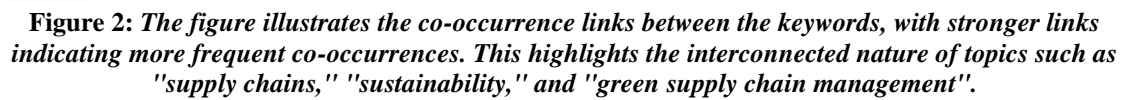
¹ <https://www.vosviewer.com/>

The dataset includes two metrics for each keyword: the number of occurrences, indicating how often the keyword appears in the documents; and the total link strength, which measures the number of times each keyword co-occurs with others in the dataset. Using VOSviewer capabilities, a co-occurrence analysis was conducted with a minimum of eighty occurrences per keyword. Initially, 110 keywords met the criteria, but after refining the selection, the analysis focused on the top ninety keywords.

The most frequently occurring keywords are "supply chains" (2,516 occurrences, total link strength 10,312) and "supply chain management" (2,336 occurrences, total link strength 9,618) highlighting the significant role in the field. Keywords such as "sustainable development" (1,402 occurrences, link strength 6,848) and "green supply chain" (868 occurrences, link strength 4,032) indicate a strong focus on sustainability in supply chain research. Other prominent keywords include "decision making" (789 occurrences, link strength 3,876), "environmental management" (644 occurrences, link strength 3,477), and "green supply chain management" (773 occurrences, link strength 3,584).

The GSCM research, with frequent mentions of keywords like "environmental performance," "carbon footprint," and "renewable energy resources." The significant occurrences of "green technology" and "green manufacturing" suggest an emphasis on innovative approaches to reduce environmental impact. Keywords related to economic aspects, such as "cost benefit analysis" and "economic and social effects," also appear frequently, indicating the importance of balancing economic and environmental objectives. The high total link strength of keywords like "supply chains" and "sustainable development" reflects their interconnected nature and broad relevance across various studies.

Using VOSviewer, a co-occurrence analysis of the top ninety keywords was conducted to visualize the relationships between them. The resulting graph shows the connections between these keywords, highlighting how they are linked in the context of GSCM research. This visual representation helps to identify clusters of related topics and the central themes driving the field.



The network visualization displays a complex web of relationships between various concepts in supply chain management and sustainability. The nodes are colored and sized based on their degree of connectivity. Major clusters include:

- Supply Chain Management (Blue):** Includes nodes like 'supply chain management', 'sustainability', 'green economy', 'commercial phenomena', 'environmental economics', 'manufacturing', 'performance assessment', 'innovation', 'marketing', 'developing countries', 'recycling', 'circular economy', 'environmental technology', 'optimization', 'blockchain', 'cost benefit analysis', 'cost effectiveness', 'stochastic systems', 'costs', 'sensitivity analysis', 'profitability', 'multiobjective optimization', 'green products', 'green manufacturing', 'closed-loop supply chain', 'supplier selection', and 'green supplier selections'.
- Supply Chains (Green):** Includes nodes like 'supply chains', 'carbon footprint', 'life cycle', 'carbon dioxide', 'energy utilization', 'emission controls', 'greenhouse gases', 'global warming', 'investments', 'carbon', 'carbon emissions', 'cost reduction', 'uncertainty analysis', 'uncertainty', 'green supply chain', and 'green products'.
- Environmental Management (Red):** Includes nodes like 'environmental management', 'environmental sustainability', 'risk assessment', 'efficiency', 'decision making', 'competition', 'green supply chain management', 'environmental issues', 'green innovations', 'green manufacturing', 'closed-loop supply chain', 'supplier selection', and 'green supplier selections'.
- Decision Making (Purple):** Includes nodes like 'decision making', 'uncertainty analysis', 'uncertainty', 'green supply chain', and 'green products'.
- Other Concepts:** Includes 'strategic approach', 'carbon emission', 'climate change', 'fossil fuels', 'energy policy', 'energy utilization', 'carbon footprint', 'life cycle', 'carbon dioxide', 'emission controls', 'greenhouse gases', 'global warming', 'investments', 'carbon', 'carbon emissions', 'cost benefit analysis', 'cost effectiveness', 'stochastic systems', 'costs', 'sensitivity analysis', 'profitability', 'multiobjective optimization', 'green products', 'green manufacturing', 'closed-loop supply chain', 'supplier selection', and 'green supplier selections'.

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Rank	Keyword	Occurrences	Total link strength
1	supply chains	2516	10312
2	supply chain management	2336	9618
3	sustainable development	1402	6848
4	green supply chain	868	4032
5	decision making	789	3876
6	green supply chain management	773	3584
7	environmental management	644	3477
8	environmental impact	520	2752
9	costs	486	2642
10	commerce	478	2758
11	sustainability	452	1815
12	carbon	381	2303
13	profitability	361	2062
14	emission control	336	2137
15	life cycle	315	1730
16	competition	313	1640
17	game theory	291	1555
18	greenhouse gases	288	1781
19	logistics	287	1416
20	investments	285	1674

Table 1: *The data extracted after conducting the co-occurrence between the keywords.*

The frequency of keywords like "sustainable development," and "green supply chain" aligns with the increasing focus on integrating sustainability into supply chain practices. The frequent occurrence of terms related to environmental management and performance indicates a growing emphasis on measuring and improving the environmental impact of supply chains. The presence of economic-related keywords suggests that researchers are also considering the financial aspects of implementing green initiatives.

This bibliometric analysis also highlights the key themes and trends in GSCM research based on the top ninety keywords. The findings show the importance of sustainability, environmental management, and economic considerations in this field. The co-occurrence analysis provides a visual representation of the interconnected nature of these topics, emphasizing the vital role of supply chains in driving green initiatives.

5.2.2 Countries

This analysis uses data from Scopus, analyzed with VOSviewer, to highlight the contributions of the top fifty countries in GSCM research. We examined the number of documents, citations and collaboration networks among these countries.

The dataset includes three metrics for each country: the number of documents, indicating research output; the number of citations, reflecting the impact of the research; and the total link strength, measuring collaboration and co-authorship among countries. Additionally, using VOSviewer, two types of analyses were conducted:

1. Co-Authorship Analysis: Examines the collaborative links between countries based on co-authorship of research papers. Using VOSviewer, a co-authorship analysis of countries was conducted with a minimum of one hundred citations and at least one document, selecting the top fifty countries.
2. Bibliographic Coupling Analysis: Examines the connections between countries based on the number of citations they share. Using VOSviewer, a bibliographic coupling analysis was performed with a minimum of five hundred citations, selecting the top fifty countries with the greatest total link strength.

China leads with 2,441 documents, 67,699 citations, and a total link strength of 3,211,252, demonstrating its strong research output and collaborations. The United States follows with 981 documents and 60,975 citations, while India stands out with 1,052 documents and 37,162 citations. The United Kingdom and Germany show significant collaboration networks, with link strengths of 1,943,062 and 378,808, respectively. European countries like the UK, Germany, Italy, and France are major contributors, and emerging economies such as Brazil and Malaysia are becoming more involved in GSCM research.

Countries with high document output generally have a high number of citations, indicating both the quantity and quality of research. China, the US, and India exemplify this balance. High total link strength reflects strong collaboration, with the UK, China, and the US leading in this area. Canada shows that impactful research is possible with fewer documents. There is a diverse mix of contributions from both developed and emerging economies, indicating a global effort in GSCM research. This analysis highlights the critical role of both established and emerging economies in advancing GSCM.

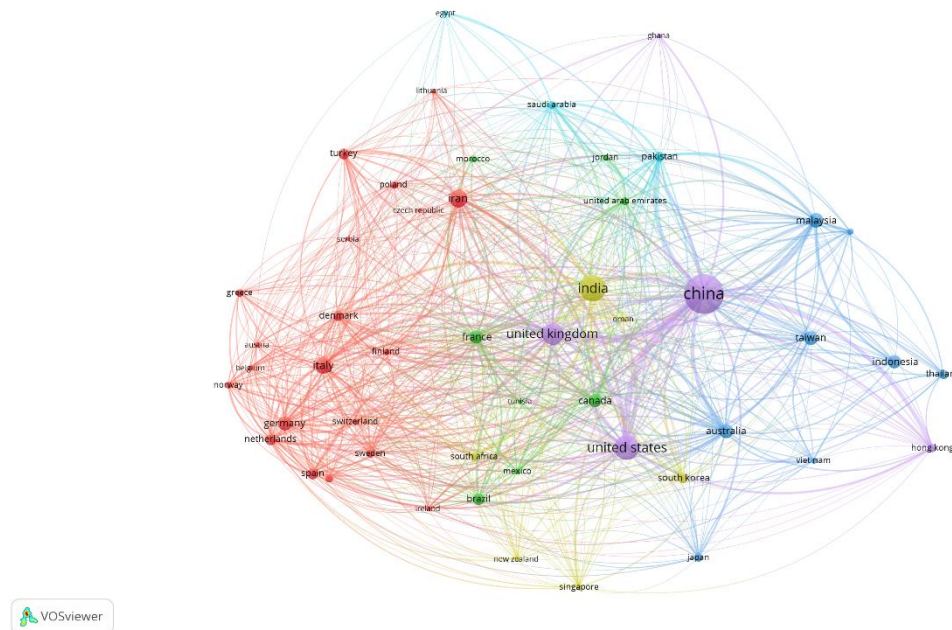


Figure 4: The first figure shows the connections among the countries, highlighting the strength of their collaborative efforts in co-authorship. This visual representation emphasizes the importance of international collaboration and the interconnected nature of GSCM research across different regions.

Now, for a better look, here is a zoom-in of the Figure 4:

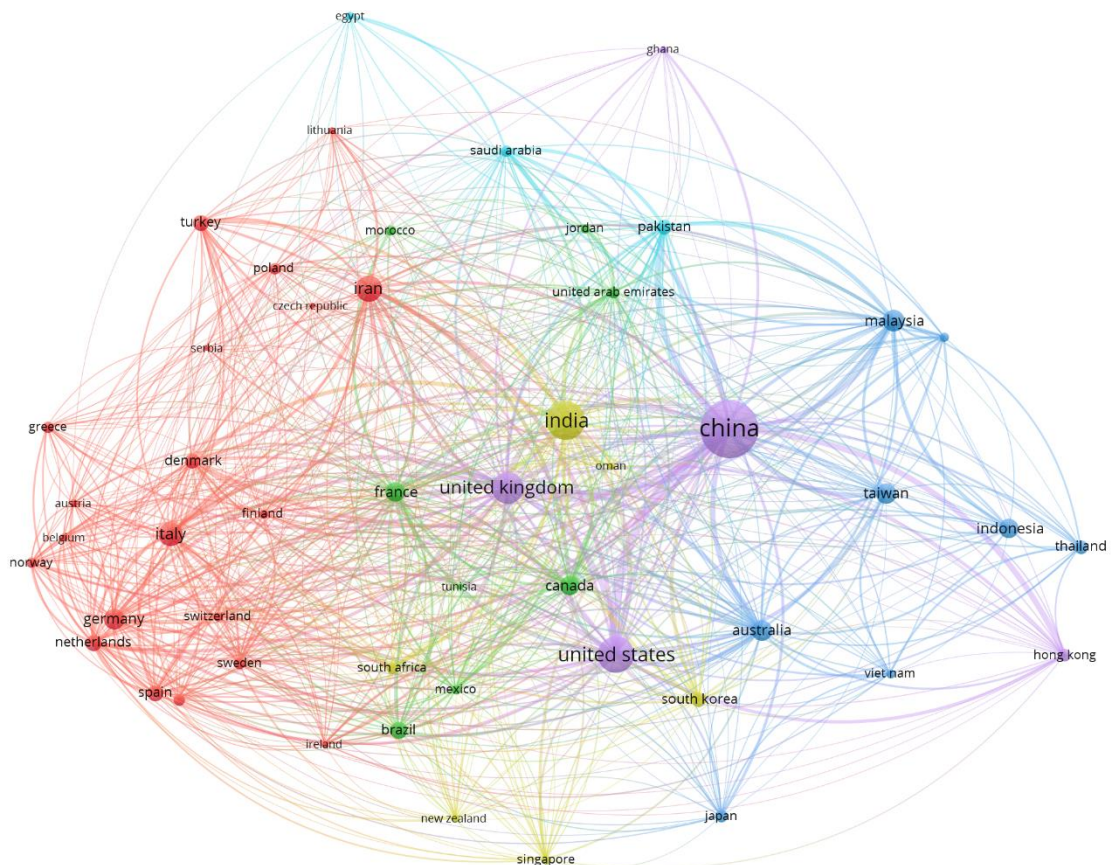


Figure 5: Zoom-in view of Figure 4.

Rank	Country	Documents	Citations	Total link strength
1	China	2441	67699	1100
2	United States	981	60975	808
3	United Kingdom	716	37586	842
4	India	1052	37162	517
5	Iran	490	17601	291
6	Taiwan	321	17120	195
7	Denmark	157	15993	224
8	Canada	268	15455	285
9	Germany	317	14235	253
10	Hong Kong	127	13668	157
11	Italy	413	13408	287
12	Australia	299	13344	366
13	Malaysia	353	9932	288
14	Netherlands	178	8470	243
15	United Arab Emirates	106	8397	144
16	France	263	8362	311
17	Brazil	214	8139	140
18	Türkiye	188	6721	133
19	Spain	184	6276	162
20	South Korea	162	6129	173

Table 2: Table with data extracted after conducting the co-authorship analysis between the countries.

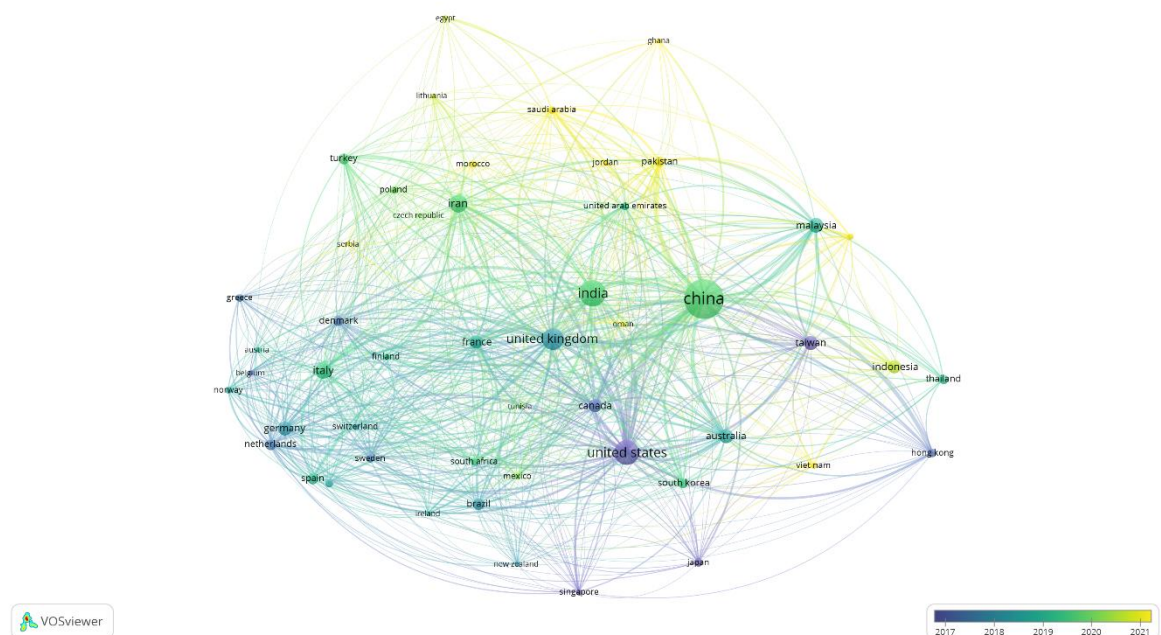


Figure 6: The second figure uses a color gradient to show the evolution of these collaborations from 2017 to 2021. This graph provides insights into how these relationships have developed over time, showing trends and shifts in international collaborations.

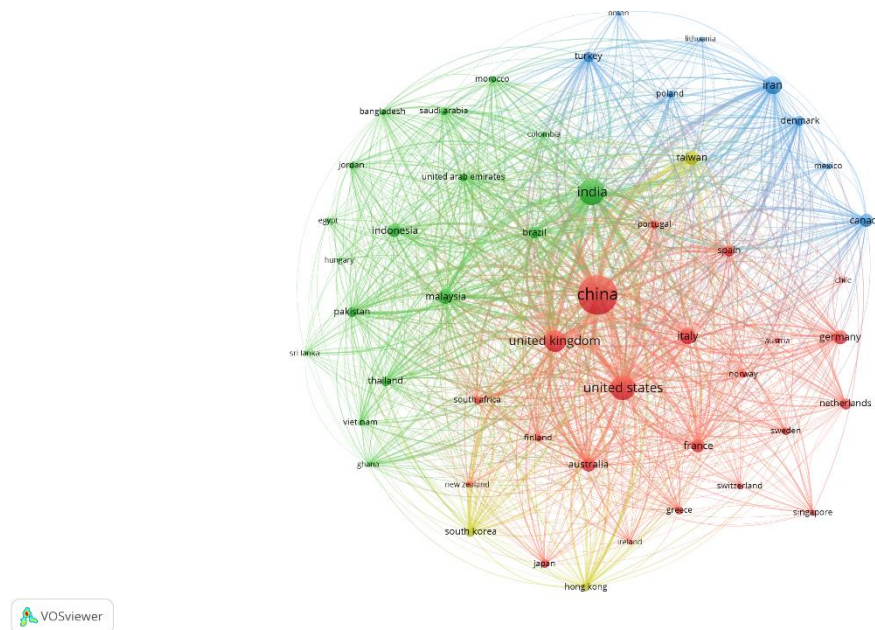


Figure 7: *The third figure from the bibliographic coupling analysis highlights the thematic connections between countries, showing how their research topics and impacts are interconnected through shared citations. This graph emphasizes the thematic clusters and similarities in research focus among different countries.*

Now, for a better look, here is a zoom-in of the Figure 7:

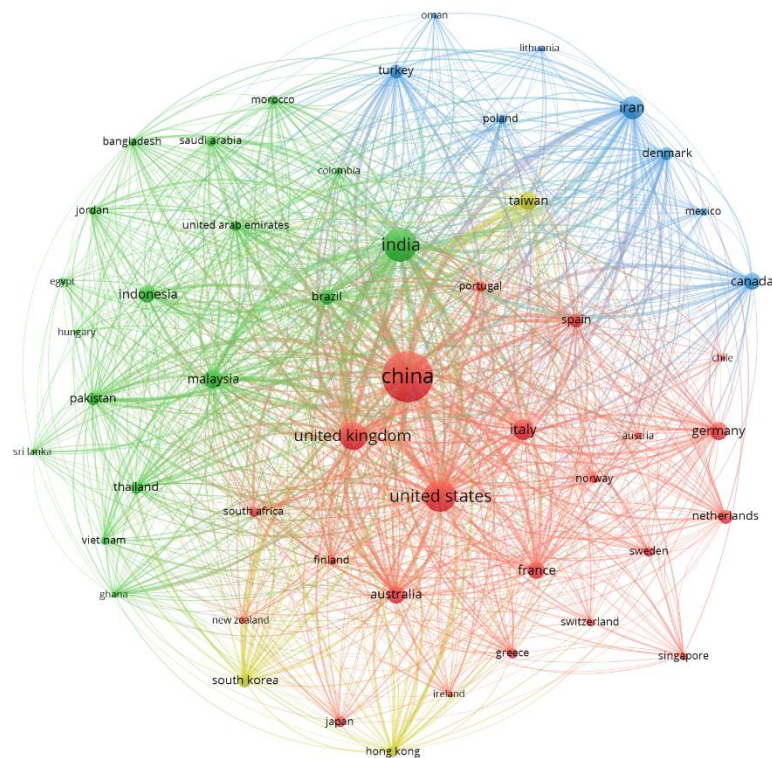


Figure 8: *Zoom-in view of Figure 7.*

Rank	Country	Documents	Citations	Total link strength
1	China	2441	67699	3211252
2	United States	981	60975	1969478
3	United Kingdom	716	37586	1943062
4	India	1052	37162	2958956
5	Iran	490	17601	1014563
6	Taiwan	321	17120	830103
7	Denmark	157	15993	518320
8	Canada	268	15455	497543
9	Germany	317	14235	378808
10	Hong Kong	127	13668	418314
11	Italy	413	13408	642806
12	Australia	299	13344	684626
13	Malaysia	353	9932	1256796
14	Netherlands	178	8470	176554
15	United Arab Emirates	106	8397	444441
16	France	263	8362	583624
17	Brazil	214	8139	846892
18	Türkiye	188	6721	564288
19	Spain	184	6276	392599
20	South Korea	162	6129	469939

Table 3: *Table with data extracted after conducting the bibliographic coupling between the countries.*

The results of countries like China, the US, and the UK in GSCM research aligns with their large industrial bases and the need for sustainable practices. China's dominance is driven by its colossal manufacturing sector and growing focus on sustainability. The UK's high collaboration highlights its role in international research. Germany's performance reflects its industrial strength and commitment to environmental sustainability. Emerging economies like India, Brazil, and Malaysia suggest the future direction of GSCM, balancing rapid growth with sustainability. India's large output and citations show its growing emphasis on integrating green practices in industries. Brazil and Malaysia's contributions indicate a regional shift towards sustainability.

This bibliometric analysis highlights the leading countries in GSCM research and their collaborations. China, the US, and the UK are key players driving advancements in the field. The findings underscore the importance of international collaboration and the global recognition of GSCM's role in improving environmental performance and regulatory compliance.

5.2.3 Authors

This analysis uses data from Scopus, analyzed with VOSviewer, to highlight the contributions of the most influential authors in GSCM research. By examining the top authors based on their document count, citations, and link strength, we aim to understand the key contributors and their collaborative networks in this field.

The dataset includes three metrics for each author: the number of documents, indicating research output; the number of citations, reflecting the impact of their research; and the total link strength, which measures how frequently each author collaborates with others in the dataset. Using VOSviewer capabilities, a co-authorship analysis was conducted by selecting the top fifty authors with the greatest total link strength and a minimum of 1,000 citations.

The key findings of the analysis are that Joseph Sarkis leads with eighty-eight documents, 21,828 citations, and a total link strength of 2,747, making him a central figure in GSCM research. Qinghua Zhu follows with forty-six documents, 14,338 citations, and a link strength of 2,167. Other notable contributors include Kannan Govindan (54 documents, 9,960 citations, link strength 1,291), Kee-Hung Lai (20 documents, 7,203 citations, link strength 1,180), and Robert D. Klassen (9 documents, 3,975 citations, link strength 389). These authors demonstrate strong research output and significant influence in the field.

The analysis reveals that significant authors often collaborate extensively, as indicated by their high total link strength. Joseph Sarkis (88 documents, 21,828 citations, link strength 2,747) and Qinghua Zhu (46 documents, 14,338 citations, link strength 2,167), for example, not only have high document counts and citation numbers but also strong collaborative networks. This pattern suggests that collaboration is a key factor in producing high-impact research.

Moreover, by using VOSviewer, a co-authorship analysis of the top authors was conducted to visualize their collaborative networks. The resulting graph shows the connections between these authors, highlighting how they work together on GSCM research. This visual representation helps to identify clusters of related researchers and the central figures driving the field.

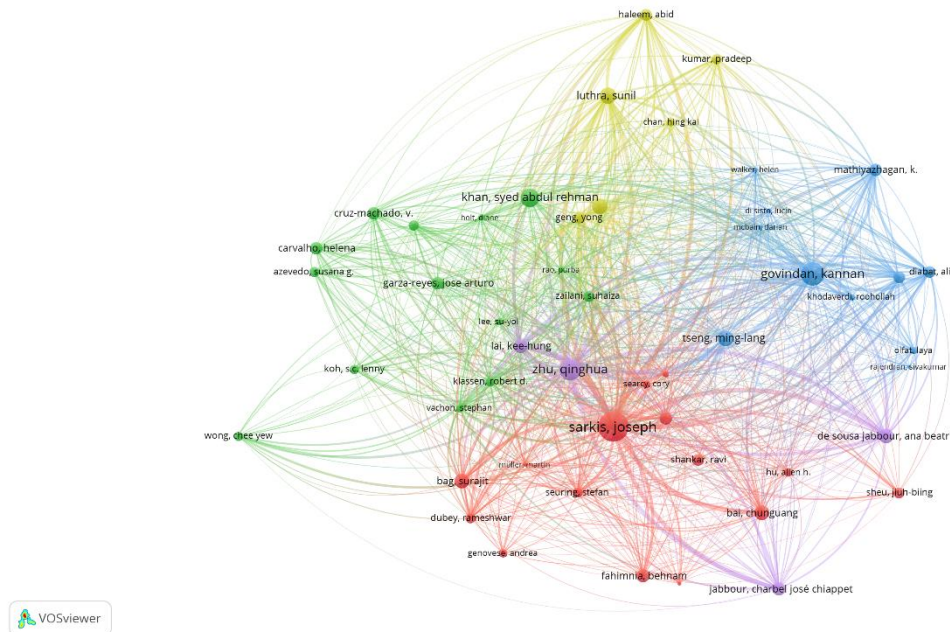


Figure 9: This figure illustrates the co-authorship links between the authors, with stronger links indicating more frequent collaborations. This highlights the connections between the authors, the impact of the research community and the importance of collaboration in advancing GSCM.

Rank	author	documents	citations	total link strength
1	Sarkis Joseph	88	21828	79
2	Zhu Qinghua	46	14338	51
3	Govindan Kannan	54	9960	46
4	Lai Kee-hung	20	7203	28
5	Seuring Stefan	10	5447	1
6	Klassen Robert D.	9	3975	7
7	Vachon Stephan	6	3334	5
8	Geng Yong	14	3253	24
9	Diabat Ali	14	3211	15
10	Kannan Devika	14	3196	23
11	Luthra Sunil	27	2779	23
12	Fahimnia Behnam	17	2639	13
13	Mangla Sachin Kumar	24	2268	10
14	De Sousa Jabbour Ana Beatriz Lopes	22	2014	21
15	Tseng Ming-lang	25	1919	2
16	Mathiyazhagan K.	16	1889	12
17	Haleem Abid	14	1863	13
18	Gunasekaran Angappa	15	1791	7
19	Carvalho Helena	15	1765	15
20	Jabbour Charbel José Chiappetta	18	1740	25

Table 4: Table with data extracted after conducting the co-authorship analysis between the authors.

The distinction of authors like Joseph Sarkis, Qinghua Zhu, and Kannan Govindan in GSCM research aligns with their extensive publication records and strong collaborative networks, as they seem to be among the leading authors driving advancements in the field. The findings underscore the importance of collaboration and the central role of key authors in shaping the research agenda. The frequent collaboration among top authors suggests that future research will likely continue with a strong emphasis on interdisciplinary approaches to solving complex supply chain challenges.

5.3 Conclusion after Bibliometric analysis

The bibliometric analysis presented in this chapter provides valuable insights into the research. The findings highlight the central role of keywords such as "sustainable development," and "green supply chain management," emphasizing the importance of sustainability and environmental performance in supply chain studies. The country analysis reveals that China, the United States, and the United Kingdom are leading contributors, with strong research outputs and extensive collaborative networks. Similarly, the author analysis identifies key figures such as J. Sarkis, Q. Zhu, and K. Govindan, who are pivotal in advancing the field through extensive publications and collaborations.

Moreover, this comprehensive overview helps to understand the current state of GSCM research and suggests future directions for the field. The analysis shows the need for ongoing collaboration and innovation to address the challenges of integrating sustainability into supply chains. As research in GSCM continues to grow, it will be important to focus on developing new technologies and policies that improve transparency, efficiency, and environmental performance. To conclude, this bibliometric analysis shows the importance of collaboration and highlights the key contributions of leading authors and countries. By continuing to build on these collaborative networks and focusing on innovative solutions, the field of GSCM can make significant progress in promoting sustainable practices and achieving regulatory compliance.

6. Literature review

The purpose of this literature review is to identify and categorize fifty (50) key studies of existing literature. The sources included in this review were found through extensive research in academic databases such as Scopus, ResearchGate, Google Scholar, and Emerald Insight. To organize the literature effectively, the sources are categorized into four main groups:

1. Studies with questionnaires, samples, and statistical analysis
2. Literature reviews and bibliometric analyses
3. Journals that propose a quantitative model or technique, such as regression models
4. Case studies

The table summarizing these sources will contain the following key information: the Authors, the Category number (1-4) that each journal/study will be placed, the Study Objective, the Methodology/Sample used in each journal/study, and Study Findings/Conclusion. By categorizing the sources in this manner and providing this information in a structured table, the literature review will offer a clear and detailed examination of the various methodologies and findings in the field, while understanding the current state of research on the topic.

6.1 Literature review table

Table 5: Literature review table of fifty selected sources.

Authors	Category	Study Objective	Sample & Methodology	Findings & Conclusions
Abdallah, et al. (2019)	1	Examining the impact of green supply chain management on environmental performance, operational performance, and business performance in Jordan.	The study included 215 manufacturing companies in Jordan. Convenience sampling was used to select participating companies.	Green supply chain management (GSCM) has a positive and significant effect on environmental performance (EP) and operational performance (OP), which in turn positively impact business performance (BP). EP and OP fully mediate the relationship between GSCM and BP.
Adomako, S. et al. (2022)	1	Investigating the impact of environmental collaboration on	The study collected data from a sample of 600	The study found that environmental collaboration positively influences responsible innovation, and this relationship is stronger when there

		firm performance through the mediating mechanism of responsible innovation, and to examine the moderating role of stakeholder pressure in this relationship.	manufacturing ventures in Ghana. Data was collected through questionnaires delivered in person to CEOs and finance managers of the firms. The study used regression analysis to test the hypotheses.	is high stakeholder pressure. Responsible innovation, in turn, mediates the relationship between environmental collaboration and firm performance. The study provides practical implications for managers to improve sustainable practices and highlights the importance of stakeholder management in driving responsible innovation.
Ahi, P., et al. (2013)	2	Identifying and analyze the published definitions of green supply chain management (GSCM) and sustainable supply chain management (SSCM).	The study conducted a systematic literature review of articles published in the Scopus database. A total of 22 definitions for GSCM and 12 definitions for SSCM were identified and analyzed.	The analysis showed that definitions for GSCM were more narrowly focused on environmental issues, while definitions for SSCM had a broader triple bottom line perspective. Some definitions of SSCM overlapped with definitions of GSCM, suggesting that SSCM is an extension of GSCM. No complete definition of GSCM or SSCM was identified, so a new definition for SSCM was proposed.
Ali, S. S. (2021)	1	Exploring the initiatives and practices adopted by logistics, specifically warehousing operations organizations, in implementing social sustainability measures in developing countries.	Data was collected from 217 organizations in the warehousing hub of Gurugram, India, through a survey-based approach. The social sustainability practices were identified and ranked using the Best Worst Method (BWM). Binary logistic	The study found that the most effective social sustainability practice in warehousing organizations is a responsible work environment. However, training and development and corporate ethical responsibility commitment were found to be lacking in improving social footprints. Philanthropy and corporate ethical responsibility commitment also require further exploration.

			regression was used to evaluate the effectiveness of corporate social responsibility (CSR) in implementing these practices.	
Al-Ma'aith, N. (2018)	1	Investigating the relationship between green supply chain management (GSCM) practices and performance (environmental, economic, and organizational) in the construction sector in Jordan. The study aims to provide insights into GSCM practices in the construction sector of a developing country.	The study used a self-administered survey to collect data from middle and high-level managers in the Jordanian Construction Contractors Association. The sample consisted of 133 respondents.	The study reveals that green supply chain management practices, particularly in construction and investment recovery, positively impact environmental and economic performance in the Jordanian construction sector. However, the relationship between GSCM practices and organizational performance is only partially supported.
Amjad, A. et al. (2022)	1	Investigating the effects of green supply chain management practices on firm performance and sustainable development, with a focus on the leather industry in Pakistan. The study aims to understand how green practices impact the firm's performance and how competitiveness	The study used a survey-based investigation with a questionnaire to explore the impact of green supply chain management (GSCM) practices on the performance of the leather industry in Pakistan. The study used a cross-sectional design and gathered data	The study reveals that eco-design, internal environmental management, green distribution, green purchasing, customer cooperation, and investment recovery positively impact environmental performance, economic performance, and operational performance. However, green distribution and customer cooperation have no significant impact. Implementing GSCM practices can enhance Pakistan's leather industry performance.

		and investment recovery mediate this relationship.	from ISO certified leather industries through snowball and convenience sampling.	
Ansari, Z. N., et al. (2017)	2	Conducting a literature review on sustainable supply chain management (SSCM) and identify gaps in knowledge and future research opportunities in the field.	The sample used in this study includes 286 papers published in different journals from 2002 to 2016. The papers were analyzed based on various categories such as research methodology, research design, industry sector, and enablers and barriers for SSCM.	The study found that research on SSCM is dominated by qualitative research methods, with case studies being the most common methodology used. The study concluded that there are opportunities for further research in the field of SSCM, particularly in areas such as modeling complex sustainability factors and studying the implementation of SSCM in specific industry sectors.
Arshad Ali et al. (2020)	1	Investigating the impact of various enabling practices on process innovation in manufacturing organizations. The study examines the relationships between lean manufacturing, organizational culture, human resource management, total quality management, supply chain management, and process innovation.	The study used a questionnaire to collect data from 1143 respondents in the industrial sectors of Pakistan. Structural Equation Modeling (SEM) was used to analyze the data and test the proposed hypotheses.	The study found that Lean Manufacturing (LM), Human Resource Management (HRM), and Organizational Culture (OC) significantly contribute to Process Innovation (PI). Total Quality Management (TQM) and Supply Chain Management (SCM) partially mediate the relationships between LM, HRM, OC, and PI. The findings suggest that organizations should focus on implementing effective LM, HRM, and OC practices to improve PI.
Asghar, M. (2023)	1	Determining the impact of green supply chain	The study used a quantitative research	The study found that there is a significant impact of green purchasing, green logistics, green

		management on organizational performance, establish the relationship among variables such as green purchasing, green manufacturing, ecological design, and green logistics, and explore new ways of implementing green supply chain management to increase organizational performance, especially in the automotive industry.	approach with a deductive and descriptive research design. Convenience sampling was used to collect data from 152 respondents working in the automobile industry in Karachi. A questionnaire with rating scales was used as the data collection instrument. Statistical analysis was conducted using SPSS software.	manufacturing, and ecological design on organizational performance in the automobile industry. The findings suggest that adopting green supply chain practices can enhance organizational performance and provide a competitive edge. Recommendations include promoting and implementing green supply chain initiatives and further research in different industries.
Azadi, E., Moghad das et al. (2023)	4	Proposing a network data envelopment analysis (NDEA) model to evaluate the performance of green supply chains. The model aims to address the complexity of supply chains and provide a comprehensive evaluation framework.	The study proposes a network data envelopment analysis (NDEA) model to evaluate the performance of green supply chains. The model is applied to the wire and cable industry.	The developed NDEA model based on a common set of weights can effectively evaluate the performance of green supply chains compared to classic models. The model provides insights into the cost efficiency of different stages in the supply chain and identifies inefficient supply chains that need improvement.
Bai, C. et al. (2017)	4	Developing an implementation path model for green information technology systems (GITS) in the Ghanaian mining industry.	The study used a sample of six large-scale multinational Ghanaian gold mining companies. The methodology involved using	The study found that the implementation order of GSCM practices should start with developing strategic supplier partnerships, followed by end-of-life practices, eco-innovative practices, internal environmental management, operations and logistics integration, and finally,

			grey system theory, DEMATEL, and the NK fitness landscapes model to evaluate and develop a path framework for green supply chain management practices.	green information technology and systems.
Bakhsh Magsi, H. et al. (2018)	1	Examining the impact of organizational culture on environmental performance in the manufacturing industry of Pakistan.	The study surveyed 314 manufacturing firms in Pakistan and used Smart-PLS for data analysis, to analyze the data and test the relationship between organizational culture and environmental performance.	The study found that adaptability, mission, and consistency positively affect environmental performance, while involvement does not have an effect. Organizational culture has a strong impact on environmental performance.
Balon, V. (2019)	2	Critically reviewing the existing literature on pressures, practices, and performance of green supply chain management (GSCM).	The study surveyed more than 150 research articles published in high impact refereed academic journals. The review synthesis discussed GSCM pressures, practices, and performance.	The study found that GSCM pressures include government rules and regulations, corporate social responsibility, investment recovery, and the green market. GSCM practices include eco-design, internal environmental management, waste management, green purchasing, quality, and product recovery. GSCM performance includes financial, operational, and environmental aspects.
Bals, L. et al. (2018)	4	Advancing the theory of supply chain management by analyzing the sustainable	The study analyzes four social businesses located in Haiti as cases of	The study found that social businesses in Haiti have complex networks of stakeholders, including competitors, NGOs, government, communities, and suppliers. The design of the supply chain is

		supply chain design at social businesses. The aim is to understand how supply chains are designed to deliver on triple bottom line (TBL) objectives, which include economic, environmental, and social gains. The study also explores how different supply chain configurations support sustainability.	innovative supply chain structures for triple bottom line (TBL) sustainability. The study uses interviews and analysis of business plans and financial statements to understand the design parameters, stakeholder involvement, and supply chain configurations of these social businesses.	influenced by the need to deliver sustainable TBL value to these stakeholders. The study also found that the financial support chain is initiated before the physical material flows, and the support chains can take multiple flow directions. The study proposed several propositions related to the design and support of sustainable supply chains in social businesses.
Brammer S. et al. (2011)	1	Addressing the gaps in knowledge about how public sector organizations internationally are responding to sustainable procurement (SP) and the conditions that are most conducive to SP. The study aims to inform policy development at the government and organizational levels.	The study surveyed over 280 public procurement practitioners from 20 countries to understand how public sector organizations are implementing sustainable procurement (SP) practices. The survey was conducted using a snowball sampling method.	The study found that while most public sector organizations are incorporating some sustainability criteria in their procurement, there is significant variation across regions in the extent and nature of SP practices. Leadership support and financial resources were identified as important facilitators of SP, while financial concerns and legal barriers were identified as major barriers. The study also highlighted the importance of policy and legislation in shaping engagement with SP.
Büyükoçkan, G. Et al. (2011)	4	Evaluating green supply chain management practices using a fuzzy analytic network process	The study uses Ford Otosan, a pioneering company in environmental subjects in Türkiye, as a case study to	The fuzzy ANP model provides a more accurate and precise analysis by considering interdependent relationships. The study finds that System B, which focuses on just-in-time (JIT) inventory management, is the best alternative for Ford Otosan.

		(ANP) approach.	illustrate the application of the ANP model. The researchers develop an evaluation framework for green supply chain management and use fuzzy ANP to assess the components and elements of GSCM.	
Cao, J., Zhang, X. et al. (2018)	3	Investigating the decision-making processes of both the government and related enterprises in the emerging remanufacturing industry. The study focuses on the implementation of environmental regulations and financial instruments in a reverse supply chain consisting of a manufacturer and a recycler. The objective is to understand how these policies and measures impact the remanufacturing industry and motivate supply chain members to undertake environmentally friendly initiatives.	The study uses a bi-level programming model to analyze the interactions between the government and a supply chain system consisting of a manufacturer and a recycler. The model considers environmental regulations, financial instruments, and incentives for channel members.	The study suggests that proper policies can motivate supply chain members to undertake environmentally friendly initiatives, leading to an increase in the remanufacturing rate and strengthening of the recovery effort. This can boost the remanufacturing industry, especially in its initial stages.

Cho, C. K. et al. (2018)	3	Examining the impact of managerial characteristics and consumer proximity on corporate environmental performance (CEP).	The study used data from 49 companies in the textile and apparel industries in Korea. The researchers analyzed the effects of CEO characteristics (tenure, educational level, and functional background) on CEP, as well as the moderating effect of consumer proximity.	The study found that CEO tenure, educational level, and output orientation were positively associated with CEP. Consumer proximity also positively moderated the relationship between CEO educational level and CEP, as well as the relationship between CEO output orientation and CEP.
Choudhary, K. et al. (2021)	2	Critically analyzing the literature on green supply chain management (GSCM) pressures, practices, and performance for manufacturing enterprises.	The study used the Scopus database for literature search and conducted bibliometric, network, and frequency analyses to review the evolution of GSCM constructs and measures.	The study found that GSCM practices and performance are interconnected and can enhance the level of implementation in manufacturing enterprises and their supply chains. The implementation of these practices can improve the performance of manufacturing enterprises. The study also identified future research directions and provided managerial implications for manufacturing enterprises in adopting green practices and assessing their performance.
Davis-Sramek, B. et al. (2020)	3	Exploring how firms can use strategic priorities, such as environmental strategic focus and environmental sourcing practices, to enhance environmental supplier	The study used structural equation modeling to analyze primary data from 268 supply chain professionals in the U.S.A. The participants held managerial positions in manufacturing,	The research found that environmental sourcing practices and environmental strategic focus positively influence environmental supplier collaboration. Additionally, environmental supplier collaboration is associated with interorganizational citizenship behavior. The study also found that environmental regulatory pressure moderates the relationship between these variables, with mixed effects.

		collaboration in sustainable supply chain management.	distribution, and service firms.	
Dzikria nsyah, M. A. et al. (2023)	3	Investigating the role of green supply chain management practices on environmental performance in Indonesian small and medium enterprises (SMEs).	The sample consisted of 89 Indonesian small and medium business managers and owners. The methodology used was a quantitative approach, and research instruments with partial least squares - structural equation modeling (PLS-SEM) were applied.	The conclusions of the study were that internal factors such as strategic orientation and internal environment management do not drive SMEs to consider green supply chain management. However, government regulation plays a significant role in adopting green supply chain management. Additionally, adopting green supply chain management can affect SMEs' environmental performance. Internal factors do not directly affect environmental performance through green supply chain management, but green supply chain management adoption can mediate the impact of government regulation on environmental performance.
Fahim F. et al. (2022)	2	Conducting a bibliometric analysis of the last twenty years of research on green supply chain management and green finance using the Scopus database.	The study analyzed a total of 2385 articles retrieved from the Scopus database. The analysis included information on publication output, preferred journals, leading countries and institutions, and international collaborations. Bibliometric maps were created using VOSviewer to visualize the relationships between different items such as author	The study found that China, India, Iran, and Taiwan were the top contributors to research on green supply chain management and green finance. The most productive journal was the Journal of Cleaner Production. The study identified new areas of research such as green innovation, green information technology, and green credit policy. The study concluded that integrated work on green supply chain management and green finance is limited, making this research area novel and valuable for credit managers and policymakers.

			keywords and countries.	
Fu, L., Yang, D. et al. (2022)	3	Analyzing the relationships between green supply chain management (GSCM) and enterprise environmental performance (EEP) and explore the moderating role of market environment, regional culture, sampling area, and industry type.	The study conducted a meta-analysis of 65 independent samples with a total sample size of 14,196. The researchers constructed a comprehensive theoretical model and analyzed the relationships between GSCM and EEP using effect sizes and statistical analysis.	The study found that GSCM has a moderate positive impact on EEP. All dimensions of GSCM positively influence EEP, with internal environmental management having the most significant effect. The relationships between GSCM and EEP can be moderated by the market environment, regional culture, sampling area, and industry type. The study provides more general and regular conclusions about the impact of GSCM on EEP and enriches the theoretical research boundary of GSCM.
Gao, S., Lim, et al. (2021)	1	Identifying the critical failure factors of green supply chain management in China's SMEs.	The study collected evaluation data from 21 experts through online questionnaires and used a combination of fuzzy synthetic evaluation (FSE) and decision-making trial and evaluation laboratory (DEMATEL) to analyze the data and identify the critical failure factors.	The study found that the most critical failure factors of green supply chain management in China's SMEs are lack of top management support, poor guidance from authorities, difficulty in supplier selection, and inadequate supplier commitment. Collaboration and support were identified as the most critical perspectives for successful green supply chain management.
Hartmann, J. et al. (2017)	3	Examining the effect of industry context variables (munificence, dynamism, and complexity) on the relationship between	The study compiled a sample of 336 European manufacturing firms listed in the Asset4 database between 2003	The study found that environmental management activities significantly improve a company's environmental performance. The relationship between environmental management and performance is moderated by industry context, with munificence (abundance of

		environmental management and organizational performance.	and 2013. The environmental performance and management of these firms were measured using data from the Asset4 database and Thomson Reuters WorldScope.	resources) positively influencing the relationship.
Jayant, A. et al. (2014)	1	Identifying the barriers to implementing Green Supply Chain Management (GSCM) in the Indian auto component manufacturing industry.	The study was conducted in three phases, which included identifying barriers from literature and interviews with department managers. A total of 20 barriers were identified using this methodology.	The study found that lack of government support systems was the most dominant barrier to implementing GSCM in the Indian industry.
Jum'a, L. et al. (2021)	1	Assessing the factors affecting the adoption of GSCM practices in manufacturing firms in Jordan, and to analyze the role of firm size as a moderator in this relationship.	The study collected data from 387 managers of manufacturing firms in Jordan using a well-administered online survey. The data were analyzed using descriptive statistics and structural equation modeling.	The study found that customer, cost, supplier, and environmental factors significantly influenced managers' intention to adopt GSCM practices.
Kannan, D. et al. (2014)	3	Proposing a framework using Fuzzy TOPSIS to select green suppliers for a Brazilian electronics	The study used the fuzzy TOPSIS methodology to solve a multi-criteria decision-making problem. The	The study concluded that the proposed fuzzy TOPSIS approach was effective in ranking green suppliers. Also, a sensitivity analysis was conducted to examine the influence of decision makers' preferences on the selection of green suppliers showing that the

		company based on the criteria of green supply chain management practices.	methodology involved constructing a fuzzy decision-making matrix, normalizing the matrix, determining the positive and negative ideal solutions, calculating the distance of alternatives from the ideal solutions, and ranking the alternatives based on their closeness to the positive ideal solution.	ranking of green suppliers changed slightly with different preferences.
Khan, M. T. et al. (2022)	3	Examining the impact of GSCM practices on operational performance, with the mediation of technological innovation, in Pakistani manufacturing firms.	The study collected data from various manufacturing organizations in Pakistan through a survey-based questionnaire. The data was analyzed using PLS-structural equation modeling.	The study found that GSCM practices have a positive impact on technological innovation and operational performance. Implementing GSCM practices can improve operational efficiency, product quality, and flexibility in manufacturing firms.
Khan, S. J. et al. (2021)	2	Conducting a systematic literature review on green process innovations to understand the issues, challenges, and gaps in the literature.	The study conducted a comprehensive review of studies on green process innovation using a systematic literature review methodology.	The study found that research has gained increased attention in recent years, while also identified gaps in the literature, such as the need for more research in different geographical contexts and the use of diverse theoretical perspectives.
Kim, M. et al. (2017).	1	Investigating the impact of supplier innovativeness on supply chain collaboration	The study used a survey questionnaire (measurements of supplier innovativeness,	The study found that supplier innovativeness positively affects information sharing and supply chain agility. Also, it found that the impact of these factors on supply chain agility is stronger in domestic

		and agility, and to examine the moderating role of global sourcing in this relationship.	information sharing, strategic sourcing, and supply chain agility) to collect data from supply and purchasing managers in manufacturing firms in Korea.	sourcing compared to global sourcing.
Kuo, T.-C. et al. (2018)	2	Providing a holistic view of the progression of technologies that have contributed to the realization of sustainability and to identify future technology directions towards sustainability.	The study used a structured keyword search on major databases to select quality research review papers on sustainability. The selected papers were analyzed and evaluated and classified into different technology-based eco-innovation dimensions.	The study identified four technology-based eco-innovation dimensions: green/sustainable product development, business model integration, green marketing and sustainable consumption, and hybrid model construction and optimization.
Lee, S. (2008)	1	Examining the factors that facilitate small and medium-sized suppliers in participating in green supply chain initiatives.	The study used a sample of 855 small and medium-sized manufacturing suppliers in Korea. Data was collected through questionnaires and analyzed using hierarchical linear regression.	The study found that buyer GSC practices, government involvement, and GSC readiness of SME suppliers all have a positive influence on SME supplier participation in GSC initiatives.
Linton, J. D. et al. (2007)	2	Exploring the convergence of supply chains and sustainability,	The study provides a background on current trends in the field of	The study highlights the importance of integrating sustainability into supply chain management, considering issues such as product design, manufacturing by-products,

		focusing on the environmental management and operations of the entire supply chain.	sustainable supply chains, drawing on interdisciplinary research and considering the implications for operations management.	product life extension, and end-of-life processes. It emphasizes the need for further research and the potential impact on government policy and business models.
Liu, J. et al. (2018)	1	Clarifying the linkages between GSCM and the circular economy by identifying mutual theory applications used to study both concepts.	The study conducted a systematic literature review to identify theories.	The study concludes that the found theories have potential for advancing research in both GSCM and CE. However, the study also acknowledges limitations and suggests further research.
Luthra, S. et al. (2017)	3	Proposing a framework for evaluating sustainable supplier selection in supply chains.	The study used an integrated AHP-VIKOR approach to evaluate supplier selection for sustainability in the automotive industry in India. The research involved a decision group of five experts and utilized a hierarchical structure to identify and finalize sustainable supplier evaluation criteria, sub-criteria, and alternatives.	The proposed framework has practical implications for managers in selecting and evaluating sustainable suppliers in the supply chain.
Mathivathanan, D. et al. (2018)	1	Understanding the interrelated influences among Sustainable	The study used a literature review to identify common sustainable	The study found that management commitment, supply chain orientation, and the triple bottom line approach were the most prominent SSCM practices. These

		Supply Chain Management practices in the automotive industry, specifically in India, and identify the most influential practices for implementing sustainable supply chain management.	supply chain management (SSCM) practices. A questionnaire was then administered to stakeholders in the automotive industry to analyze the practices using the DEMATEL method.	practices were found to have a high influence on other practices and were identified as prerequisites for successful implementation of SSCM.
Mitra, S. et al. (2013)	2	Exploring the adoption of green supply chain management practices in Indian manufacturing firms and examine the impact of these practices on firm performance.	The research methodology involved a survey. The survey instrument was developed based on existing literature and data was collected through in-person and telephone interviews. The respondents varied in size and industry sector.	The study found that the adoption of GSCM practices in India is still low, with most firms adopting them voluntarily. There is a lack of regulatory and customer pressure for adoption.
Mollenkopf, D. A. et al. (2022)	1	Exploring how consumers develop impressions of a company's products based on different evaluative dimensions, specifically the positive integrity signal of supply chain transparency (SCT) and the negative capability signal	The study used an experimental research design to investigate the impact of supply chain transparency (SCT). Participants were randomly assigned to different scenarios and their responses were measured using Likert scales.	The study suggests that SCT can be a strategic tool for firms to manage consumer perceptions and mitigate the negative impact of product recalls. However, the effectiveness of SCT may depend on the severity of the recall and the temporal sequence of signals.

		of a product recall.		
Petljak, K. et al. (2018)	1	Assessing the relationship between green in-store activities, green supply chain management (GSCM), and environmental and economic performance outcomes in the context of food retailing.	The study collected data from 210 food retailers in Croatia through a questionnaire. The data was analyzed using structural equation modeling.	The study found that green in-store practices, such as water and energy management and waste management, are positively associated with green supply chain management practices. These practices, in turn, positively impact environmental performance. However, there was no direct link between green supply chain practices and economic performance. The study suggests that economic performance is more influenced by cost savings rather than environmental initiatives.
Karim R. et al. (2023)	1	Investigating the effects of green supply chain management practices on customer behavioral intentions and the mediating role of customer satisfaction in the hospitality industry in Bangladesh.	The study collected data using a structured questionnaire was used, and data were gathered from 384 participants using convenience sampling.	The study found that GSCM practices have a positive impact on customer satisfaction (CS) and behavioral intentions, including willingness to pay (WTP), revisit intention (RI), and word of mouth (WOM). The findings suggest that implementing GSCM practices can attract and retain customers in the hotel industry.
Rexhepi, G. et al. (2023)	2	Examining the effects of green entrepreneurship on firm performance using enterprise data for the Republic of Albania.	The study used data from the Business Environment Enterprise Performance Surveys (BEEPS) of 377 companies in Albania in 2019. The OLS estimator was applied to analyze the relationship between green entrepreneurship and productivity.	The study found that innovation activities, green entrepreneurship, foreign ownership, monitoring energy, and certification were all significantly related to better firm performance. Recommendations include promoting sustainability education, providing funding for renewable resources, and fostering collaboration between institutions, governments, NGOs, and businesses.

Roehrich, J. et al. (2017)	4	Exploring the factors contributing towards second-tier suppliers' willingness to drive GSCM performance.	This study used an abductive research approach and an in-depth case study of a German aircraft interior company and its key suppliers to investigate green supply chain management (GSCM) practices and performance in the aerospace industry.	The study found that green supplier selection and value internalization are crucial for driving GSCM performance. External factors such as industry competition, buyer expectations, and regulations also play a role in driving GSCM practices. The study also identified autonomy, competence, and relatedness as key dimensions for value internalization at suppliers.
Sarkis, J. et al. (2017)	2	Providing an overview of how research on production and operations management has evolved alongside environmental sustainability.	The study identified three major research methodologies used in the articles: modelling, conceptual, and empirical.	The study found that 44% of the papers were primarily modelling oriented, 48% focused on empirical perspectives, and only 8% were purely conceptual. The top two cited papers focused on green supply chain management.
Sellitto, M. A. et al. (2016)	3	Defining priorities for green practices in the supply chains of the peach industry.	The sample consisted of four focal companies in the peach industry supply chains in Pelotas, Brazil. The methodology used was qualitative and quantitative modeling, with data collected through direct observation, documentation analysis, and interviews with managers of the companies.	The study concluded that the highest priority green practice in the peach industry supply chains is innovation, specifically through the practice of Eco-design. Cooperation, performance evaluation, green purchasing, and green manufacturing were also identified as important practices.

Shaharudin, M. R. et. al. (2019).	3	Exploring the mediating effects of product returns on the relationship between a firm's green capabilities and its adoption of closed-loop supply chain.	The study used survey data from ISO 14001 certified manufacturers in Malaysia. The researchers used a structural equation model to analyze the data and test the research hypotheses and examined their effects on product returns and closed-loop supply chain adoption.	The conclusions of this study are that recovery and integration capabilities positively influence product returns, and that product returns partially mediate the relationship between recovery and integration capabilities and closed loop supply chain adoption.
Shin, S., & Cho, M. (2022).	1	Exploring how green supply chain management (GSCM) implemented by suppliers can improve the ethical attitudes and cooperative behaviors of restaurants towards green suppliers, ultimately leading to better environmental performance.	The data for this study was collected through an online survey conducted and consisted of 259 subjects.	The study found that green suppliers and their implementation of green supply chain management practices have a significant impact on restaurant ethical attitudes and cooperative behaviors.
Soda, S. et al. (2015).	2	Examining the adoption and implementation of Green Supply Chain Management (GSCM) practices in developing countries, specifically in India, and to identify the challenges and opportunities for	The study used a literature review to gather information on GSCM practices in India and other countries. It compared the adoption and implementation of GSCM in India with that of China and the US.	The study concludes that GSCM is an effective tool for minimizing environmental degradation while achieving economic growth. However, adoption of GSCM practices in India is still limited due to prohibitive costs, lack of awareness, and dithering in implementing green initiatives.

		its implementation.		
Tian, Y., et al. (2014).	3	Developing a system dynamics model using evolutionary game theory to guide subsidy policies and promote the diffusion of green supply chain management among Chinese manufacturers.	The study used a combination of system dynamics and evolutionary game theory to analyze the relationships and behaviors of manufacturers, government, and consumers in the diffusion of GSCM.	The study concludes that government subsidies and environmental awareness are key factors in promoting the diffusion of green supply chain management (GSCM) among manufacturers.

7. Findings

7.1 Summary of Findings

The findings of this study provide a comprehensive understanding of the significant impact that Green Supply Chain Initiatives (GSCIs) have on environmental performance and regulatory compliance. Through a thorough review of existing literature, it is evident that GSCIs can lead to substantial improvements in various aspects of environmental sustainability. The study identifies key areas such as waste management, emission reductions, and resource efficiency where GSCIs make a noticeable difference.

One of the primary findings is that companies implementing GSCIs report considerable reductions in greenhouse gas emissions. This reduction is often achieved through practices like green manufacturing, which involves the use of energy-efficient technologies and processes that minimize environmental harm. Additionally, GSCIs such as reverse logistics and eco-design contribute significantly to better waste management. These practices promote recycling and the use of sustainable materials, which helps companies reduce the amount of waste that ends up in landfills and enhances overall resource recovery.

The study also highlights the importance of green procurement and sustainable sourcing strategies in improving resource efficiency. By selecting suppliers and materials based on their environmental performance, companies can significantly reduce their environmental footprint and foster a more sustainable supply chain. Moreover, the analysis reveals that while all GSCIs contribute positively to environmental performance, some initiatives are more effective than others in specific contexts. This variation in effectiveness underscores the need for companies to carefully consider which GSCIs to implement based on their unique operational and environmental circumstances.

Overall, the findings emphasize the multifaceted benefits of GSCIs, not only in enhancing environmental performance but also in driving regulatory compliance and competitive advantage. These insights provide a solid foundation for businesses, policymakers, and researchers to understand the value of integrating sustainability into supply chain management.

7.2 Impact of Green Supply Chain Initiatives on Environmental Performance

The implementation of Green Supply Chain Initiatives (GSCIs) has a profound impact on enhancing environmental performance across multiple metrics. One of the most significant outcomes observed is the reduction in greenhouse gas emissions. Companies that adopt GSCIs often report substantial decreases in emissions, which is largely attributed to the adoption of green manufacturing practices. These practices involve the use of energy-efficient technologies and processes that are designed to minimize environmental impact while maintaining production efficiency.

Another critical area where GSCIs make a significant impact is waste management. Initiatives such as reverse logistics and eco-design, play a pivotal role in promoting recycling and the use of sustainable materials. Reverse logistics focuses on reclaiming products and materials for reuse and recycling, thereby reducing the amount of waste that ends up in landfills. Eco-design, on the other hand, integrates environmental considerations into product design to minimize negative impacts throughout the product lifecycle. These practices not only help companies manage waste more effectively but also contribute to overall resource recovery and sustainability.

Furthermore, green procurement and sustainable sourcing strategies are essential components of GSCIs that enhance resource efficiency. By prioritizing suppliers and materials with strong environmental performance, companies can significantly reduce their environmental footprint. This approach encourages a more sustainable supply chain and fosters a culture of environmental responsibility among suppliers and partners.

The study also highlights that the effectiveness of GSCIs can vary depending on the specific context and industry in which they are implemented. Some initiatives may yield more significant environmental benefits in certain sectors than others, underscoring the importance of tailoring GSCI implementation to the unique needs and circumstances of each company. Overall, the impact of GSCIs on environmental performance is substantial, demonstrating their value in promoting sustainability and reducing the ecological footprint of supply chain operations.

7.3 Impact of Green Supply Chain Initiatives on Regulatory Compliance

Green Supply Chain Initiatives (GSCIs) are instrumental in helping companies meet and exceed regulatory requirements. The study reveals that companies adopting GSCIs are better equipped to navigate the increasingly changing landscape of environmental regulations. By integrating sustainability into their operations, these companies can ensure that their practices align with regulatory standards, thereby reducing the risk of non-compliance and the associated legal penalties.

One of the key findings is that GSCIs enhance a company's ability to comply with environmental regulations by promoting practices that are inherently aligned with regulatory expectations. For instance, green manufacturing processes that emphasize energy efficiency and waste reduction help companies meet emission standards and waste management requirements. Similarly, eco-design practices that focus on sustainable product design and lifecycle management ensure that products meet environmental standards from inception to disposal.

Moreover, GSCIs such as green procurement and sustainable sourcing contribute to regulatory compliance by ensuring that the entire supply chain adheres to environmental standards. By selecting suppliers based on their environmental performance, companies can create a supply chain that is compliant with environmental regulations, thereby mitigating risks associated with non-compliance. This proactive approach not only helps in avoiding fines and legal issues but also enhances the overall sustainability of the supply chain.

The study also highlights the role of GSCIs in providing companies with a competitive edge in markets with strict environmental regulations. Compliance with these regulations is often a prerequisite for market entry, particularly in regions with rigorous environmental standards. Companies that implement GSCIs are better positioned to access these markets, thereby enhancing their competitive position and opening up new business opportunities.

Overall, the impact of GSCIs on regulatory compliance is significant, providing companies with the tools and practices needed to navigate complex regulatory landscapes. This not only helps in maintaining smooth operations but also reinforces the importance of sustainability as a core component of business strategy.

7.4 Recommendations for Future Research

While this study provides valuable insights into the impact of Green Supply Chain Initiatives (GSCIs), several areas warrant further investigation to build a more comprehensive understanding of their effectiveness and potential. Future research should focus on conducting detailed comparative analyses of different types of GSCIs to determine their relative effectiveness across various industries and contexts. Empirical studies that measure the specific outcomes of each initiative would be particularly beneficial in identifying best practices and areas for improvement.

Additionally, there is a need for studies that track the long-term impacts of GSCIs on environmental performance and regulatory compliance. Such studies would provide a deeper understanding of the sustainability benefits and potential challenges over time, offering insights into the durability and adaptability of GSCIs in the face of evolving environmental and regulatory landscapes.

Exploring the role of emerging technologies, such as blockchain and the Internet of Things (IoT), in enhancing the effectiveness of GSCIs could also provide new insights. Research could investigate how these technologies can improve transparency, traceability, and overall efficiency in green supply chains. Understanding the integration of these technologies with GSCIs could pave the way for more innovative and effective sustainable supply chain practices.

Furthermore, more research is needed on the adoption and impact of GSCIs in small and medium-sized enterprises (SMEs). SMEs often face unique challenges in implementing sustainability initiatives due to limited resources and capabilities. Understanding these challenges and identifying tailored strategies for SMEs can help in promoting sustainability across a broader range of businesses.

Examining the impact of GSCIs in different geographical regions can also reveal how local regulatory environments, cultural factors, and economic conditions influence the effectiveness of these initiatives. This could help in formulating region-specific policies and practices that enhance the adoption and impact of GSCIs globally.

By addressing these areas, future research can build on the findings of this study, contributing to a more comprehensive understanding of Green Supply Chain Initiatives and

their role in promoting sustainability in supply chain management. This continued research will be crucial in developing strategies that effectively balance environmental performance, regulatory compliance, and economic viability.

8. Discussion

8.1 Implications of the Findings

The findings of this thesis suggest several implications for businesses, policymakers, and researchers. For businesses, adopting Green Supply Chain Initiatives (GSCIs) may lead to improved environmental performance by reducing waste, lowering emissions, and enhancing resource efficiency. These insights could help companies integrate more sustainable practices into their supply chains. Additionally, GSCIs can assist companies in meeting strict environmental regulations, potentially helping them avoid legal penalties and improve market access. Understanding these regulatory benefits might encourage companies to consider implementing these initiatives. Moreover, companies that adopt GSCIs might gain a competitive advantage by appealing to environmentally conscious consumers and enhancing their corporate image, which could lead to increased customer loyalty and potentially higher revenues.

For policymakers, this study provides some evidence that GSCIs can positively impact environmental performance and regulatory compliance. This could support the development of policies that promote the adoption of these practices. Policymakers might use these findings to design incentives and regulations that encourage sustainable supply chain practices. Furthermore, the insights from this research could help refine existing regulatory frameworks to ensure they effectively drive the adoption of GSCIs and achieve desired environmental outcomes.

For researchers, this thesis highlights the need for further research on the comparative effectiveness of diverse types of GSCIs. Future studies could explore new dimensions of GSCIs and their impacts in various industrial contexts. Additionally, the study's approach to categorizing and analyzing GSCIs might serve as a foundation for future research methodologies in sustainable supply chain management.

8.2 Limitations of the Study

Despite the valuable insights provided, several limitations of this thesis should be acknowledged. The literature review primarily focuses on studies available in academic databases such as Scopus and Google Scholar. There may be relevant studies and practical

case studies in other sources that were not included, potentially limiting the comprehensiveness of the review. Moreover, the findings are based on a review of existing literature and may not fully capture the diversity of GSCIs across different industries and regions, limiting the generalizability of the conclusions.

Green supply chain practices are continuously evolving, driven by technological advancements and changing regulatory landscapes. This thesis reflects the state of knowledge at the time of writing, and future developments may alter some of the findings and implications. Additionally, the analysis relies on secondary data from existing studies. The accuracy and reliability of the findings are dependent on the quality of the original research. Any biases or limitations in the original studies could affect the conclusions of this thesis.

While the study aims to compare different types of GSCIs, the available data may not allow for a fully detailed comparative analysis. Further empirical research is needed to provide a clearer understanding of the relative effectiveness of various GSCIs. By acknowledging these limitations, this thesis sets a clear foundation for future research to build upon and address the gaps identified.

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