



DOCTORAL SCHOOL OF ECONOMICS AND REGIONAL SCIENCES

Doctoral Ph.D. Dissertation

**A Critical Evaluation of Sustainable Supply Chain Management Practices
within the South African Manufacturing Industry: Unpacking Structural
Challenges and Emerging Opportunities in Durban and Johannesburg.**

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ORIGINALITY OF AUTHORSHIP

The doctoral dissertation titled “A Critical Evaluation of Sustainable Supply Chain Management Practices within the South African Manufacturing Industry: Unpacking Structural Challenges and Emerging Opportunities in Durban and Johannesburg.” Represents original work, with all ideas and findings attributed solely to the author. No part of this dissertation has been previously submitted for any other academic qualification or degree.

Signed  Anathi Sokhetye

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1. INTRODUCTION

This chapter introduces the research by highlighting the importance of sustainable supply chain management (SSCM) for the South African manufacturing sector. It declares the industry history, the trend towards SSCM, and the strategic value of sustainability initiatives in terms of enhancing operating performance and global competitiveness. Special focus is given to industrial hubs of Durban and Johannesburg, which offer complementary but contrasting manufacturing profiles and are central to the country's supply chains.

1.1 Background

The manufacturing industry in South Africa has played an important role in the country's economic development, evolving from its inception. Its historical and present state provides insight into the problems, success, and prospects that define this critical sector. The roots of South Africa's manufacturing industry can be traced back to the late 19th century, primarily driven by the mining sector's demand for goods and machinery (Andalib et al., 2023). The discovery of valuable mineral resources, notably gold and diamonds, spiked industrialization efforts as the need for processing and infrastructure grew (Kaur and Singh, 2019). The first manufacturing activities centred around basic processing plants and machinery fabrication to support mining operations. Khan and Farooq (2021) state that during the early to mid-20th century, the manufacturing sector expanded rapidly, fuelled by factors such as urbanization, population growth, and government-led industrialization policies. The establishment of import-substitution strategies aimed to reduce dependency on foreign goods and foster domestic production (Khan and Farooq, 2021). This period witnessed the emergence of various manufacturing subsectors, including textiles, automotive, steel, and chemicals.

Sustainable supply chain management (SSCM) has gained traction in the South African manufacturing industry because of worldwide pressures on the preservation of the environment, social, and economic factors (Shah et al., 2023). South Africa, as a developing country, has a diverse manufacturing sector that faces various difficulties and opportunities in implementing sustainable supply chain strategies. Durban and Johannesburg, as two of South Africa's largest industrial hubs, have divergent complementary profiles within the country's manufacturing industry. Durban's manufacturing history is linked to its status as a port city, with industrialization establishing itself early in the 20th century owing to the development of the

Port of Durban. The city's industrial base, historically rooted in automobile manufacturing and apparel, has been shaped by the presence of major manufacturing companies such as Toyota South Africa Motors and the establishment of export hubs such as the Dube trade port (Epoh et al., 2024; Khambule, 2025). Johannesburg evolved from its humble beginnings as a mining town into South Africa's economic hub centre it is also known as the “City of Gold”, Johannesburg has an industrially diversified manufacturing industry that manufactures and processes metals, chemicals, electronics, and food processing just to name a few (Harrison and Zack, 2012).Johannesburg's manufacturing sector is faced with pressing challenges such as the volatile energy supply and rising operational costs, which hinder the extensive implementation of sustainable supply chain management (SSCM) practices (Kaziboni, 2018). Durban and Johannesburg cities play critical roles in driving SSCM in South Africa, Durban offers logistic advantages and Johannesburg institutional and technological capabilities to enable the transition towards a more sustainable industrial economy (Khan and Farooq, 2021).



Figure 1: South African Map

Source: Mabotja and Mavutha, 2024

Despite the challenges, there exist opportunities for South African manufacturers to improve SSCM. The South African government has introduced policies promoting sustainability, such as the National Development Plan (NDP), Extended Producer Responsibility (EPR) legislation, and carbon tax programs. However, to what extent manufacturing companies in Durban and

Johannesburg have adopted sustainable practices remains inadequately examined (Maama Doorasamy et al., 2021). The knowledge of SSCM drivers and obstacles in such key industrial centres is crucial in guiding policies, improving operational performance, and realizing competitive advantage in a globalized economy.

According to Schilling and Seuring (2024), there are a variety of factors that influence the incorporation of sustainable supply chain practices in the manufacturing sector. Regulatory frameworks, market demands, and resource availability are examples of these. Legislative frameworks, such as environmental restrictions, influence how manufacturing firms approach supply chain sustainability. Bansal et al. (2023) further expounds on several factors that influence the future trajectory of sustainable supply chain management in the manufacturing industry. Policy support, technical developments, and increased consumer awareness are all essential. There is an importance of research and innovation in developing solutions that will match with the country's sustainable challenges and global sustainable trends. Richardson et al. (2022) details the link in sustainable supply chain management in manufacturing aligns closely with several of the United Nations' Sustainable Development Goals (SDGs), but it is particularly associated with goal number 12 which is Responsible Consumption and Production.

SDG 12 aims to ensure sustainable consumption and production trends by promoting resource efficiency, reducing waste and pollution, and encouraging organizations to integrate sustainability practices throughout their supply chains. Sustainable supply chain management in manufacturing directly contributes to this goal by:

- *Enhancing Efficiency and Innovation:* This leads to increased efficiency, cost savings, and innovation, driving economic growth while minimizing negative environmental and social impacts.
- *Promoting Ethical Practices:* This involves ensuring fair labour practices, respecting human rights, and upholding ethical standards throughout the supply chain.
- *Reducing Environmental Impact:* By optimizing resource use, minimizing waste, and adopting cleaner production methods, manufacturers can lessen their environmental footprint and contribute to more sustainable consumption and production patterns.

1.2 Research Significance

The primary purpose of this research is to empirically examine the adoption and implementation of sustainable supply chain management (SSCM) practices within the South African manufacturing sector, with specific focus on manufacturers operating in Durban and Johannesburg. The study aims to investigate how environmental, social, and economic dimensions of SSCM interact under the structural constraint's characteristic of an emerging economy context. While existing SSCM studies in South Africa have predominantly concentrated on conceptual discussions, regulatory compliance, or isolated sustainability initiatives, they offer limited empirical insight into the interconnected barriers and enabling conditions shaping SSCM adoption at firm level. In contrast, this research differentiates itself by integrating environmental, social, and economic dimensions within a single empirical framework, thereby capturing the complex and interdependent nature of SSCM implementation in practice.

Furthermore, unlike prior studies that treat financial, technological, and institutional challenges as discrete factors, this study demonstrates how these constraints are structurally interlinked, creating self-reinforcing barriers that hinder SSCM maturity among manufacturing firms. By empirically uncovering these interaction effects, the research moves beyond descriptive analysis to provide a deeper explanatory understanding of why SSCM adoption remains uneven and slow within the South African manufacturing sector.

Consequently, the study makes an original contribution by offering context-specific empirical evidence from an under-researched emerging economy manufacturing setting, generating actionable managerial and policy-relevant insights, and advancing SSCM literature through a more integrated and systemic understanding of sustainability implementation challenges and opportunities.

1.3 Research Problem

One of the major problems confronting the South African manufacturing industry in adopting sustainable supply chain management practices is the limited availability and access to resources. The country is dealing with water and electricity scarcity Du Plessis (2023) explains that the country is rated the 30th driest in the world; with a rapidly increasing population, the rating is based on its average rainfall of 500mm compared to the world average of 860mm. The manufacturing industry relies extensively on water for a variety of operations, including production, cooling, and cleaning. However, water scarcity affects these processes, causing

production delays, higher costs, and potential reputational harm. Manufacturers must prioritize water allocation. Similarly, electricity scarcity adds to the problems confronting the manufacturing industry, with frequent power outages and load shedding, which is an extended period of widespread nation-wide blackouts of energy supplies it is caused by an ageing electricity infrastructure and supply-demand imbalances. Companies particularly Small-medium enterprises find that they must invest in back up energy when the electricity switches off due to load shedding and power cuts. This limits their access to finance and investments which further causes delays in the adoption of environmentally beneficial technologies and innovative sustainability practices.

Furthermore, technological limits and infrastructure limitations are a challenge that prevents the implementation of SSCM practices. A lot of manufacturing companies, particularly small-medium, have the infrastructure but they lack technological developments, the high expenses of moving to environmentally beneficial technologies or establishing advanced supply chain management practices are a problem for these manufacturing companies. Lastly, manufacturers seeking to embrace SSCM practices face challenges in policy and regulatory frameworks. One policy is South Africa's carbon tax, which is tax paid on carbon emissions from the production of goods and services. Carbon taxes are designed to highlight the hidden social costs of carbon emissions. It was introduced in June 2019, in a phased approach to ease the transition to net zero. The official tax was set at a rate of R120 (or about US\$7) per tonne of CO₂e in phase one and increased to R134 (or about US\$8) by the end of 2022 (Thokoa et al.,2022 and Wiseman, 2024). While regulations exist to encourage environmental sustainability and social responsibility, inconsistent enforcement and unclear guidelines frequently cause uncertainty for organizations.

1.4 Research Gap

Due to increasing global pressure in sustainable supply chain management (SSCM), empirical research examining how SSCM practices are adopted within the South African manufacturing sector remains limited. Existing studies largely focus on sustainability trends at a national level or provide general discussions of manufacturing-sector challenges, offering limited insight into how SSCM adoption may vary across different industrial locations. There is a lack of comparative research examining SSCM practices within Durban and Johannesburg, which represent two of South Africa's most significant manufacturing and logistics industrial hubs.

These cities are different in terms of industrial structure, infrastructure, supply chain connectivity, and logistical factors, all of which may influence or contribute how firms adopt and implement SSCM practices.

Furthermore, while SSCM research is commonly informed by Stakeholder Theory and the Resource-Based View (RBV), limited empirical work has explored how external stakeholder pressures interact with firm-level resource constraints within emerging economy manufacturing contexts. Stakeholder Theory suggests that sustainability adoption is driven by pressures from regulators, customers, and society, while RBV emphasizes that firms require Technological resources, internal capabilities, and organizational competencies to successfully implement sustainability practices. However, how these external pressures and internal resource limitations jointly influence SSCM adoption among manufacturing firms in South Africa remains insufficiently understood.

There remains a significant knowledge gap regarding the drivers, barriers, and performance outcomes of SSCM adoption at the firm level, particularly when comparing major industrial cities with different economic and logistical environments. This study addresses this gap by providing an empirical investigation of SSCM adoption and implementation among manufacturing firms in Durban and Johannesburg, offering a comparative city-level perspective on sustainability practices within South Africa's manufacturing sector.

1.5 Research Objectives

- To assess the evidence of existing sustainable supply chain management practices prevalent in the South African manufacturing industry.
- To examine the challenges faced by manufacturing firms in implementing sustainable supply chain practices.
- To evaluate the impact of sustainable supply chain management practices on the performance metrics and competitiveness of manufacturing firms.
- To investigate the factors that influence the successful integration of sustainability within supply chains.
- To Assess the strategies that can be recommended to enhance the adoption and effectiveness of SSCM in the manufacturing sector.

1.6 Research Questions

- What evidence exists of sustainable supply chain management practices adopted in the South African manufacturing industry?
- What challenges do manufacturing firms meet in implementing sustainable supply chain practices?
- How do sustainable supply chain practices affect the performance and competitiveness of manufacturing firms?
- What are the key factors influencing the successful adoption and integration of sustainability within supply chains in the sector?
- What strategies can be recommended to enhance the adoption and effectiveness of SSCM in the manufacturing sector?

1.7 Research Hypotheses

- Hypothesis 1: Manufacturing firms that effectively implement sustainable supply chain practices will experience improved operational efficiency, cost savings, and enhanced competitiveness in the global market. This hypothesis assumes that the implementation of sustainable supply chain practices positively influences firm performance outcomes, particularly operational efficiency, cost reduction, and market competitiveness. The hypothesis therefore examines whether firms adopting sustainability-oriented supply chain strategies demonstrate measurable improvements in these performance indicators.
- Hypothesis 2: The major challenges faced by manufacturing firms in adopting sustainable supply chain practices include regulatory compliance, resource constraints, and supplier engagement. This hypothesis assumes that institutional, organizational, and supply chain-related barriers influence the adoption of sustainable supply chain practices. Specifically, regulatory requirements, limited resources, and insufficient supplier participation were expected to act as constraints that hinder effective implementation.
- Hypothesis 3: The integration of circular economy principles into supply chain operations will lead to reduced waste, resource optimization, and enhanced sustainability performance. This hypothesis assumes that the adoption of circular economy practices within supply chain operations improves environmental performance outcomes, particularly through waste reduction and more efficient resource utilization.

- Hypothesis 4: Government policies that support mechanisms promoting sustainability initiatives within the manufacturing sector positively influence the adoption and implementation of sustainable supply chain practices. This hypothesis assumes that institutional support mechanisms such as government regulations, policy incentives, and sustainability guidelines encourage firms to adopt sustainable supply chain practices.

1.8 Research contribution

The study addresses critical gaps in the SSCM literature by providing a multi-stakeholder empirical analysis that includes industry professionals, employees, suppliers, and managers within South Africa's manufacturing sector. It advances understanding by illustrating the current stage and progression of sustainability practices across manufacturing supply chains in Durban and Johannesburg. Such contextualised empirical depth and sector-specific insight are largely not available from existing SSCM research in South Africa.

The novelty of the study lies in its ability to generate:

A comprehensive, multi-layered empirical assessment that captures diverse viewpoints across the supply chain, rather than relying on single-stakeholder or firm-level perspectives. A structured examination of SSCM drivers, barriers, institutional pressures, and technological readiness, forming an integrated analytical framework specific to a developing-country. A practical framework for identifying how mature SSCM practices are, which contributes to both theory and practice by identifying where South African manufacturers currently stand and what is needed to advance toward higher sustainability performance.

2. LITERATURE REVIEW

This chapter reviews the existing academic and empirical literature related to sustainable supply chain management (SSCM), with a particular focus on the manufacturing sector in the South African context. The review synthesizes global and regional studies to identify key concepts, theoretical perspectives, challenges, and opportunities associated with SSCM adoption. The chapter is structured around major thematic areas including sustainability concepts, current practices in South Africa, theoretical frameworks highlighting SSCM, implementation challenges and opportunities, international best practices, and identified research gaps.

2.1 Sustainable supply chain management

Sustainable Supply Chain Management (SSCM) refers to the strategic integration of environmental, social, and economic practices across the supply chain to create long-term value (Carter and Rogers, 2008). SSCM encompasses a comprehensive approach, focusing on minimizing waste, focusing on ethical sourcing, and promoting being responsible socially within the entire supply chain process (Seuring and Müller, 2008).

Keeble (1988) explained the concept of sustainability, in its modern form, it gained relevance in the late 20th century, after the publication of the Brundtland Report in 1987, this report, officially titled “Our Common Future” was published by the World Commission on Environment and Development (WCED) under the leadership of Gro Harlem Brundtland, who was the then Prime Minister of Norway. The report defined sustainability as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Keeble,1988). While the term "sustainability" acquired prominence after the Brundtland Report, the ideas behind sustainable development have an extended history, long before the term was developed, conservationists, scientists, and philosophers were addressing and promoting sustainable practices (Keeble,1988). Conservationists such as Rachel Carson, who released her book titled 'Silent Spring' in 1962, brought attention to the negative effects of pesticides on the environment, which resulted in discussions about the sustainability of the environment.

In South Africa, SSCM is gaining attention due to increasing pressure globally to respond to environmental and social challenges. Manufacturing is recognizing the significance of incorporating sustainability principles in its operations to reduce environmental, social, and economic risks (Maama Doorasamy et al., 2021). Naidoo and Gasparatos (2023) state that implementing SSCM practices involves various stages, starting from supplier selection to product design, production, distribution, and end-of-life considerations. Dale (2021) details an example of a South African manufacturing and distribution company called Woolworths, which has a huge emphasis on sustainable sourcing by partnering with local farmers and suppliers who are committed to ethical and environmental practices. Regulatory frameworks and governance are critical in defining South African SSCM practices. The manufacturing industry is one of South Africa's economic pillars, contributing vastly to Gross Domestic Product (GDP), job creation, and manufacturing growth.

Internal challenges such as limited infrastructure, and global pressure have impacted the sector's competitiveness and development capacity. South Africa's manufacturing sector has been modernizing in recent decades, particularly with a greater emphasis on technological advancement and adaptation. The rise of Industry 4.0 such as automation, digitization, and sustainable manufacturing provides prospects for the industry to improve effectiveness, and efficiency, and to compete well in the global market (Matt, 2020). Several current trends are linked with sustainability principles, reflecting the sector's efforts to balance economic growth with environmental and social considerations. The following companies in South Africa follow the current trends in manufacturing that speak to sustainability. Brixova et al (2020) state that South Africa, a key player in the global economy with a diverse manufacturing sector, faces unique challenges and opportunities in adopting sustainable supply chain practices. As a developing country, with issues such as poverty, inequality, and unemployment. While also striving to achieve sustainable development goals (Statistics South Africa, 2020). The manufacturing industry, a significant contributor to the country's GDP and employment, holds immense potential for driving sustainable growth and development (Brixova et al., 2020).

Despite the growing awareness of sustainability issues, the adoption of SSCM practices in the South African manufacturing industry remains low compared to developed economies (Haj Mohammad et al., 2024). This presents both challenges and opportunities for manufacturing firms operating in the country. While there is a need to address pressing environmental and social

issues, such as climate change and pollution, manufacturing firms also stand to benefit from the implementation of sustainable practices, which include cost savings, improved operational efficiency, and enhanced reputation (Gualandris et al., 2024).

2.2 Evidence of Current sustainable supply chain practices in South Africa

A study conducted by Ali and Shoaib (2023) demonstrates a comprehensive analysis of SSCM practices in South Africa, identifying several key initiatives adopted by manufacturing firms. One prominent evidence of the initiative is waste reduction, where companies strive to minimize waste generation and optimize resource utilization to enhance efficiency and reduce environmental impact (Asif et al, 2020). This includes efforts to reduce packaging waste, recycle materials, and implement lean manufacturing principles to eliminate inefficiencies (Ali and Shoaib, 2023). South African owned Company such as Nampak leading in renowned packaging implements sustainable practices across its production operations, with a focus on lightweight packaging materials to reduce waste and uses materials efficiently and effectively to optimize resources. Nampak also invests in recycling initiatives to create closed-loop systems for its packaging materials, aligning with circular economy principles (Bhana et al., 2023).

In addition to waste reduction, energy efficiency measures are widely implemented by South African manufacturing firms as part of their SSCM strategies. The adoption of energy-efficient technologies, such as renewable energy sources and energy-efficient equipment, helps companies reduce their carbon footprint and lower energy costs (Shahparvari et al., 2021). Research by Bag et al. (2023) found that many manufacturing firms in South Africa have invested in energy-efficient lighting systems, improved insulation, and energy management systems to optimize energy consumption and reduce greenhouse gas emissions. Overall, the current state of SSCM practices in the South African manufacturing industry reflects a growing commitment to sustainability among companies. By adopting initiatives such as waste reduction, energy efficiency, green procurement, and eco-friendly transportation, manufacturing firms are taking proactive steps towards achieving environmental sustainability and social responsibility objectives (Govindan and Hasanagic, 2018). However, there is still room for improvement, particularly in addressing social issues such as labour rights, fair wages, and community development within the supply chain (Patabandige and Galahitiyawe, 2020). Future research should focus on identifying best practices and innovative solutions to enhance the effectiveness and scalability of SSCM.

2.3 Factors Influencing Successful Adoption of Sustainability in Supply Chains

The successful adoption of sustainability in supply chains is influenced by various factors that shape firms' ability to integrate sustainable practices into their operations effectively. Understanding these factors is essential for identifying enablers and barriers to sustainability adoption and informing strategies to enhance the effectiveness of sustainability initiatives in the South African manufacturing industry. One critical factor influencing the successful adoption of sustainability in supply chains is top management support and commitment to sustainability goals (Khan et al., 2023). Research has shown that strong leadership and a clear vision for sustainability are essential for driving organizational change and mobilizing resources towards sustainability initiatives (Bag et al., 2023). By demonstrating leadership and providing resources and incentives for sustainability, top management can create a culture of sustainability within the organization and motivate employees to embrace sustainability practices (Shahparvari et al., 2021). Stakeholder collaboration and engagement are also vital for the successful adoption of sustainability in supply chains (Brandenburg et al., 2023). Given the interconnected nature of supply chains, collaboration among suppliers, customers, regulators, and other stakeholders is essential for addressing sustainability challenges and achieving shared goals (Asif et al., 2020). By fostering partnerships and dialogue with stakeholders, manufacturing firms can gain insights into sustainability risks and opportunities, build trust and credibility, and develop innovative solutions to sustainability challenges (Panwar and Niesten, 2020).

Furthermore, investment in employee training and capacity-building is critical for building internal capabilities and fostering a culture of sustainability within organizations (Yawar and Seuring, 2023). Research has shown that providing employees with the necessary skills and knowledge to implement sustainable practices is essential for overcoming resistance to change and ensuring the successful implementation of sustainability initiatives (Patabandige and Galahitiyawe, 2020). By investing in training programs, workshops, and awareness campaigns, companies can empower employees to embrace sustainability as part of their day-to-day operations and contribute to the organization's sustainability goals (Shevchenko et al., 2022).

In addition to internal factors, external factors such as government policies and regulations play a significant role in shaping firms' sustainability strategies and practices (Ali and Shoaib, 2023). Government policies that support sustainability, such as environmental regulations, incentives for renewable energy, and sustainable procurement guidelines, can create a conducive

environment for sustainability adoption and encourage firms to invest in sustainable practices (Shevchenko et al., 2022). By aligning policies and regulations with sustainability objectives, governments can incentivize firms to adopt sustainable supply chain practices and drive positive environmental and social outcomes (Rogers et al, 2023).

2.4 Strategies to Enhance Adoption and Effectiveness of SSCM

Given the complex and dynamic nature of supply chains, adopting effective strategies is crucial for enhancing the adoption and effectiveness of sustainable supply chain management (SSCM) practices in the South African manufacturing industry. By leveraging innovative approaches and best practices, firms can overcome barriers to sustainability integration and drive meaningful change throughout their supply chains. One key strategy to enhance the adoption and effectiveness of SSCM is the development of supplier certification programs and industry standards for sustainability (Hajmohammad et al., 2024). By establishing clear criteria and requirements for sustainable sourcing and production, companies can ensure the ethical and responsible conduct of their suppliers and promote sustainability throughout the supply chain (Khan et al., 2023). Supplier certification programs provide a framework for assessing and verifying supplier performance against sustainability criteria, enabling companies to make informed sourcing decisions and mitigate sustainability risks (Govindan and Hasanagic, 2018). Moreover, investing in technology and digitalization can significantly enhance the effectiveness of SSCM practices in the South African manufacturing industry (Gualandris et al., 2024). Technologies such as blockchain, Internet of Things (IoT), and artificial intelligence (AI) can improve supply chain transparency, traceability, and visibility, enabling companies to better monitor and manage their sustainability performance (Brandenburg, et al., 2023). By participating in industry-wide initiatives and collaborative partnerships, companies can leverage collective expertise and resources to address common sustainability challenges and drive continuous improvement in supply chain sustainability (Panwar and Niesten, 2020).

Furthermore, integrating sustainability considerations into procurement and sourcing decisions is essential for promoting responsible sourcing and ethical procurement practices (Bag et al., 2023). By incorporating sustainability criteria into supplier selection and evaluation processes, companies can incentivize suppliers to adopt sustainable practices and align their operations with sustainability goals (Ali and Shoaib, 2023).

2.5 Synthesis of Current Practices According to Economic, Social, and Environmental Dimensions

The existing literature on SSCM in South Africa shows an increasing awareness of economic performance and social responsibility and environmental stewardship in manufacturing and wider supply chain contexts. In support, empirical evidence portraying a range of practices by South African organizations can be systematically conceived under the TBL framework, which has demarcated sustainability into economic, social, and environmental dimensions (Elkington, 1997; Carter and Rogers, 2008). Thematic organization of the literature along these dimensions provides clarity on the multifaceted nature of SSCM and illustrates areas of convergence and divergence or potential gaps in the local context.

2.5.1 Economic Dimension

The economic sustainability in SSCM addresses the improvement of operational efficiency, cost reduction, and long-term profitability, together with the strategic integration of sustainable practices. In recent years, South African manufacturing firms have integrated practices such as green procurement, lean production, and resource optimization to achieve both economic performance improvement and sustainability outcomes (Epoh et al., 2024). According to the literature, companies with eco-efficient operations experience reductions in production costs and inventory wastes while at the same time gaining competitive advantages through enhanced resilience in the supply chain (Atieh et al., 2024). Significantly, studies conducted within the South African context indicate that economic incentives, such as conformance with regulations, potential differentiation in the market, and easy access to government or international funding, are determining factors for SSCM (Anathi, 2023). However, at present, key challenges remain, especially for SMEs, which often face resource constraints that delimit the size and scope of economically oriented sustainable practices. These findings hint that while there are economic benefits from the main drive of SSCM, the materialization of such economic benefits is dependent on both organizational capacity and enabling policy environments.

2.5.2 Social Dimension

The social dimension of SSCM entails those practices dedicated to labour welfare, ethical sourcing, community engagement, and general stakeholder well-being. Supply chains in South Africa, mostly aligned with the manufacturing sector, function in a diversified socio-economic

landscape entailing persistent inequity and significant disparities in terms of employment and skills development (Siems, 2023). Therefore, social sustainability represents an issue not only of crucial concern for corporate social responsibility but also for the pursuit of equal opportunities in development for communities related to supply chains.

A study by Lozano-Oviedo et al. (2024) highlights that socially responsible practices in South African supply chains include fair labour policies, skills development programs, and initiatives to strengthen supplier capabilities. Such practices go beyond mere regulatory compliance and demonstrate a proactive approach toward human and social welfare. In addition, Mahache et al. (2025) further adds that there is evidence to suggest that companies adopting social sustainability practices develop more effective relationships and trust in their supply chains, leading to a multiplier effect that extends more knowledge and cooperation within supply chain networks. However, despite these encouraging trends, significant gaps still exist in systematic monitoring and measurement of social outputs, indicating a requirement for more effective metrics and improved governance mechanisms within the specific context of South Africa.

2.5.3 Environmental Dimension

Environmental sustainability is one of the most researched dimensions in SSCM literature, integral to worldwide and local imperatives for mitigating ecological impacts. South African manufacturing firms have increasingly implemented environmental practices relating to energy efficiency measures, waste reduction programs, eco-design initiatives, and reverse logistics during the past two decades (Nguyen and Zuidwijk, 2025). This stems from both national environmental policies that require firms to preserve the environment and international market pressures compelling them to reduce their carbon footprint while ensuring resource scarcity is at a minimum. Research shows that environmental sustainability practices often have a dual benefit in contributing to ecological preservation and enhancing operational performance through efficiencies in energy use, materials consumption, and process optimization (Nwaila et al., 2024). However, studies also reveal challenges particular to the South African manufacturing context, such as limited access to green technologies, financial constraints, and inconsistencies in regulatory enforcement (Nwankwo et al., 2024) These constraints provide a clear rationale for environmental strategies that are tailored to specific contexts, considering both organizational capabilities and broader systemic factors.

2.6 Theoretical Frameworks focusing on Sustainable Supply Chain Management

While the previous sections examined practical applications, practices and drivers of SSCM, the following section discusses the theoretical foundations that explain why firms adopt sustainable supply chain practices.

2.6.1 Identification Criteria for Relevant Theoretical Models

The theoretical model selection for the study of SSCM needs to be done through a sound and transparent rationale that makes sure the conceptual coherence and contextual relevance are ensured. Based on four critical identifying factors, the underlying dissertation identified three frameworks: Stakeholder Theory, Resource-Based View, and Institutional Theory.

2.6.2 Frequency of Use in the SSCM Literature

A review of seminal and contemporary SSCM literature, such as Seuring and Müller (2008), Carter and Rogers (2008), Pagell and Wu (2009), and Sarkis et al. (2021), provides evidence that these three theories remain among the dominant conceptual lenses applied to describe and explain the sustainability-related behaviours, decisions, and performance of firms. Recurring applications across diverse industries and geographies further speak to their theoretical robustness and explanatory power.

2.6.3 Relevance to the South African Context

Manufacturing in South Africa is set within a particularly complex socio-economic context marked by high inequality, regulatory volatility, and rising environmental concerns. Of these contextual dynamics, the selected theories Mahajan et al. (2023)-explain the social and ethical pressures on firms through Stakeholder Theory, how firms use internal capabilities for sustainable competitiveness through RBV, and how the influence of policy and regulation, and industry norms shape the adoption of sustainability through Institutional Theory.

2.6.4 Applicability in the Industrial Sector

These theories have shown empirical utility in the manufacturing settings of operational sustainability, supplier collaboration, and innovation (Gold et al., 2010; Beske et al., 2014). In manufacturing supply chains, very often there is a multitude of tiers from suppliers, thereby making constructs of stakeholder influence, resource orchestration, and institutional conformity quite applicable.

2.6.5 Stakeholder Theory and SSCM

Stakeholder Theory Freeman, (1984) suggests that organizations have been made to exist within the nexus of relationships arising from a variety of actors such as shareholders, employees, customers, suppliers, communities, and regulators; their generally conflicting interests must be identified and harmonized for long-term success. In SSCM, this theory goes beyond financial performance into the realms of environmental and social dimensions of stakeholder engagement (Carter and Rogers, 2008).

This theory assumes that sustainability performance is connected to a firm's ability to manage the competing expectations of multiple stakeholders while aligning them with strategic objectives. Stakeholder salience-which is rooted in attributes of power, legitimacy, and urgency (Mitchell et al., 1997)-dictates which pressures would be prioritized in the decision-making of sustainability. Application to Sustainable Supply Chain Management Stakeholder Theory has been widely used to explain the reasons why companies would adopt sustainability practices and how they respond to pressures emanating from their external stakeholders, such as customers, governments, and civil society. Companies subject to stakeholder scrutiny have successfully integrated sustainability throughout procurement, logistics, and production as a means of managing risk and improving reputation. Stakeholder pressure in the South African manufacturing sector is strongly directed from three directions: The regulatory stakeholders include the DTIC, as well as the Department of Environmental Affairs for environmental compliance and industrial development policies. Community stakeholders, especially in the urban zones of Durban and Johannesburg, where firms are expected to contribute to local socio-economic development; and Market players include multinational buyers and consumers requiring ethically sourced products. Stakeholder expectations integrated into the fabric of supply chain governance enhance accountability and disclosure. For example, local manufacturers in international supply chains would be required to operate under global sustainability standards such as ISO 14001 and the Global Reporting Initiative-developed through the joint efforts of stakeholder activism and regulation-as discussed by (Nkulu and Kapunda, 2020).

2.6.6 Resource-Based View and SSCM

Barney's Resource-Based View (1991) views a firm as a bundle of unique resources and capabilities that may create a source of sustained competitive advantage, provided these resources/capabilities are valuable, rare, inimitable, and non-substitutable. Applied to SSCM, RBV means that sustainability performance depends not only on the external pressures but also on the internal capability of the firm to develop such resources like environmental management systems, green technologies, and skilled human capital that support sustainable operations.

2.6.7 Application to Sustainable Supply Chain Management

SSCM literature extends the RBV through the Natural Resource-Based View to include environmental capabilities. The NRBV maintained that in the sustainability perspective, the source of competitive advantages was hinged on three interrelated strategies, namely pollution prevention, product stewardship, and sustainable development. These capabilities enable a firm to reduce waste, innovate in green products, and collaborate with stakeholders for long-term environmental resilience. In manufacturing contexts, companies developing internal sustainability competencies, such as inhouse cleaner production technologies, energy-efficient processes, and supplier development programs, usually record operation efficiencies that are sources of competitive advantages in their respective lines of business (Zhu et al., 2013). For example, within the South African automobile and food manufacturers who develop internal sustainability competencies, while addressing some existing regulatory demands, become able to increase resource productivity and brand reputation through the adoption of circular economy practices (Machingura, 2022)

2.6.8 Rationale for inclusion

The RBV is included because it complements Stakeholder Theory, as it focuses on the internal organizational capabilities rather than the external pressures. Whereas stakeholders may push firms toward sustainability, only those firms that have the resources and competencies will be able to implement and sustain the SSCM practices. It is of relevance in the South African context, given that resource constraints, like limited access to technology, skills, and finance, are the primary barrier to sustainable transitions. RBV lays the analytical foundation for studying how firms marshal their internal assets, such as leadership commitment, innovation capacity, and supplier partnerships, turning pressures for sustainability into strategic

opportunities. The RBV also enables the testing of the firm's dynamic capabilities in the integration, building, and reconfiguration of internal and external competences that address the rapidly changing environments (Teece, Pisano and Shuen, 1997). This is particularly relevant in such a turbulent market as South Africa's manufacturing sector, where policy shifts, energy crises, and market instability require adaptive responses.

2.6.9 Institutional Theory and SSCM

Overview and Core Assumptions In contrast, Institutional Theory addresses how organizational behaviour is embedded in and influenced by the formal and informal rules, norms, and cultural expectations of a larger institutional environment. The theory postulates that, to gain legitimacy, stability, and social acceptance, businesses will be inclined to comply with coercive, normative, or mimetic pressures exerted on them by institutions.

2.6.10 Application to Sustainable Supply Chain Management

It explains through Institutional Theory how and why firms in SSCM adopt sustainability practices that do not provide immediate perceived financial benefits yet are necessary to maintain legitimacy and competitiveness. As an example, the adoption of environmental management systems into manufacturing facilities often emanates from coercive pressures-regulation, normative pressures-professional associations, and mimetic pressures-benchmarking against competitors (Zhu and Sarkis, 2007). In South Africa, institutional pressures are especially salient given the post-apartheid emphasis on inclusive industrialization and environmental governance. The National Development Plan (2030) and the Industrial Policy Action Plan encourage sustainable industrial practices, and international trade agreements are increasingly embedding sustainability clauses. Thus, manufacturing firms in Durban and Johannesburg operate within a multi-layered institutional environment where compliance will drive SSCM adoption.

2.6.11 Justification for Inclusion Institutional

Theory is included because it provides the macrolevel contextual lens that completes the microlevel perspectives of Stakeholder Theory and RBV. It illustrates how regulatory, cultural, and normative structures influence the sustainability behaviours of firms, especially in contexts where the external institutional frameworks strongly influence corporate practice. In South Africa, with its convergence of sustainability regulations, industrial policy, and global trade norms, Institutional Theory enables one to interpret how firms navigate institutional complexity

and align SSCM practices with evolving expectations. The theory also allows for the analysis of institutional voids or gaps in formal rules or enforcement mechanisms that may prohibit effective SSCM. Implementation in developing economies. The understanding of such voids becomes important for developing context-sensitive policy recommendations.

2.6.12 Why Other Models Were Not Selected

While other frameworks, such as Contingency Theory, Transaction Cost Economics, or Systems Theory, offer useful insights, they have not been included in this review because they lack either the comprehensiveness of explanation or the contextual relevance for the present research. Contingency Theory is mainly about fit between environment and structure without an ethical grounding; Transaction Cost Economics focuses on cost efficiency rather than sustainability; and Systems Theory, holistic though it may be, is lacking empirical detail to adequately capture firm-level adoption behaviours' contrast, Stakeholder Theory, RBV, and Institutional Theory together present a balanced and contextually relevant framework that integrates moral, strategic, and institutional dimensions of SSCM, hence aligns with the objectives of the study in evaluating the challenges and opportunities within the South African manufacturing industry.

2.6.13 The Triple Bottom Line Approach in the South African Context

The TBL model by Elkington (1997) expands the view of business performance from a focus on financial outcomes to one that also encompasses social and environmental dimensions: profit, people, and planet. According to Khan et al. (2021), the TBL approach bears immense relevance for the South African manufacturing industry since the latter has been facing challenges in economic competitiveness, environmental sustainability, and social equity.

South African manufacturers operate within the context of energy constraints, skill shortages, and social inequality. The application of the TBL model provides firms with a balanced way of realizing profitability while taking responsibility for social causes and ensuring environmental protection. A study by Onyekwelu et al. (2024), reveal that, firms that adopt socially inclusive employment policies, invest in worker upskilling, or participate in community development projects are operationalizing the "people" dimension of TBL. In the same way, the "planet" dimension manifests itself in companies through carbon reduction, integration with renewable energy, and environmentally friendly product design.

2.6.14 Supplier Relationship Management Model in the South African context

The SRMM by Truong et al. (2018) underlines the strategic relevance of partnership and

collaboration at different tiers within the supply chain. In the South African context, this would mean that SRM cannot be most effectively practiced either due to the fragmented nature of supply networks or simply because a lot of SMEs make up the backbone of industrial production in the country. Strong supplier relationships build trust, knowledge sharing, and joint innovation; these are essential in achieving sustainability objectives in areas like the automotive, food and beverage, and chemicals sectors. SRM supports the realization of Broad-Based Black Economic Empowerment objectives through the stimulation of supplier diversity and the involvement of historically disadvantaged groups. Hence, the SRM model reconciles operational excellence with socio-economic transformation and therefore is an integral part of sustainable industrial growth in South Africa.

2.6.15 The Sustainable Procurement Model in the South African Context

The Sustainable procurement model is a model that incorporates environmental, social, and governance criteria into purchasing and supply management decisions. In South Africa, sustainable procurement is encouraged through several regulatory and policy instruments, including the Preferential Procurement Policy Framework Act (PPPFA), which has been reinforced by the Public Procurement Bill (2020), placing emphasis on local content, fair labour practices, and environmental compliance (Reyburn, 2020). Manufacturing firms are increasingly adopting SPM to reduce risks associated with unethical sourcing, environmental degradation, and reputational damage.

2.6.16 Life Cycle Assessment Model and Environmental Decision-Making in South Africa

LCA is a model used in systematically assessing the environmental impacts of products and processes, from cradle to grave. Its relevance to South African manufacturing is based on its capacity to support evidence-based environmental management and eco-innovation. Because of its energy-intensive industrial base, dominated by coal-fired electricity, LCA offers a critical tool for identifying high-impact production stages and optimizing resource efficiency (Ge et al., 2025). Research institutions like the Council for scientific and industrial research CSIR have been instrumental in developing LCA databases relevant to the South African context. These tools help manufacturers quantify emissions, waste, and resource usage, thereby enabling informed decisions on material substitution, recycling, and product redesign (Moonsamy, 2024). LCA methodologies thus have very practical use in industries like packaging, construction materials, and automotive manufacturing, where environmental performance may have a significant influence on profitability and competitiveness and where there are global trade

standards. According to Karkour et al. (2021) the act of adopting LCA allows South African firms to operate their businesses in tune with international best practice in terms of sustainability standards, including ISO 14040/44. Such a position enhances export readiness and improves corporate reputation in foreign markets. These further supports compliance with local regulations such as the Carbon Tax Act of 2019 and the Air Quality Act of 2004, thus reinforcing sustainable industrial operations. Integrative Value of SSCM Models in the South African Industrial Landscape While each of the SSCM models provides distinct advantages, their full potential can be realized by integration rather than in isolation. In the South African manufacturing context, blending the Circular Economy Model with the TBL and LCA frameworks produces synergistic benefits that balance economic performance with environmental stewardship and social inclusion. In similar fashion, the integration of SRM and Sustainable Procurement models fosters systemic resilience and shared accountability across the supply chain.

2.7 Challenges

Despite the growing recognition of sustainability within supply chains, manufacturing firms continue to encounter significant implementation challenges. The following section outlines key structural and operational challenges affecting SSCM adoption.

2.7.1 Challenges in Implementing Sustainable Supply Chain Practices

While there has been progress in the adoption of sustainable supply chain practices in the South African manufacturing industry, organizations face several challenges in effectively implementing these practices. Understanding and addressing these challenges is essential for overcoming barriers to sustainability integration and fostering meaningful change throughout the supply chain. One of the primary challenges faced by manufacturing firms in South Africa is regulatory compliance. According to Mabe-Madisa. (2019) The manufacturing sector encounters challenges arising from the complex regulatory policies that govern the industrial industry operations. This complexity is within a framework of various legislative directives, environmental standards, and compliance requirements, collectively impacting the industry's potential to fully practice sustainability in its operations.

One of the main challenges is the extensive environmental regulations prevalent in South Africa, such as the National Environmental Management Act of 1998 (NEMA) this act provides for cooperative, environmental governance by establishing principles for decision-making on

matters affecting the environment (Mabe-Madisa, 2019). Anathi, (2024) further states that this act provides for matters connected with and its associated regulations encompassing waste management, air quality, and water resources, while these regulations aim to ensure environmental protection, their intricate nature, continuous updates, and the breadth of compliance obligations present difficulties for manufacturers in understanding and adhering to evolving standards. Manufacturers face uncertainty because of a lack of policy clarity, inconsistency across regulatory agencies, and conflicting interpretations of legislation. The uncertainty in policy interpretation, combined with overlapping regulatory borders among regulatory bodies, hinders strategic planning in the business and discourages confidence in investments in sustainable projects within the sector (Burger and Fourie, 2019). challenges due to conflicting agendas and operational complexities (South African Department of Trade, Industry, and Competition, 2021).

Another challenge is the lack of supplier engagement and collaboration in sustainability initiatives. Many manufacturing firms in South Africa rely on a network of suppliers and subcontractors to fulfil their production requirements, making supply chain transparency and traceability essential for ensuring ethical sourcing and responsible production practices (Yawar and Seuring, 2023). However, limited visibility into supplier operations, coupled with a lack of incentives and accountability mechanisms, hinders firms' ability to monitor and address sustainability issues within their supply chains (Panwar and Niesten, 2020).

Furthermore, cultural barriers and institutional inactivity pose challenges to the adoption of sustainable supply chain practices in South Africa. Deep-rooted cultural norms and practices, coupled with resistance to change within organizations and across supply chain partners, hinder progress towards sustainability. (Patabandige and Galahitiyawwe, 2020). Moreover, the legacy of historical inequalities continues to shape socio-economic dynamics within the country, presenting additional challenges for firms seeking to address social issues such as labour rights and community development (Ali and Shoaib, 2023).

Addressing these challenges requires a multi-faceted approach that involves collaboration among stakeholders, investment in capacity-building and technology, and alignment of policies and regulations with sustainability objectives (Craighead et al., 2023). By overcoming barriers to sustainability integration, manufacturing firms in South Africa can unlock opportunities for innovation, cost savings, and competitive advantage while contributing to the country's broader

sustainable development goals.

Muller, M. (2023) states that Eskom is South Africa's state-owned energy provider, in charge of generating, transferring, and distributing 95% of the country's electricity. It is crucial in fuelling South Africa's economy and industrial industries. However, the energy supplier has experienced significant issues since 2007, affecting its operations as well as the country's broader energy market. Load shedding is the intentional and temporary reduction of energy supply to specific areas or regions by a power provider, due to limited generation capacity or a supply-demand imbalance (Erero, 2023).

Erero. (2023) explains that there are various reasons why there is load shedding:

- *Demand-Supply Imbalance:* When the electricity demand exceeds the available supply, such as during hot summer days or peak business hours. This imbalance in demand and supply may force Eskom to apply load shedding as a precautionary step to avoid a system-wide blackout.
- *Insufficient Generation Capacity:* Load shedding takes place when the power demand exceeds the available supply, due to insufficient generating capacity. Eskom is struggling to satisfy the country's energy demand, resulting in scheduled power interruptions.
- *Maintenance and Unplanned Breakdowns:* Eskom faces difficulties with maintaining and improving its old power plants and infrastructure, as well as unplanned breakdowns. Due to a lack of maintenance and frequent breakdowns in power-producing units, load shedding is frequently required to stop the national grid from collapsing due to overloading.
- *Hours of national load shedding:* Naidoo, C. (2023) explains how load shedding affects manufacturing by disrupting the production schedule, resulting in delays and inefficiency. Du Venage, G. (2020) further states that power outages cause production machinery to shut down, wasting important manufacturing time and lowering productivity. Electricity is used extensively by manufacturers to operate their machinery, equipment, and lighting systems, industries seek other energy sources, such as generators, which can be costly to operate and maintain (Walsh et al., 2021). The Impact on small and Medium Enterprises (SMEs) are particularly affected by the effects of load shedding. The extent of electricity disruptions affecting the manufacturing sector in South Africa is illustrated in Figure 2 below.

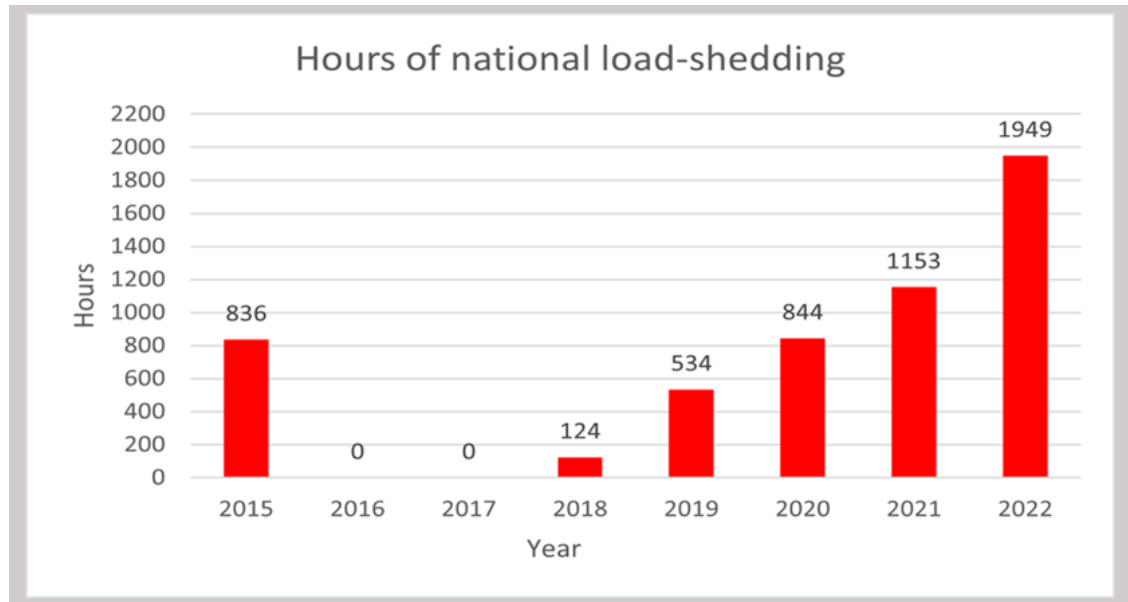


Figure 2- Hours of national load shedding over the years.

Source: Mabunda, 2022

2.7.2 Waste Management and Circular Economy Transition

Research and literature have shown that the manufacturing industry faces big challenges in waste management and moving to a circular economy, slowing down sustainable practices and resource optimization. Mateus et al. (2023) defines circular economy as a model of production and consumption, that involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products for as long as possible Anathi (2023) further explains the aim of the circular economy is therefore to make the most of the material resources available by applying three basic principles: reduce, reuse, and recycle. Waste management is a resource reduction, recycling, reuse, and recovery of hazardous and non-hazardous wastes that are generated from manufacturing activities.

2.7.3 Skills and Knowledge Gaps in the Manufacturing Sector

Research shows that there is a knowledge gap in the manufacturing industry about sustainable supply chain management practices and ethical sourcing. This involves understanding the importance of responsible purchasing, supplier involvement for sustainability, and incorporating social and environmental factors into procurement decisions (Epoh, 2023). For example, a manufacturing company may come across difficulties in ensuring ethical sourcing practices because of a lack of knowledge or skills in evaluating suppliers' environmental and

social commitments to being sustainable. Insufficient expertise in sustainable procurement slows down the organization's efforts to select suppliers that are in line with ethical and environmentally responsible practices.

2.7.4 Global Market Competitiveness

Udeagha and Muchapondwa. (2023) states that in response to global pressure, there is global market competitiveness this market demands cost-competitive products, making it challenging for manufacturers to balance sustainability and price competitiveness. end consumers and clients will often prioritize affordability, there is a need for manufacturers to address sustainability concerns without significantly increasing product prices there is a need for further research and development particularly for manufacturing production managers and various suppliers they work with, manufacturers exporting goods globally may face challenges in meeting sustainability standards according to global policies and standards without compromising on cost. The need to conform to global market environmental policies and regulations.

2.7.5 Initial Investment Costs

Udeagha and Muchapondwa. (2023) further explain that investments in sustainable supply chain management in manufacturing may require significant upfront capital for technology improvements, operational adjustments, or the procurement of eco-friendly products. When compared to older methods, shifting to clean energy sources, adopting waste-reduction initiatives, or adopting green technologies may incur higher upfront expenses. A manufacturing company considering installing energy-efficient machinery may face difficulties due to the larger initial expenditure required, while the long-term advantages of lower operational costs and less environmental effect are apparent, the immediate financial strain poses a barrier, particularly in competitive market circumstances.

2.7.6 Regulatory Compliance Costs

Manufacturers' compliance costs might rise because of strict environmental rules and sustainability standards. Environmental legislation, emission standards, waste disposal rules, and sustainable certifications frequently necessitate investment in technology, audits, and operational modifications, a manufacturing company may experience higher costs because of new environmental laws. The obligation to devote funds to emission control technologies or waste treatment facilities to meet regulatory standards increases financial strain, affecting the company's cost competitiveness within the industry (Udeagha and Muchapondwa, 2023).

2.8 Projects initiated to respond to challenges.

Below are examples of projects and initiatives related to waste management and the move to a circular economy in the manufacturing industry.

2.8.1 Extended Producer Responsibility (EPR) Programs

The Extended Producer Responsibility (EPR) program encourages manufacturers to embrace responsibility for managing their products' entire lifecycle. This includes designing items for recycling capacity, collecting, and handling post-consumer waste, and taking part in waste reduction and recycling activities (Cai and Choi, 2019).

2.8.2 Resource Efficiency and Cleaner Production (RECP) Programme (South African National Cleaner Production Centre)

The RECP program helps industries adopt cleaner production processes to maximize resource consumption and reduce waste output. It offers technical help, analysis, and advice on resource-efficient technology and processes, easing the move to sustainable manufacturing (Maama, Doorasamy et al., 2021)

2.8.3 Circular Economy Business Models (Green Cape, South Africa)

Green Cape works on promoting circular economy business models in various industries, including manufacturing. Godfrey et al. (2022) Green Cape facilitates workshops, provides resources, and supports organizations to develop circular economy strategies, encouraging the implementation of innovative models that prioritize resource conservation and minimizing waste. Godfrey et al. (2022) further adds that these initiatives demonstrate diverse initiatives and programs that are focused on addressing waste management challenges and show an advancement in the transition toward a circular economy in the manufacturing sector. Through Extended Producer Responsibility programs, resource efficiency initiatives, circular economy business models, and waste exchange platforms Energy supply constraints have surfaced as a serious challenge, with the country dealing with irregular power outages and an unreliable power grid. These limits not only disrupt production schedules but also hamper efforts to shift to cleaner and more environmentally friendly energy sources, as organizations struggle to maintain uninterrupted operations in the face of these restraints. Complications in policy and regulation add another layer of difficulty. While regulations have the aim to promote sustainability, the regulatory landscape frequently lacks uniformity and consistency, resulting in inconsistency and compliance challenges for manufacturing organizations. Regulatory

barriers have an impact on strategic planning, which makes it difficult for organizations to incorporate sustainability goals with firm and frequently contradicting policies.

2.9 Opportunities

Even though there are several challenges that stop the adoption of SSCM, the literature also identifies multiple opportunities that can enhance sustainability performance within the manufacturing sector.

2.9.1 Access to New Markets and Clients

The opportunities to embrace sustainable supply chain practices drive not only environmental factors but also present an opportunity to new markets and client segments, the incorporation of sustainability into manufacturing operations allows the firms to set themselves out and access niche markets opening new doors of market penetration (Andalib, 2023). Through campaigns and projects like using recycled or biodegradable materials, firms can show a commitment to environmental responsibility, resonating with clients looking for eco-friendly alternatives. This opportunity not only enhances brand loyalty among existing clients but also attracts a new client base.

2.9.2 Cost Savings through Efficiency

According to Ding et al. (2023) This may assist firms in achieving significant cost reductions that lead to profit under the sustainability model by improving operational efficiency, optimizing resource utilization, reducing waste, and implementing eco-friendly procedures. Efficiency benefits can be realized through a variety of activities, including the adoption of energy-efficient technologies, the use of renewable energy sources, and the implementation of waste reduction measures. Investing in energy-efficient machinery, such as high-performance equipment or systems that reduce energy usage, can drastically reduce energy costs, and reduce dependency on older, more expensive energy sources (Ding et al., 2023). Furthermore, incorporating renewable energy sources, such as solar or wind power, provides long-term cost savings by reducing dependency on fossil fuels and lowering energy-related expenses.

2.9.3 Regulatory Compliance Benefits

Ding et al. (2023) expounds that compliance with evolving environmental standards and using available incentives can promote manufacturing sustainability, governments and regulatory authorities are increasingly providing incentives, tax breaks, or subsidies to businesses that

adopt. Sustainable practices. Compliance policies with strong environmental requirements can also help a firm gain a competitive advantage in global markets with more focus on sustainability criteria, manufacturing organizations can take advantage of governmental incentives by investing in energy-efficient machinery or implementing waste reduction programs, using tax rebates for adopting renewable energy sources or conforming to tight emission regulations can not only assure regulatory compliance but also cut operational expenses over time while strengthening sustainability efforts, this opportunity emphasizes the potential benefits for manufacturing organizations in aligning with and capitalizing on developing regulatory landscapes and accessible technologies (Andalib et al., 2023) .

2.10 Models that exist.

2.10.1 Circular Economy Model

The circular economy concept has gained popularity in recent years, inspiring environmentalists, governments, and business organizations alike. Circularity is now widely recognized as the most promising solution to our planet's growing sustainability problems (Anathi, 2024). Here is how the circular economy works.

2.10.2 The Circular Economy Model and Its Application in South Africa

According to Wiseman. (2024) The CE model is gaining momentum in the world as a transformational approach for resource efficiency, waste reduction, and sustainable industrial growth. The relevance of CE to South Africa is supported by the country's past reliance on extractive industries, high generation of waste, and energy-intensive production systems. These call for designing products and processes that allow for durability, reusability, and recyclability, hence closely meeting the goals set by the NWMS and the EPR regulations introduced under the National Environmental Management: Waste Act No. 59 of 2008. In the manufacturing industry of Johannesburg and Durban, CE principles manifest in growing industrial symbiosis initiatives and resource recovery programs. For example, the KwaZulu-Natal Industrial Symbiosis Programme allows companies to exchange their by-products, reducing the amount of waste discarded and decreasing input costs simultaneously (Department of Trade, Industry and Competition [DTIC], 2023). This shows that the circular economy is not only an imperative environmentally, but a strategic business opportunity which aligns with national development goals such as the Green Economy Accord and the National Development Plan (NDP) 2030 (Zulu and Singh, 2023). By fostering collaboration, CE encourages local job creation and

economic resilience-both important in a developing country grappling with high rates of unemployment and inequality.

2.10.3 The Triple bottom-line approach model

Khan et al. (2021) The triple bottom line (TBL) is a business concept that commits to that concentrates as much on social and environmental problems as it does on profits. the TBL model, instead of it being a single bottom line (Profit), it encompasses three elements: profit, people, and the planet. it attempts to assess a company's commitment to corporate social responsibility and its long-term environmental impact.

2.10.4 The Triple Bottom Line Approach in the South African Context

The TBL model by Elkington (1997) expands the view of business performance from a focus on financial outcomes to one that also encompasses social and environmental dimensions: profit, people, and planet. According to Khan et al. (2021), the TBL approach bears immense relevance for the South African manufacturing industry since the latter has been facing challenges in economic competitiveness, environmental sustainability, and social equity. South African manufacturers operate within the context of energy constraints, skill shortages, and social inequality. The application of the TBL model provides firms with a balanced way of realizing profitability while taking responsibility for social causes and ensuring environmental protection. A study by Onyekwelu et al (2024) reveals that, firms that adopt socially inclusive employment policies, invest in worker upskilling, or participate in community development projects are operationalizing the "people" dimension of TBL. In the same way, the "planet" dimension manifests itself in companies through carbon reduction, integration with renewable energy, and environmentally friendly product design.

2.10.5 Sustainable Procurement Model

According to Kaur and Singh (2019) and Sokhetye (2023), sustainable procurement is the process of incorporating environmental, social, and governance (ESG) goals into procurement, purchasing, and supply chain activities, Sustainable procurement incorporates responsible business practices and actions into procurement procedures, policies, and decisions, it strikes a balance between sustainability, profitability, and achieving stakeholder expectations.

2.10.6 The Sustainable Procurement Model in the South African Context

The Sustainable procurement model is a model that incorporates environmental, social, and governance criteria into purchasing and supply management decisions. In South Africa,

sustainable procurement is encouraged through several regulatory and policy instruments, including the Preferential Procurement Policy Framework Act (PPPFA), which has been reinforced by the Public Procurement Bill (2020), placing emphasis on local content, fair labour practices, and environmental compliance (Reyburn, 2020).

Manufacturing firms are increasingly adopting SPM to reduce risks associated with unethical sourcing, environmental degradation, and reputational damage.

2.10.7 Life Assessment Cycle Model

According to Kaur, and Singh. (2019). LCA is a model used to examine the environmental implications of a product, process, or service over its entire life cycle, from raw material extraction to disposal or recycling, LCA assists in identifying and quantifying environmental impacts and potential improvement possibilities at each step of a product's life cycle. It considers aspects such as resource use, energy consumption, emissions, and the production of waste, assisting decision-making to minimize environmental impacts.

2.10.8 Life Cycle Assessment Model and Environmental Decision-Making in South Africa

LCA is a model used in systematically assessing the environmental impacts of products and processes, from cradle to grave. Its relevance to South African manufacturing is based on its capacity to support evidence-based environmental management and eco-innovation. Because of its energy-intensive industrial base, dominated by coal-fired electricity, LCA offers a critical tool for identifying high-impact production stages and optimizing resource efficiency Ge et al. (2025) and Moonsamy. (2024) further states that Research institutions like the Council for scientific and industrial research CSIR have been instrumental in developing LCA databases relevant to the South African context. These tools help manufacturers quantify emissions, waste, and resource usage, thereby enabling informed decisions on material substitution, recycling, and product redesign, CA methodologies thus have very practical use in industries like packaging, construction materials, and automotive manufacturing, where environmental performance may have a considerable influence on profitability and competitiveness and where there are global trade standards. According to Karkour et al. (2021) the act of adopting LCA allows South African firms to operate their businesses in tune with international best practice in terms of sustainability standards, including ISO 14040/44.

2.10.9 Alternative Roles of the Models

A critical review of the five models indicates that they are complementary and not mutually exclusive. Each of them deals with a different dimension of sustainability, and when combined, they yield an overall framework of SSCM. CE focuses on resource efficiency and waste reduction at a system level. The Triple Bottom Line provides a holistic performance framework, integrating social, environmental, and economic outcomes. SRM enhances collaboration and social inclusions across the supply chains operationalizes sustainability principles through responsible purchasing and compliance. Life Cycle Assessment (LCA) provides quantitative, science-based assessment of environmental impacts.

2.10.10 Synthesis of existing models

The integration of the Circular Economy model, Life Cycle Assessment (LCA) approach, Triple Bottom Line (TBL) model, and Sustainable Procurement Model within sustainable supply chain management represents a diverse approach. Throughout the entire life cycle, this comprehensive approach emphasizes resource efficiency, waste minimization, and environmental impact assessment. It emphasizes the significance of assessing firm performance not only in financial terms but also in terms of social and environmental elements. Sustainable procurement strategies and collaborative supplier partnerships strengthen ethical sourcing and transparency, assuring compliance with sustainability requirements, these models, when combined, form a clear framework that promotes resilient, environmentally conscious supply chains while also encouraging economic advantages, stakeholder confidence, and brand reputation. The author below demonstrates how all the models can work together (Ge et al., 2025). The model which is explained above places a focus on the triple bottom line approach factoring in supplier relationship management, sustainable procurement, circular economy, and life cycle assessment, to assist in its input, process, and output whenever it is applied in any project in the manufacturing sector, additionally this model assists in being sustainable directing it to the 3 pillars of the triple bottom line.

2.11 Gaps in literature

2.11.1 Restricted Empirical Studies

There is a limited number of empirical studies directly concentrating on SSCM practices in the South African manufacturing industry. More empirical research is needed to understand the present state of sustainability projects, implementation barriers, and successful outcomes used by the manufacturing industry.

2.11.2 Regulatory and Policy Frameworks

Research can further examine the impact of government regulations and policies on SSCM uptake and performance in the manufacturing sector. Understanding how policy structures promote or obstruct sustainable activities may assist in providing useful information within the SSCM framework.

2.12 Best practices in the world

To further understand how SSCM can be effectively implemented, this study found it to be useful to examine international best practices from leading manufacturing economies.

2.12.1 Japan

Japan's sustainable supply chain practices are deeply interwoven into the regulatory and cultural systems that foster environmental responsibility and operational efficiency. While the original discussion in your paper focused on Lean and the Toyota Production System, it is crucial to put those concepts into a broader Japanese context of sustainability. Several of Japan's environmental procurement policies, such as the Green Purchasing Law and Keidanren Environmental Vision, encourage sustainable sourcing and corporate environmental accountability. Lean principles like Just-in-Time and Kaizen continue to support manufacturing industry waste minimisation, efficiency, and continuous improvement (De Treville et al., 2023). The Toyota Production System focuses on Jidoka to ensure that automation enhances, rather than replaces, human well-being by combining both social and operational sustainability.

2.12.2 United states of America

The United States integrates sustainability across supply chains through a combination of corporate leadership, voluntary reporting systems, and targeted incentives. According to the sustainability-oriented practices described by Moutinho. (2022), green procurement, supplier

engagement, and collaboration are embedded in a broader governance environment that encourages firms to surpass minimum environmental compliance. The case of Procter and Gamble shows how firms operationalise sustainability through explicit long-term strategies, like its Ambition 2030 program, emphasizing climate responsibility, waste reduction, water stewardship, and the well-being of communities. These initiatives prove that SSCM is further reinforced when corporate governance, technological advancement, and public incentives are in place.

2.12.3 Germany

In Germany, the strength of SSCM comes through integrating high-level regulation with advanced technological innovation. According to Liu Z. (2022), Industry 4.0 connects automation with digitalization and data analytics for sustainable goals. This is further supported by strict EU sustainability directives such as the CSRD, which calls for supply chain transparency and due diligence. For example, companies like BMW already implement circular economy strategies by using up to 30% recycled content in their vehicles and by improving end-of-life recovery technologies. Germany thus stands as a case study for how innovation, regulation, and circularity can combine to lower carbon intensity and make international value creation more sustainable. For South Africa, Germany demonstrates the potential gains of formalizing circular economy pathways and strengthening policy coherence (Kouhhabibi and Mohammadi, 2023).

2.12.4 Sweden

The Swedish approach focuses on deep integration of social and environmental sustainability. The approach by Nimwal et al. (2023) recognizes circularity through recycling, lifecycle extension, and eco-design, driven by Swedish firms such as HandM. Sweden differs in that it has a collaborative governance model in which the government, industry, and labour all take part in defining the sustainability strategy. Partnerships among stakeholders facilitate sharing knowledge and make sustainable practices widespread. The approach of Sweden to integrating social partnership, skills development, and community involvement in the supply chain transitions offers important lessons for South Africa, where such initiatives remain underdeveloped.

2.12.5 What practices can the South African manufacturing industry adopt?

The South African manufacturing industry could improve its sustainability practices by taking inspiration from leading countries in manufacturing such as Japan, the United States, Germany, and Sweden. By adopting and implementing key principles and practices from these countries,

the manufacturing industry in South Africa can boost its position as one of the global leaders in sustainable manufacturing while solving environmental issues and promoting economic growth.

2.12.6 Leveraging Innovation and Digital Technologies: Inspired by Germany

Germany's "Industry 4.0" project emphasises the use of digital technology, automation, and data analytics to improve supply chain efficiency and sustainability. South African manufacturers can use digital technology to optimise manufacturing processes, increase resource efficiency, and reduce environmental impact (Burger and Weinmann, 2024).

2.12.7 Adopting Lean Manufacturing Principles from Japan

Japan's Lean Manufacturing principles, such as "Just-in-Time" and "Kaizen," prioritise efficiency, quality, and waste reduction. South African manufacturers can use these approaches to improve inventory management, eliminate overproduction, and lower environmental impact. South African businesses can increase productivity while lowering resource consumption and emissions by emphasising continuous improvement and enabling staff to identify and remove waste (Kumar et al., 2024). Furthermore, Vanichchinchai (2022) states that South African manufacturers can benefit from Toyota's Production System (TPS), which emphasises "Jidoka" or automation with a delicate touch. South African manufacturing firms may improve production processes and offer high-quality products adapted to the needs of their customers by incorporating automation technologies that prioritise human well-being and increase job productivity.

2.12.8 Integrating Sustainable Practices Throughout the Supply Chain, Inspired by the United States

According to Ali et al. (2024) sustainable supply chain management in the United States entails incorporating sustainable practices throughout the whole supply chain, from raw material procurement to product delivery. South African manufacturers can implement green procurement policies, work with suppliers to achieve sustainability improvements, and form collaborative partnerships to solve environmental and social issues. South African manufacturers can follow the lead of Procter and Gamble, which has set ambitious sustainability targets for 2030, and build complete sustainability plans centred on climate action, waste reduction, and water conservation. Working together with suppliers and stakeholders, South Africa's manufacturing industry can promote good change throughout the supply chain,

increasing competitiveness and resilience.

2.12.9 Regional Differences and the Transferability of SSCM Practices in Africa

The transferability of Sustainable Supply Chain Management (SSCM) practices across African countries is significantly influenced by heterogeneous political, economic, infrastructural, and socio-cultural conditions. While South Africa has comparatively advanced logistics networks and regulatory structures, countries such as Nigeria, Kenya, and Ethiopia exhibit diverse institutional contexts that shape the adoption, scalability, and diffusion of SSCM initiatives (Olawumi and Chan, 2018; Agyemang et al., 2019).

Institutional and Regulatory Environments

The strength of environmental regulation, enforcement capacity, and policy stability varies widely across African regions.

- *Nigeria* has environmental regulations such as the National Environmental Standards and Regulations Enforcement Agency (NESREA), but enforcement remains inconsistent due to bureaucratic fragmentation and corruption (Nwosu and Olojede, 2020). This weak enforcement environment constrains the adoption of global sustainability standards such as ISO 14001, limitedly aligning with the more structured compliance environment in South Africa (Odesola, 2022).
- *Kenya*, by contrast, has demonstrated stronger progress in climate-related governance and renewable energy legislation, particularly through the National Climate Change Act (2016), which supports greener procurement and logistics (Kamau, 2023). This more aligned policy environment allows SSCM practices from South Africa such as green procurement and carbon reporting to be more easily transferrable.
- *Ethiopia*, with its state-led development model, has ambitious national sustainability commitments (the Climate Resilient Green Economy Strategy), but logistical infrastructure limitations and restricted private-sector autonomy limit supply-chain transparency and innovation (Gebreeyesus et al., 2020).

Infrastructure and Logistics Capability

SSCM practices often rely on efficient transport corridors, digital tracking systems, and advanced logistics platforms (Christopher, 2016).

- *Nigeria* faces chronic port congestion (especially in Lagos), poor road networks, and electricity instability that increase operational risks and costs (Adeniran, 2021). Adeniran.

(2021) further adds that practices such as real-time emissions monitoring or green last-mile delivery which may be viable in South Africa become difficult to implement at scale.

- *Kenya* benefits from superior logistics infrastructure in East Africa, anchored by the Port of Mombasa and the Standard Gauge Railway (SGR) connecting Nairobi and inland regions (Panya et al., 2021). This strengthens supply-chain integration and enhances the transferability of green logistics and lean inventory initiatives.
- *Ethiopia* is a landlocked country, relying on Djibouti's port for over 90% of its trade. This structural constraint increases transportation distances and carbon intensity (Habib, 2025). South Africa's port-driven SSCM models such as multimodal freight optimisation are therefore less applicable without significant adaptation.

Technology Readiness and Digital Infrastructure

Digitalisation such as IoT-enabled tracking, blockchain for traceability, and renewable energy technologies is central to modern SSCM (Assefa., et al 2021).

- *Nigeria* has a growing tech industry but suffers from unreliable power supply, which limits the functionality of digital supply-chain systems (Egbulem et al., 2024).
- *Kenya*, the “Silicon Savannah,” leads Africa in ICT-driven innovation, mobile-money integration, and digital logistics platforms, enabling smoother implementation of technologically enabled SSCM initiatives (Odello, 2024).
- *Ethiopia's* restrictive internet governance and limited ICT penetration slow digital adoption across value chains (Teferi, et al 2024), constraining transferability of technology-heavy SSCM systems.

2.13 Future research work

Continuous research work is required in sustainable supply chain management in manufacturing. With a focus on key factors of advancing sustainability practices, the incorporation of circular economy is an answer to achieving environmental sustainability. Another significant area for research is on the socioeconomic effects of sustainable supply chain practices. The effect of sustainable efforts on local communities and economic development, researching how these factors affect employment, economic distribution, and societal well-being. Further research work is also essential in supplier relationship management and sustainable sourcing in the process of supply chain management further research on the role and impact of sustainability in encouraging the interchange of sustainable practices Lastly future

research in South African sustainable supply chain management should concentrate largely on social factors, policy influences, and economic competitiveness. Further research probe on these factors can assist in advancing sustainable practices in the manufacturing sector.

2.14 Web of Science graphs and charts that are related to sustainable supply chain management.

To illustrate global research trends in sustainable supply chain management (SSCM), bibliographic data were retrieved from the Web of Science Core Collection database. The search was conducted using keywords such as “sustainable supply chain management”, “green supply chain management”, and “supply chain sustainability” within titles, abstracts, and keywords. The search covered publications from 1997 to 2024, capturing the development of SSCM research over time. The resulting dataset was used to generate graphical representations of publication trends, including the number of publications over time, topic categories, country-level publication distribution, and author contributions. These figures provide an overview of the evolution of SSCM research globally and highlight the growing academic attention to sustainability in supply chain management.

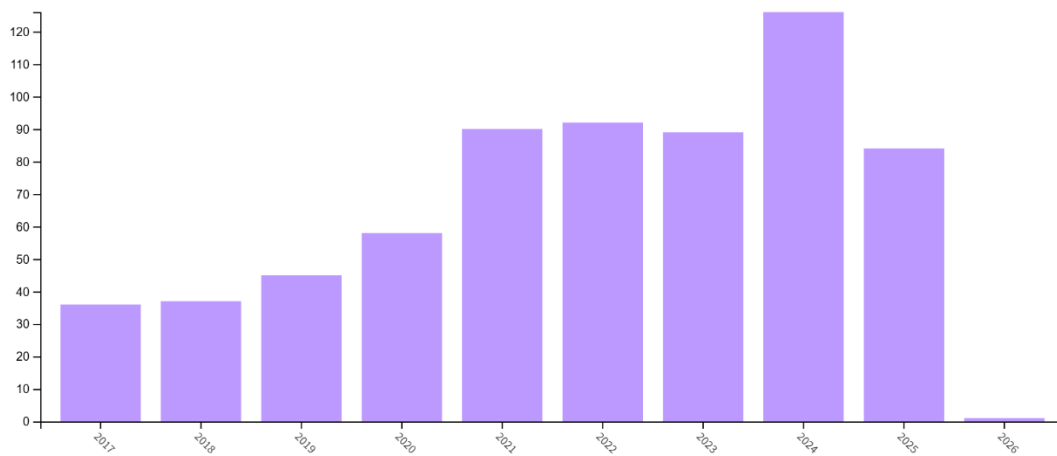


Figure 3- the Number of Publications between 2017-2026 based on sustainable supply chain management.

Source: Author’s compilation based on data retrieved from the Web of Science Core Collection (Web of Science, 2025).



Figure 4- Web of Science topic categories related to sustainable supply chain management from 1997-2024

Source: Author's compilation based on data retrieved from the Web of Science Core Collection (Web of Science, 2025).

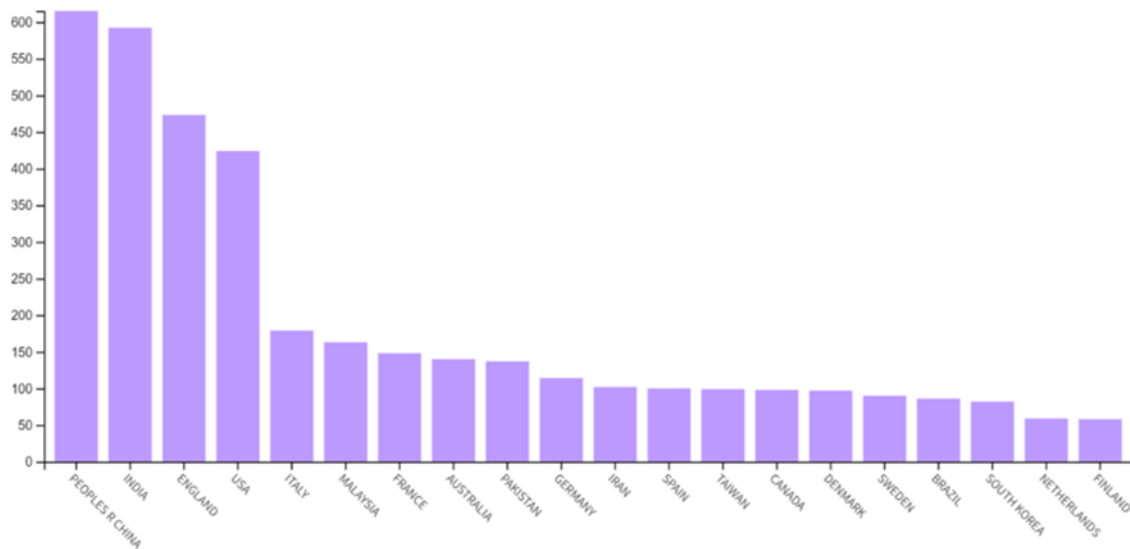


Figure 5- publications on sustainable supply chain management. Per country publications from 1997-2024

Source: Author's compilation based on data retrieved from the Web of Science Core Collection (Web of Science, 2025).

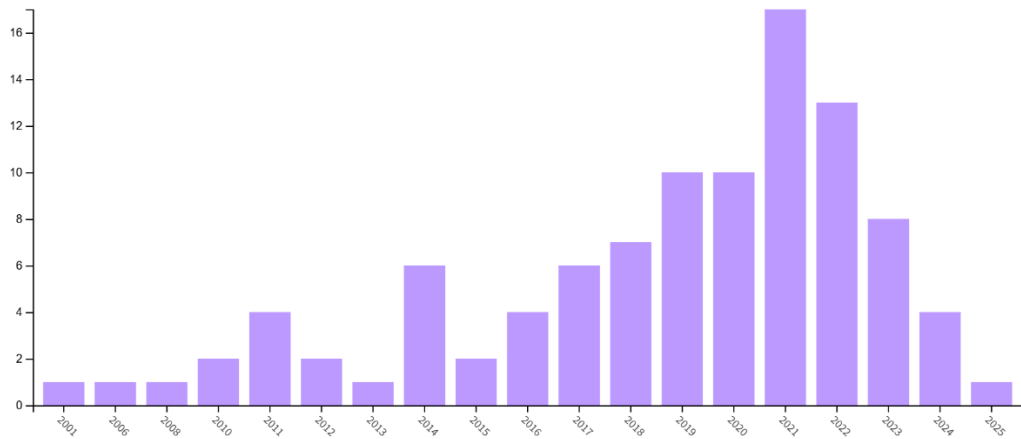


Figure 6- Number of publications, based on sustainable supply chain management in South Africa from 2001-2025

Source: Author's compilation based on data retrieved from the Web of Science Core Collection (Web of Science, 2025).



Figure 7- Web of Science Categories, based on sustainable supply chain management in South Africa

Source: Author's compilation based on data retrieved from the Web of Science Core Collection (Web of Science, 2025).

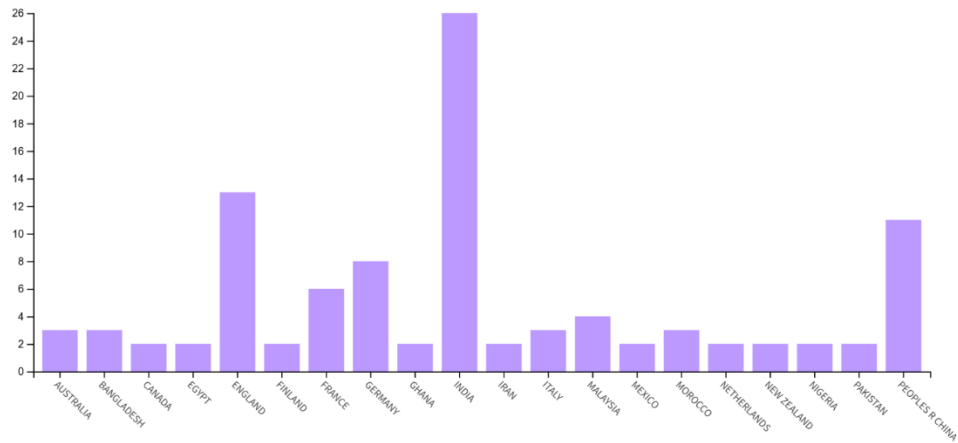


Figure 8- By country, publications on sustainable supply chain management in South Africa

Source: Author's compilation based on data retrieved from the Web of Science Core Collection (Web of Science, 2025).

3. MATERIALS AND METHODOLOGY

3.1 Introduction

This chapter provides a step-by-step explanation of how the research was conducted to ensure the study is valid and transparent. The research design explained the overall structure of the dissertation and the strategy used in addressing the research problems. This study utilized a mixed qualitative and quantitative method. The study design was chosen to answer the research questions. Participants and sample selection detailed the characteristics of the population in the study, how they were picked, and why they were appropriate for the study. Purposive sampling was employed for this study to ensure the selection of participants who possessed specific knowledge, experience, and characteristics relevant to the research objectives. Inclusion and Exclusion Criteria: This section outlined the specific criteria used to identify who was included or excluded from participating in the study. The Sample size described justified the accuracy of the results. Data Collection Methods described the instruments and techniques used to gather data. Data Analysis explained the procedures that were carried out to examine the data gathered. SPSS Statistical software, frequency distribution descriptive statistical analysis, and univariate descriptive analysis for a continuous variable was utilized to analyse data. Validity and Reliability were described as how they were established. Ethical considerations explained how the research was ethical. It included obtaining informed consent from participants, keeping participants anonymous, and confidential. Research limitations: This chapter acknowledged any methodological limitations or restrictions that might have affected the study outcome.

3.2 Research Design

The chosen research design for this study utilized a mixed-methods approach, strategically employed to provide a comprehensive understanding of sustainable supply chain management in the manufacturing industry in South Africa. This approach integrated quantitative and qualitative methodologies, aligning with the versatile nature of the research objectives in the context of South Africa.

3.2.1 Quantitative Component

This Study employed Quantitative data collection methods, surveys, were used to enable the systematic gathering of numerical data related to demographic characteristics, sustainable

practices, challenges in implementation, opportunities for the existing sustainable supply chain management practices prevalent in the South African manufacturing industry, the impact of sustainable supply chain management practices on the performance metrics and competitiveness of manufacturing firms, and the factors that influence the successful integration of sustainability within the supply chain. Statistical analysis techniques were employed to identify patterns, trends, and relationships within the data. This quantitative component allowed for the examination of trends and statistical associations, providing empirical insights into the sustainable supply chain management practices in the South African manufacturing industry.

3.2.2 Qualitative Component

This study employed a Qualitative data collection method; semi-structured interviews were utilized as they facilitate in-depth exploration of managers', Suppliers and Industry Professionals' perspectives, and narratives related to sustainable supply chain management. Reflexive thematic analysis (RTA) was utilized. Reflexive thematic analysis is an important qualitative approach because it provides a systematic but flexible method for assigning and interpreting patterns of meaning in data. Content coding techniques were utilized to identify recurring narratives and insights embedded within qualitative data. The Quotations of direct managers provided key points, with literature relevant to the discussion being used to support the discussion. This component offered rich contextual understanding and captured the complexities of sustainable supply chain practices in the manufacturing sector.

3.2.3 Integration

The integration of quantitative and qualitative data assisted in the enhancement of the depth of the research findings; it allowed for the triangulation of evidence from multiple sources. By combining quantitative statistical analysis with qualitative Reflexive Thematic Analysis, this mixed-methods approach ensured detailed exploration of sustainable supply chain management practices capturing both the breadth and depth of challenges and opportunities in the South African manufacturing industry in the cities of (Johannesburg and Durban).

3.2.4 Alignment with Research Questions

The chosen research design was aligned with research questions, ensuring coherence and relevance in addressing the versatile dimensions in sustainable supply chain management practices. This section involved the alignment between the research design, research relevance, and the research questions outlined in Chapter 1.

Table 1. Alignment of Research Questions, Research Hypotheses, and Research Design

Research Question	Alignment with Research Design
1. Evidence of sustainable supply chain management practices	The mixed-methods approach examined the current sustainable supply chain management practices using both qualitative and quantitative data sources. This research question also provides empirical grounding for Hypothesis 1 , which evaluates whether the implementation of sustainable supply chain practices improves operational efficiency, cost savings, and competitiveness.
2. Challenges in integrating sustainable supply chain management practices	The research design explored the challenges faced while attempting to integrate sustainable supply chain management practices. Qualitative interviews and survey responses were used to identify barriers such as regulatory compliance, resource constraints, and supplier engagement, which directly correspond to Hypothesis 2 .
3. The impact on performance and competitiveness	The survey data focused on an exploration of how sustainable supply chain practices influence firm performance and competitiveness. This research question is directly linked to Hypothesis 1 , which examines the relationship between SSCM implementation and improved operational and competitive results.
4. Key factors influencing the successful adoption and integration of sustainability within the supply chain	The study examined organizational, firm, and stakeholder-related factors influencing the adoption and integration of sustainability in supply chains within the manufacturing industry. These factors support the examination of Hypothesis 4 , which evaluates the role of government policies and institutional mechanisms in influencing SSCM adoption.
5. What strategies and recommendations can enhance effectiveness?	The study evaluated strategies and recommendations to enhance the effectiveness, productivity, and adoption of sustainable practices within the manufacturing sector. These insights contribute to the practical interpretation of Hypothesis 3 , which examines how circular economy integration can improve sustainability performance and resource optimization.

Source: Authors own compilation

3.2.5 Participants and Sample Selection

Participant selection in this research involved a process aimed at capturing different representatives across various sectors in the manufacturing industry namely Employees, Managers, Suppliers, and Industry Professionals. According to (Robinson, R.,2024) Purposive sampling is crucial as it allows researchers to deliberately select participants who share some characteristics, expertise or experience relevant to the research at hand.(Ahmad, M. and Wilkins, S., 2024) further state that this method is particularly beneficial in qualitative research, when the goal is to obtain rich, detailed information rather than generalizing results across a population. By focusing on providing rich and detailed information. purposive sampling enhances the richness and depth of the information gathered. It is especially useful when the study requires experts in the field or hard-to-reach groups, where random sampling would be ineffective. Purposive sampling also ensures that the data collected is immediately pertinent to the research questions, so the study becomes more focused and efficient (Thomas, F.B.,2022). Employing purposive sampling techniques for this study was relevant due to the nature of this study. This Study engaged with individuals and industry sectors directly involved in sustainable supply chain management in the manufacturing sector in South Africa in the cities of Johannesburg and Durban.

3.2.6 Inclusion Criteria

- *Managers:* Interviewing managers that are involved in supply chain management decision-making processes, who provided direct view of sustainability practices within their respective organizations. Their responses shed light on organizational priorities and the integration of sustainability practices into their respective supply chain operations.
- *Employees:* Interviewing employees offered frontline and first-hand experiences and views on the practical challenges and opportunities. Their experiences and insights provided value into operational problems, stakeholder engagement, and the effectiveness of sustainability practices at their various operational levels.
- *Suppliers:* Interviews with suppliers played a crucial role in the context of sustainable supply chain management practices. Their views on the challenges and opportunities of supplying sustainable materials provided a better understanding and assisted in identifying barriers to cooperation, resource constraints, and opportunities for collaboration to drive sustainability improvements.

- *Industry professionals*: Interviews with industry professionals, assisted with providing advisory services to the manufacturing industry on environmental sustainability issues, including energy efficiency, waste management, and environmental compliance. Interviews with Academic Researchers assisted in providing more research on sustainable supply chain management trends and further contributed to advancing knowledge and understanding in the field.

3.3 Sample Size

Due to the nature of this study, the sample size was based on the experience and expertise required to ensure sufficient depth and diversity in the data collected. This research included a total of 198 participants, comprising 162 employees, 10 suppliers, 11 managers, and 15 industry professionals. All participants were drawn from the manufacturing sector in the industrial cities of Johannesburg and Durban, with a focus on supply chain management activities. The inclusion of multiple stakeholder groups was necessary to capture different perspectives within the supply chain ecosystem. Employees represented the largest proportion of the sample because they are directly involved in day-to-day supply chain operations and sustainability implementation practices within manufacturing firms. Managers were included to provide insights into strategic decision-making, policy implementation, and organizational commitment toward sustainable supply chain management. Suppliers were incorporated to examine external supply chain collaboration and sustainability expectations across the supplier network. Finally, industry professionals were selected to provide broader sector-level perspectives on sustainability trends, regulatory influences, and operational challenges affecting SSCM adoption.

The distribution of participants across these stakeholder categories was designed to ensure that the study captured both operational-level and strategic-level insights, thereby enhancing the robustness and reliability of the findings. Furthermore, the total sample size was considered adequate for the statistical analyses employed in this study, while remaining feasible within the practical constraints of field data collection across two major industrial cities.

Sample size is one of the fundamental aspects of research design as it directly affects the validity, precision, and generalizability of studies' outcomes. A sufficiently large sample provides greater statistical power, which reduces the risk of Type II errors (Cohen, 2016). According to Faber and Fonseca (2014), larger samples also minimize sampling error and enable outcomes to be more representative of the target population, thereby increasing external validity. Conversely, an inadequate sample size can compromise the rigour of statistical analysis by producing unstable estimates and limiting the interpretability and applicability of findings

(Etikan et al., 2016). Besides these methodological concerns, ethical principles must also be followed. Selecting too few participants can render studies inconclusive or misleading, while unnecessarily large samples may waste resources and expose participants to undue burden without scientific benefit (Biau, Kernéis, and Porcher, 2008). Therefore, determining an appropriate sample size requires balancing statistical rigour, practical feasibility, and ethical responsibility.

Semi-structured interviews served as important measure in qualitative data collection. Participants included Managers, suppliers, and Industry professionals. Quantitative data collection, seeking to answer questions with regards to sustainable supply chain management practices, included employees. In addition, the selected stakeholder groups were chosen to reflect the key factors within the manufacturing supply chain industry. Employees represent operational level implementation of supply chain practices, while managers provide strategic views on manufacturing companies policies and decision-making. Suppliers represent upstream supply chain partners whose collaboration is important for implementing sustainable procurement and production practices. Industry professionals offer broader sector-level views on regulatory developments and sustainability trends. By incorporating perspectives from these different stakeholder groups, the study captures multiple levels of the supply chain system, thereby enhancing the representativeness of the findings. Although the research focuses on firms in Durban and Johannesburg, these cities are among South Africa's most significant industrial hubs, providing a relevant context for generating insights applicable to the wider manufacturing sector.

3.4 Data Collection Methods

In this section, the methodologies were employed to collect data for the study outlined. Sustainability supply chain management in the South African manufacturing sector, exploring challenges and opportunities in Johannesburg and Durban. Both qualitative and quantitative methods were adopted. These methodologies were carefully selected to ensure the contextuality of rich data from managers, employees, suppliers, and industry professionals. This assisted in enabling a comprehensive understanding of exploring the challenges and opportunities in sustainable supply chain management in the South African manufacturing industry.

Qualitative Data Collection Semi-Structured Interviews: Semi-structured interviews served as a cornerstone of qualitative data collection, offering a platform for in-depth information.

Participants included Managers, suppliers, and Industry professionals. Open-ended questions were included in the interviews for managers, closed-ended questions were included in the interview questions for Suppliers and Industry Professionals. these interviews unveiled various narratives, and they allowed for a deeper understanding of sustainability in supply chain management. The interviews were documented and thematically analysed, allowing for the discovery of emerging themes and patterns that drove theoretical frameworks and policy recommendations. Qualitative data were analysed using Reflexive Thematic Analysis (RTA), which is a systematic yet adaptive procedure for revealing and explicating patterns of meaning in the data. Inductive analysis was used to allow themes to emerge naturally from managers' responses. Content coding procedures were used to label and categorize recurring concepts and ideas related to sustainable supply chain management. Key themes were presented using direct quotes from managers, and accompanying literature was added for further depth in identifying interpretation.

Quantitative data collection using Surveys: Surveys constituted a pivotal component of quantitative data collection, enabling the systematic gathering of demographic information, sustainable supply chain management practices, and different perspectives employees, across various fields. The surveys were distributed digitally to participants. The survey instruments were carefully designed to capture quantitative data based on sustainable supply chain management practices in the South African manufacturing industry. Data obtained from surveys were subjected to rigorous statistical analysis (SPSS), frequency distribution descriptive statistical analysis, and univariate descriptive analysis for a continuous variable. Integrating both qualitative and quantitative methodologies, enabled a comprehensive exploration in sustainability in supply chain management in the South African manufacturing sector, thus contributing to scholarly discourse and policy regulation in the field of sustainability and supply chain management.

Statistical Analysis Software: Quantitative data were analysed using the Statistical Package for the Social Sciences (SPSS), a statistical computer application that supports both descriptive and inferential analysis of survey data. Sweet and Grace-Martin (1999) detail that the software program enables the application of precise statistical methodology for determining patterns, trends, and relationships in the quantitative data, including ANOVA, Spearman correlation, and regression modelling.

3.5 Data Analysis

After the collection of qualitative and quantitative data, the next phase involved rigorous data analysis processes aimed at deriving meaningful insights to address the research objectives.

3.5.1 Qualitative Data Analysis

Thematic Analysis: Thematic analysis constitutes qualitative data analysis. semi-structured interviews were carefully reviewed and organized into themes and sub-themes. Through a thorough process of categorization, recurring topics were identified, allowing for a comprehensive understanding of the narratives in sustainable supply chain management practices.

3.5.2 Quantitative Data Analysis

Descriptive Statistics: By utilizing SPSS, descriptive statistics were used to summarize and describe the quantitative data obtained from surveys. Measures such as means, frequencies, ANOVA, Spearman correlation, and standard deviations were calculated within the framework of the study's objectives. Descriptive statistics provided a significance of key trends and patterns within the quantitative dataset.

Explanation of Statistical Calculations and Their Relevance: To analyse the survey data and draw meaningful conclusions about the implementation of sustainable supply chain management (SSCM) practices, a combination of descriptive and inferential statistical techniques was used. Each calculation provided unique information about the characteristics of the data, trends among variables, and relationships among constructs of interest to SSCM in South African manufacturing contexts.

Count and Percentage: Frequency (number) and percentage were used to explain categorical variables such as company promotion of SSCM, availability of sustainability training, and perceived challenges. These descriptive measures count the number of respondents who selected each category and report it as a proportion of the total sample. This makes trends and the frequency of certain kinds of responses in the data clear and easy to understand. Field (2024) encourages the use of Frequency and percentage distributions, which are important in providing a clear overview of the distribution of responses within categories, particularly in survey research. They are handy in ascertaining the dominant themes, the most prevalent barriers, as well as awareness levels among the sample (Saunders et al., 2009).

Minimum, Maximum, Mean, and Standard Deviation: They were utilized to describe the central tendency and dispersion of continuous or ordinal data, such as rating scales approximating SSCM practices, sustainability matters, or organizational performance. Minimum and maximum values are utilized to describe the range of responses and to identify any outliers. The mean provides an approximation of the central or average opinion of the respondents. The standard deviation (SD) measures the variability in responses; how close or wide apart responses tend to cluster around the mean. Using these measures, researchers can measure consistency or lack of consensus, in this instance with relevance to measuring variability of degree of adoption of sustainability levels among companies. Descriptive statistics such as these form the basis for summarizing survey data before conducting inferential analysis (Pallant, 2020; Hair, 2014).

Valid Frequency, Percentage, Valid Percentage, and Cumulative Percentage: These measures were used to account for missing or excluded data and to illustrate the way that the responses accumulate across categories. Gravetter and Wallnau. (2021) State that Valid percentage and frequency exclude missing responses so that proportions are based only on valid cases. Cumulative percentage allows for the interpretation of how responses build up across ordered categories, useful for examining ordinal scales (e.g., Likert-type responses). These calculations provide a cleaner and more transparent display of data quality and distribution, with results obtained from whole, viable cases.

Spearman's Rank-Order Correlation Coefficient: The Spearman's coefficient (ρ) was used to measure the direction and magnitude of monotonic relations between ordinal or non-normally distributed variables. This nonparametric statistical test is particularly appropriate for survey data in the form of Likert scales that provide ordinal-level data (Laerd Statistics, 2018). The test helps to determine if improvements in one variable (for this research in training on sustainability) are connected to improvements or deteriorations in another (SSCM implementation or awareness). This is most crucial in SSCM research as it enables the establishment of statistically significant relationships between organizational activities and sustainability performance.

Analysis of Variance (ANOVA): ANOVA was applied to test whether statistically significant differences between the means of more than two groups existed, for example, in comparing SSCM practices between different company sizes, industries, or levels of staff. ANOVA helps determine whether the differences result from chance variation or rather reflect true underlying group differences. According to Niranjana et al. (2025), in SSCM research, ANOVA is

particularly useful in research exploring trends in the adoption of sustainability across different organizational settings, therefore revealing structural or contextual determinants in the context of sustainability performance.

Number and Sum: Number (N) and sum were included to give the total number of valid responses and the total sum of specific variables. Miller (2021) states that these statistics are the foundation for calculating descriptive statistics such as means, percentages, and proportions. Reporting N and sum ensures transparency and replication by making it evident the data coverage and completeness.

Correlation Significance: The correlation tests' significance (p-value) determines if the observed relationships among variables are statistically significant or could have occurred randomly (Kafle, 2019). Presenting significance values is an essential part of inferential statistics because it enables researchers to ascertain the trustworthiness of their results and make valid inferences regarding relationships between SSCM variables.

3.6 Evaluation and Testing of Hypotheses Across Stakeholder Groups

The approach of evaluating hypotheses through descriptive and interpretive analysis was chosen to ensure methodological alignment with the nature of the data collected from multiple stakeholder groups and to maintain thoroughness in a mixed-methods design. Quantitative survey data from employees, suppliers, and industry professionals included ordinal and perception-based measures, while managerial data were qualitative, capturing experiential and strategic perspectives. Using parametric inferential statistics would have been inappropriate for small or non-interval datasets, particularly for suppliers (N = 15), industry professionals (N = 15), and managers (N = 11), as such analyses require assumptions regarding sample size, distribution, and measurement scale that were not met. Instead, descriptive pattern analysis and thematic interpretation allowed for systematic evaluation of the extent to which empirical data supported the theoretical propositions underlying each hypothesis. This approach aligns with established guidance in mixed-methods research, where hypothesis evaluation is conducted through analytical synthesis of quantitative and qualitative patterns rather than purely statistical testing (Creswell and Plano Clark, 2018). By integrating descriptive and interpretive evaluation, this method enables a thorough, contextually appropriate, and evidence-based assessment of hypotheses across diverse stakeholder perspectives, while avoiding overstatement of causal claims and respecting the exploratory nature of the study.

3.7 Data Validity and Reliability

Ensuring the validity and reliability of the data was paramount in maintaining the integrity and trustworthiness of the research findings. This section addressed measures to be taken to enhance data validity and reliability, which were discussed.

3.7.1 Data Collection Protocol

Standardized Protocols: A clear and standardized set of questions was created for interviews and surveys for data collection to ensure consistency and reliability across the different data collection sessions.

3.8 Research Ethics and Confidentiality

Ethical integrity and responsible data management formed central pillars of this research process. Given that the study involved semi-structured interviews with company managers, suppliers, and industry experts, strict adherence to ethical guidelines was always maintained so that the rights, privacy, and dignity of the participants would be safeguarded. The ethical framework adopted was informed by the principles of the Belmont Report (1979) and the Economic and Social Research Council (ESRC) Framework for Research Ethics (2021), both of which stress respect for persons, beneficence, and justice.

3.8.1 Voluntary Participation and Informed Consent

All participants were briefed in advance on the purpose, scope, and objectives of the study, including the academic purposes for which the data are used. Participation was strictly voluntary, with respondents also notified that they were free to withdraw from the interview at any stage or not answer a question if they preferred. A sheet with questions was provided for each interviewee before commencement, outlining the research aims as well as ethical safeguards.

3.8.2 Anonymity and Confidentiality

To ensure anonymity, no participant names, company names, or identifying details were recorded in the dataset or the final dissertation. This anonymization protocol was maintained for all transcripts, analyses, and quoted excerpts throughout. Interview data with potentially sensitive business information, such as details about supplier contracts, production costs, or sustainability strategies, received heightened confidentiality. Anonymized interview data was

excluded from direct quotations within the dissertation to avoid identification of any kind.

3.8.3 Ethical Approach

For this study, all findings were presented and reflected participants' authentic perspectives. Ethical reflection continued during data collection, ensuring respect, transparency, and trust in all interactions.

3.9 Ethical considerations

3.10 Reflection on Sample Adequacy and Mixed-Methods Integration

The mixed-methods design was not merely additive; rather, it enabled methodological integration where quantitative findings identified the extent and patterns of SSCM adoption, while qualitative insights highlighted the underlying reasons, the studies contextual barriers, and strategic implications. The integration enhanced validity through multiple stakeholder analysis, expanded the interpretive depth, and provided a comprehensive understanding of SSCM practices across stakeholder groups.

4. RESULTS AND DISCUSSION

The analysis primarily uses descriptive statistics, correlation analysis, and ANOVA to examine patterns and relationships related to sustainable supply chain management (SSCM) practices in the South African manufacturing sector. These techniques are appropriate for addressing the research questions as they allow the study to identify the extent of SSCM adoption, examine relationships between key variables, and compare differences across organizational and employee characteristics. Together, these methods provide a coherent analytical framework for interpreting the empirical findings. In presenting the results, both numerical coding and Likert-type response scales are used depending on the questionnaire format. Where numerical coding is applied (e.g., 0 = Not sure, 1 = No, 2 = Yes), the coding reflects the structure of the survey instrument used during data collection and is retained to ensure consistency with the statistical analysis conducted in SPSS. For clarity and consistency, explanations of the response scales are provided alongside the relevant tables and figures to ensure that the interpretation of results remains transparent and consistent throughout the chapter. Furthermore, this chapter provides the research findings and presents a critical discussion concerning the study's objectives and research questions. Which are:

1. What evidence exists of sustainable supply chain management practices adopted in the South African manufacturing industry?
2. What challenges do manufacturing firms meet in implementing sustainable supply chain practices?
3. How do sustainable supply chain practices affect the performance and competitiveness of manufacturing firms?
4. What are the key factors influencing the successful adoption and integration of sustainability within supply chains in the sector?
5. What strategies can be recommended to enhance the adoption and effectiveness of SSCM in the manufacturing sector?

The following section presents the descriptive results that were obtained from the **supplier respondents**.

4.1 Results for Suppliers

Table 2. Primary sector where suppliers are operating in

Table 2 provides background on the industries in which the supplier respondents operate, the study first examined the primary sector of the participating supplier firms.

Response	Count	Percent
Automotive	6	60.0
Food and Beverage	2	20.0
Textiles	2	20.0

Source: Author's compilation

Interpretation:

Table 2 presents the sectoral distribution of the supplier firms participating in the study. Most suppliers (60%) operate within the automotive sector, while 20% belong to the food and beverage sector and 20% to the textile sector. This distribution is analytically significant because the automotive industry is highly integrated into global supply chains where multinational manufacturers impose strict environmental and sustainability requirements on their suppliers. Such requirements often include compliance with international standards such as ISO environmental management certifications, environmental compliance regulations, and green procurement practices. From a stakeholder theory perspective, suppliers operating in globally integrated industries experience stronger sustainability pressures from dominant supply chain actors such as multinational manufacturers and international buyers. These pressures increase the likelihood that suppliers adopt or align with sustainable supply chain management (SSCM) practices. In contrast, suppliers operating in the food and beverage and textile sectors may face sustainability pressures that are more strongly influenced by local market conditions, consumer expectations, and national regulatory frameworks. Although these sectors are also important within the manufacturing ecosystem, their lower representation in the sample suggests that the empirical findings are largely influenced by industries where sustainability expectations are already embedded within global supply chain governance structures. In relation to Research Question 1, this sectoral distribution provides initial contextual evidence that SSCM practices are present within supplier networks, particularly in industries exposed to international sustainability standards. Furthermore, this finding provides indirect empirical support for Hypothesis 1, which suggests that the adoption of SSCM practices is influenced by industry integration and exposure to sustainability requirements within global supply chains.

Table 3. Company size

Table 3 provides the organizational characteristics of the supplier firms in terms of company size. Suppliers were asked to indicate the number of employees in their respective organizations.

Response	Count	Percent
300+ employees	4	40.0
101–200 employees	4	40.0
51–100 employees	1	10.0
201–300 employees	1	10.0

Source: Authors' Compilation

Interpretation:

Table 3 presents the size distribution of the supplier firms included in the study. The results show that 80% of the firms employ more than 100 employees, while only 20% employ fewer than 100 employees. This distribution indicates that most supplier firms in the sample are medium to large enterprises. Firm size is analytically important when examining the adoption of sustainable supply chain management (SSCM) practices. Larger firms generally possess greater financial resources, technological capabilities, and formal management systems that enable them to invest in sustainability initiatives such as energy efficiency programs, recycling systems, and sustainable procurement practices. While smaller firms often face resource constraints and may prioritize short-term operational survival over long-term sustainability investments. From the perspective of the Resource-Based View (RBV), the availability of internal resources and organizational capabilities plays a critical role in determining whether firms can effectively implement sustainability initiatives. Larger firms are therefore more likely to possess the financial capital, technical expertise, and managerial capacity required to integrate SSCM practices into their operations. Relating to Research Question 1, this distribution suggests that the evidence of SSCM practices identified in the study may partly reflect the greater resource capacity of larger firms within the supplier network. The results also provide contextual support for Hypothesis 1, which proposes that firms with stronger operational capabilities are better positioned to implement sustainable supply chain practices that enhance efficiency and competitiveness.

Table 4. Years in operation

Table 4 examines the number of years their companies have been in operation.

Response	Count	Percent
10 years +	8	80.0
6–10 years	2	20.0

Source: Authors own compilation

Interpretation:

Table 4 shows that 80% of the supplier firms have been operating for more than 10 years, while 20% have been in operation between 6 and 10 years. This indicates that most firms in the sample are well-established organizations with relatively stable supply chain relationships and operational systems. From an analytical perspective, firms with longer operational histories may have had greater exposure to evolving sustainability requirements and industry standards. In relation to RQ1, this suggests that evidence of SSCM practices may be more observable among established firms that have had more time to adapt to sustainability expectations. This finding also provides contextual support for Hypothesis 1, which suggests that organizational capability and operational maturity can influence the implementation of sustainable supply chain practices.

Table 5. Company location

Table 5 identifies the geographic distribution of the suppliers; respondents were asked to indicate the province in which their companies are located.

Response	Count	Percent
KwaZulu-Natal Province	6	60.0
Gauteng Province	4	40.0

Source: Author's compilation

Interpretation:

Table 5 shows that 60% of the supplier manufacturing firms are in KwaZulu-Natal Province, while 40% are based in Gauteng Province. Both provinces represent major industrial hubs within South Africa, although they differ in infrastructure and institutional support for manufacturing operations (Scholvin, 2020). In relation to RQ1, the findings indicate that the presence and development of SSCM practices may vary depending on regional industrial

conditions. This observation also provides contextual support for Hypothesis 4, which highlights the influence of institutional and policy environments on SSCM adoption.

Table 6. Number of manufacturing customers

Table 6 examined the extent of supplier engagement within manufacturing supply chains; suppliers were asked to indicate the approximate number of manufacturing customers their firms serve.

Response	Count	Percent
6–10	4	40.0
11–20	4	40.0
50+	2	20.0

Source: Author’s compilation

Interpretation:

Table 6 shows that supplier firms serve varying numbers of manufacturing customers, with 40% supplying between 6–10 customers, another 40% supplying 11–20 customers, and 20% supplying more than 50 customers. This distribution indicates that many suppliers operate within relatively broad customer networks. From an analytical perspective, suppliers with larger customer bases are more likely to encounter diverse sustainability requirements across their supply chains. Different customers may impose varying environmental standards, procurement policies, and sustainability expectations. In relation to RQ1, this finding suggests that exposure to multiple manufacturing customers may increase the likelihood that suppliers engage with sustainable supply chain management (SSCM) practices. The result also provides contextual support for Hypothesis 4, which highlights the role of external supply chain pressures in influencing SSCM adoption

Table 7a and b awareness of sustainability requirements

Table 7 and b assess the level of awareness of sustainability requirements among suppliers, respondents were asked to indicate how aware they are of sustainability expectations communicated by their manufacturing customers.

Response	Count	Percent
Slightly aware	3	30.0
Aware	3	30.0
Not aware at all	2	20.0
Very aware	2	20.0

n	Mean	SD	Min	Max
10.0	2.5	1.08	1.0	4.0

Source: Author's Compilation

Interpretation:

Table 7a and 7b present supplier awareness of sustainability requirements within their supply chain relationships. The results indicate uneven awareness levels among suppliers. While 20% reported being very aware and 30% aware of sustainability requirements, a notable proportion of respondents indicated limited awareness, with 30% being slightly aware and 20% not aware at all. The mean score of 2.5 (on a 1–4 scale) suggests a moderate level of awareness overall, while the relatively high standard deviation (1.08) indicates variation in awareness levels across supplier firms. From an analytical perspective, these findings suggest that sustainability expectations are not uniformly communicated or understood across supplier networks. Awareness is a fundamental prerequisite for the adoption of sustainable supply chain management (SSCM) practices, as firms must first understand customer sustainability requirements before they can implement them effectively. In relation to RQ1, the results indicate that SSCM awareness exists but remains uneven across suppliers. In relation to RQ2, the variation in awareness levels suggests that communication gaps between manufacturers and suppliers may represent an important barrier to SSCM implementation. This finding also provides contextual support for Hypothesis 2, which highlights informational and organizational constraints as challenges affecting SSCM adoption.

Table 8a and b. Extent sustainability is considered

Table 8a and b assess the extent to which suppliers incorporate sustainability when engaging with manufacturing customers, suppliers were asked to indicate the degree to which sustainability influences their business interactions.

Response	Count	Percent
To a small extent	4	40.0
To some extent	4	40.0
Not at all	1	10.0
To a great extent	1	10.0

n	Mean	SD	Min	Max
10.0	2.5	0.85	1.0	4.0

Source: Author's Compilation

Interpretation:

Table 8a and b show that most suppliers consider sustainability only to a limited or moderate extent when engaging with customers. The mean score of 2.5 indicates a moderate level of sustainability consideration, while the relatively low standard deviation (0.85) suggests similar responses across suppliers. IN relation to RQ1, the findings indicate that SSCM practices are present but not yet deeply integrated within supplier operations. Regarding RQ3, the limited extent of sustainability consideration suggests that sustainability has not yet been widely used as a strategic source of competitiveness among supplier firms. This finding also provides contextual support for Hypothesis 1, which proposes that stronger integration of SSCM practices can enhance operational and competitive outcomes.

Table 9. Challenges to implementing sustainable practices

Table 9 identifies the key barriers affecting the implementation of sustainable practices among suppliers, suppliers were asked to indicate the main challenges their firms face when attempting to adopt sustainability initiatives.

Option	Count	Resp_ %
High implementation costs	7	70.0
Limited access to sustainable materials/technology	6	60.0
Lack of clear communication from customers	4	40.0
Regulatory constraints	3	30.0
Inconsistent demand	3	30.0
Lack of expertise/training	1	10.0

Source: Author's compilation

Interpretation:

Table 9 identifies the main challenges faced by suppliers when implementing sustainable practices. The most frequently reported barriers are high implementation costs (70%) and limited access to sustainable materials or technology (60%), followed by unclear communication from customers (40%) and regulatory constraints and inconsistent demand (30%). These findings suggest that financial and technological constraints represent the most significant obstacles to the adoption of sustainable supply chain management (SSCM) practices. In relation to RQ2, the results indicate that suppliers experience multiple structural challenges that hinder the implementation of sustainability initiatives. The findings also provide empirical support for Hypothesis 2, which proposes that regulatory, resource, and supply chain coordination challenges are key barriers affecting SSCM adoption.

Table 10a and b. Frequency of how often customers request to meet sustainability requests

Table 10 examines the extent of customer pressure influencing sustainability adoption, suppliers were asked how frequently their manufacturing customers request compliance with sustainability requirements.

Response	Count	Percent
Rarely	5	50.0
Often	2	20.0
Never	1	10.0
Sometimes	1	10.0
Always	1	10.0

n	Mean	SD	Min	Max
10.0	2.7	1.25	1.0	5.0

Source: Author's compilation

Interpretation:

Table 10a and 10b show how frequently manufacturing customers request suppliers to meet sustainability requirements. The results indicate that sustainability requests from customers are relatively limited, with half of the suppliers reporting that such requests occur rarely. The mean score of 2.7 suggests that customer pressure for sustainability exists but remains moderate, while the relatively high standard deviation (1.25) indicates variation in supplier experiences.

In relation to RQ1, the findings suggest that the adoption of sustainable supply chain management (SSCM) practices among suppliers is uneven, as sustainability expectations are not consistently communicated across supply chain relationships. Regarding RQ4, customer demand emerges as an important external driver influencing SSCM adoption. This finding also provides contextual support for Hypothesis 4, which proposes that external pressures from supply chain stakeholders influence the implementation of sustainability practices

Table 11. Availability of Internal Sustainability Policies

Table 11 assessed whether supplier firms have formal sustainability governance structures, suppliers were asked to indicate whether their organizations have internal sustainability policies.

Response	Count	Percent
Yes	4	40.0
In Development	4	40.0
No	2	20.0

Source: Author's Compilation

Interpretation:

Table 11 shows that 40% of suppliers have established internal sustainability policies, while another 40% are in the process of developing such policies, and 20% report having none. This distribution suggests that many supplier firms are beginning to formalize sustainability within their organizational structures, although full institutionalization has not yet been achieved.

In relation to RQ1, the findings provide evidence that sustainable supply chain management (SSCM) practices are emerging among supplier firms. Regarding RQ4, the presence or development of internal sustainability policies highlights the importance of organizational governance structures in supporting SSCM adoption. This finding also provides contextual support for Hypothesis 4, which emphasizes the role of institutional and organizational factors in influencing sustainability implementation.

Table 12a and b customers are increasingly demanding that suppliers adopt sustainable practices

Table 12 a and b assess whether suppliers perceive increasing sustainability expectations from their manufacturing customers.

Response	Count	Percent
Agree	5	50.0
Neutral	2	20.0
Strongly agree	2	20.0
Disagree	1	10.0

n	Mean	SD	Min	Max
10.0	3.8	0.92	2.0	5.0

Source: Author's compilation

Interpretation:

Table 12a and 12b show that most suppliers perceive increasing sustainability demands from their customers. The mean score of 3.8 indicates overall agreement that customer expectations regarding sustainability are rising, while the standard deviation (0.92) suggests moderate variation in responses. IN relation to RQ4, these findings highlight customer demand as an important external driver influencing the adoption of sustainable supply chain management (SSCM) practices. Regarding RQ1, the perceived increase in sustainability expectations provides contextual evidence explaining the growing presence of SSCM practices within supplier networks. In relation to RQ3, suppliers that respond effectively to these demands may strengthen their competitive positioning within supply chains. This finding also provides contextual support for Hypothesis 4, which emphasizes the role of external stakeholder pressures in influencing SSCM adoption.

Table 13a and b. our company has resources/expertise

Table 13a and b evaluate whether supplier firms possess the internal capabilities required to meet sustainability expectations.

Response	Count	Percent
Disagree	5	50.0
Neutral	4	40.0
Agree	1	10.0

n	Mean	SD	Min	Max
10.0	2.6	0.7	2.0	4.0

Source: Author's Compilation

Interpretation:

Table 13a and 13b indicate that many suppliers perceive limited internal capacity to meet sustainability requirements. Half of the respondents disagreed that their firms possess sufficient resources or expertise, while only 10% agreed. The mean score of 2.6 suggests relatively low readiness, with responses clustered around disagreement and neutrality. In relation to RQ4, the findings highlight the importance of internal capabilities such as financial resources, technical expertise, and management systems in enabling sustainable supply chain management (SSCM) implementation. Regarding RQ3, limited internal capacity may constrain suppliers' ability to leverage sustainability as a competitive advantage. This finding also provides contextual support

for Hypothesis 2, which identifies resource constraints as a key challenge affecting the adoption of SSCM practices.

Table 14a and b. South African Regulatory department support and incentives exist

Table 14a and b assess the perceived role of government support in promoting sustainability adoption, suppliers were asked whether regulatory support and incentives for sustainable practices

Response	Count	Percent
Disagree	4	40.0
Neutral	4	40.0
Agree	2	20.0

n	Mean	SD	Min	Max
10.0	2.8	0.79	2.0	4.0

Source: Author's compilation

Interpretation:

Table 14a and 14b show that many suppliers perceive limited regulatory support or incentives for sustainability adoption. Forty percent of respondents disagreed that such support exists, while another 40% remained neutral. The mean score of 2.8 indicates a relatively moderate assessment of government support. In relation to RQ2, the findings suggest that regulatory and institutional challenges may hinder the implementation of sustainable supply chain management (SSCM) practices. Regarding RQ4, the limited perception of policy incentives indicates that external institutional drivers for sustainability adoption remain relatively weak. This finding also provides contextual support for Hypothesis 4, which emphasizes the role of government policies and institutional frameworks in influencing SSCM adoption.

Table 15. Support needed

Table 15 identifies the types of support suppliers, require improving sustainability adoption, suppliers were asked to indicate the forms of assistance that would most help their firms implement sustainable practices.

Option	Count	Resp_ %
Training in sustainability best practices	9	90.0
Government incentives	6	60.0
Access to affordable sustainable materials/technology	5	50.0
Industry: wide collaboration	3	30.0
Stronger regulatory framework	1	10.0

Source: Author's compilation

Interpretation:

Table 15 identifies the types of support suppliers believe would assist them in implementing sustainable practices. The most frequently identified need is training in sustainability best practices (90%), followed by government incentives (60%) and access to affordable sustainable materials or technology (50%). In relation to RQ5, these findings highlight the practical support mechanisms that suppliers consider necessary to enhance the implementation of sustainable supply chain management (SSCM) practices. The results also reflect the challenges identified in RQ2, particularly those related to resource constraints and technological access. Furthermore, the findings provide contextual support for Hypothesis 2, which identifies resource limitations and institutional support as key factors influencing the adoption of SSCM practices.

4.1.1 Empirical Testing of Research Hypotheses (For Suppliers) Table 16. Empirical Results of Hypothesis Testing for Supplier Data

Hypothesis	Description	Empirical result	Decision (Accept/Reject)
H1	Effective SSCM implementation improves efficiency, cost, and competitiveness	Evidence of moderate adoption, policy formalization, customer demand	Accepted
H2	Challenges include regulatory, resource, and supplier engagement constraints	Excessive cost, limited technology access, weak regulation, communication gaps	Accept
H3	Circular economy integration enhances sustainability and resource optimization	Policy and awareness emerging, but limited by capacity	Reject
H4	Government support positively influences SSCM adoption	Perceived weak incentives, though strong potential impact	Accept

Source: Author's compilation

Supplier Hypothesis Evaluation

- *Methodological basis*

Supplier data (n = 15) did not meet the criteria required for regression or correlation testing, particularly with respect to sample size, normality, and statistical power. Hypotheses were therefore evaluated using a logical empirical approach based on descriptive quantitative analysis.

- *Analytical approach applied*

Supplier responses were analysed using percentages, mean scores, and standard deviations. The results were analysed by comparing response trends (such as percentages and average scores) with what each hypothesis predicted, to see whether the data supported or contradicted the expected relationships.

- *Decision logic (Accept / Reject)*

Hypotheses were accepted when descriptive empirical patterns consistently aligned with the hypothesised direction

Hypotheses were rejected when such alignment was weak, inconsistent, or absent within the supplier dataset.

- *Interpretation of results*

Acceptance or rejection reflects empirical support at the descriptive level, not statistical confirmation or causal inference. The results indicate the extent to which supplier perceptions and responses substantively support the theoretical hypotheses under investigation.

- *Methodological justification*

This approach ensures a link between the method of hypothesis evaluation and the size, structure, and empirical characteristics of the supplier data. The strategy is consistent with exploratory and mixed-methods research principles, where hypothesis evaluation is based on empirical pattern recognition and theoretical consistency rather than inferential statistical testing.

4.2 Results for employees

To examine the extent to which sustainable supply chain management (SSCM) practices are implemented within South African manufacturing firms, respondents were asked whether their companies actively promote SSCM practices. RQ1a. What evidence exists of the implementation of sustainable supply chain management practices in South African manufacturing? Link to questionnaire questions: 6,8,10,11,12

Table 17. 1How much a company promotes SSCM

Q8. Company Promotes SSCM					
		Frequency	Percent	Valid Percent	Cumulative Percent
V	0	28	17.3	17.3	17.3
	1	33	20.4	20.4	37.7
	2	101	62.3	62.3	100.0
	Total	162	100.0	100.0	

Source: Author's compilation

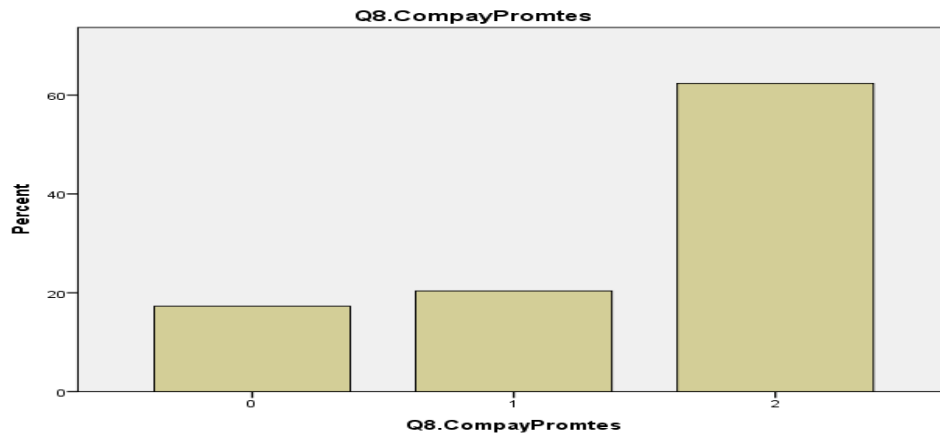


Figure 9: How much a company promotes SSCM graph.

Source: (SPSS,2025).

Interpretation:

Table 17 shows that 62.3% of respondents indicated that their companies actively promote SSCM practices, suggesting that sustainability initiatives are present within many manufacturing firms. However, 20.4% were unsure and 17.3% reported that their companies do not actively promote SSCM, indicating that SSCM adoption remains uneven across the sector. These findings provide empirical evidence addressing RQ1a and offer initial support for Hypothesis 1, as the presence of SSCM practices suggests that firms are beginning to integrate sustainability into their supply chain operations.

Table 18. Provision of training,

Table 18 assess evidence of SSCM implementation within manufacturing firms; employees were asked whether their organizations provide training or education related to sustainability practices.

Provision of Training or Education					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	50	30.9	30.9	30.9
	1	35	21.6	21.6	52.5
	2	77	47.5	47.5	100.0
	T	162	100.0	100.0	

Source: Author's Compilation

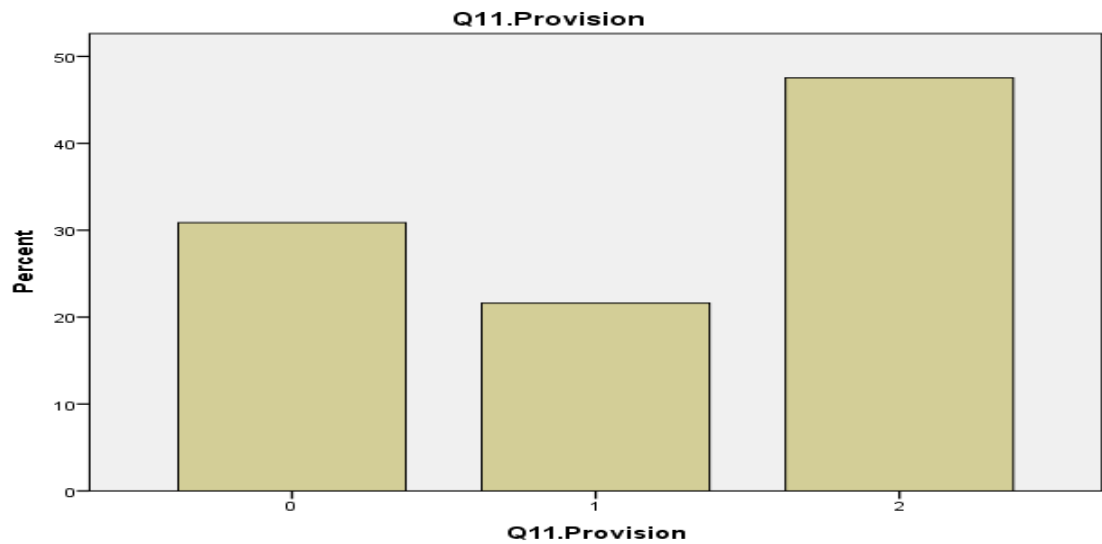


Figure 10. Provision of training

Source: SPSS, 2025

Interpretation:

Table 18 shows that 47.5% of respondents reported that their companies provide sustainability-related training, indicating that many firms are developing employee capabilities to support SSCM practices. However, 30.9% reported that no such training is provided, while 21.6% were unsure, suggesting that sustainability training initiatives are not consistently implemented or communicated across all firms. This pattern indicates that while some manufacturing firms are investing in sustainability capacity-building, SSCM integration remains uneven across the sector. These findings contribute evidence for RQ1a, demonstrating that SSCM practices are being implemented through organizational training initiatives. The results also provide support for Hypothesis 1, as employee training represents an important mechanism through which firms develop the capabilities necessary to implement sustainable supply chain practices effectively.

Correlations

Table 19 examines the relationships between employee awareness, involvement in SSCM activities, and perceived company performance, a Spearman’s rank correlation analysis was conducted.

Table 19. Correlation between awareness, involvement in SSCM and Company performance

			Awareness	Involvement in SSCM	Company Performance
Spearman's rho	Awareness	Correlation Coefficient	1.000	.444**	.525**
		Sig. (2: tailed)	.	.000	.000
		N	162	162	162
	Involvement in SSCM	Correlation Coefficient	.444**	1.000	.673**
		Sig. (2: tailed)	.000	.	.000
		N	162	162	162
	Company Performance	Correlation Coefficient	.525**	.673**	1.000
		Sig. (2: tailed)	.000	.000	.
		N	162	162	162
**. Correlation is significant at the 0.01 level (2: tailed).					

Source: Author’s compilation,

Interpretation:

Table 19 indicates statistically significant positive relationships among awareness, involvement in SSCM, and perceived company performance. A moderate positive correlation exists between awareness and SSCM involvement ($\rho = 0.444$, $p < 0.01$), suggesting that employees who are more aware of sustainability initiatives are more likely to participate in SSCM activities. Awareness also shows a moderate positive relationship with perceived company performance ($\rho = 0.525$, $p < 0.01$), indicating that higher awareness is associated with more positive evaluations of sustainability performance. The strongest relationship appears between SSCM involvement and perceived company performance ($\rho = 0.673$, $p < 0.01$), suggesting that employee participation in sustainability initiatives is closely linked to perceptions of improved organizational performance. These findings suggest that employee awareness and engagement play an important role in supporting effective SSCM implementation within manufacturing firms. The results provide empirical support for Hypothesis 1, which proposes that the implementation of SSCM practices contributes to improved organizational performance.

Compare Means by Sector

Comparing Awareness, Involvement, and Performance by Sector to determine which sector of operation influences employee awareness, involvement, or perceived performance in sustainable supply chain management (SSCM).

ANOVA**Table 20. Comparing Awareness, Involvement, and Performance by Sector**

Table 20 examines whether employee awareness, involvement in SSCM activities, and perceptions of company performance differ across industry sectors, a one-way ANOVA analysis was conducted.

		Sum of Squares	df	Mean Square	F	Sig.
Awareness	Between Groups	5.196	4	1.299	1.024	.397
	Within Groups	199.224	157	1.269		
	Total	204.420	161			
Involvement in SSCM	Between Groups	3.416	4	.854	.767	.548
	Within Groups	174.862	157	1.114		
	Total	178.278	161			
Company Performance	Between Groups	2.211	4	.553	.472	.756
	Within Groups	183.789	157	1.171		
	Total	186.000	161			

Source: Author's compilation, 2025

Interpretation:

Table 20 presents the ANOVA results comparing employee awareness, involvement in SSCM, and perceived company performance across different industry sectors. The results show no statistically significant differences across sectors for awareness ($F(4,157) = 1.024, p = 0.397$), involvement ($F(4,157) = 0.767, p = 0.548$), or perceived company performance ($F(4,157) = 0.472, p = 0.756$), as all p-values exceed the 0.05 significance threshold. Analytically, these findings suggest that employee perceptions and engagement with SSCM practices are relatively consistent across manufacturing sectors. This indicates that SSCM awareness and participation may be influenced more by organizational policies and internal management practices rather than by the specific industry sector in which firms operate. These findings provide contextual support for Hypothesis 1, as they indicate that SSCM implementation and its perceived performance outcomes are not restricted to specific sectors but are observable across the broader manufacturing industry.

Compare Means by Location

Comparing Awareness, Involvement, and Performance by Location. To determine whether company location (Gauteng vs. KwaZulu-Natal) influences employee awareness, involvement, or perceived performance in sustainable supply chain management (SSCM).

ANOVA

Table 21 examines whether geographic location influences employee awareness, involvement in SSCM activities, and perceptions of company sustainability performance, a one-way ANOVA analysis was conducted comparing firms located in Gauteng Province and KwaZulu-Natal Province.

Table 21. Comparing Awareness, Involvement, and Performance by Location

		Sum Squares	df	Mean Square	F	Sig.
Awareness	Between Groups	.998	1	.998	.785	.377
	Within Groups	203.422	160	1.271		
	Total	204.420	161			
Involvement in SSCM	Between Groups	.288	1	.288	.259	.612
	Within Groups	177.990	160	1.112		
	Total	178.278	161			
Company Performance	Between Groups	.014	1	.014	.012	.913
	Within Groups	185.986	160	1.162		
	Total	186.000	161			

Source: Author's compilation

Interpretation:

Table 21 shows that no statistically significant differences exist between the two provinces for awareness ($F(1,160) = 0.785, p = 0.377$), involvement in SSCM ($F(1,160) = 0.259, p = 0.612$), or perceived company performance ($F(1,160) = 0.012, p = 0.913$), as all p-values exceed the 0.05 significance level. Analytically, these results indicate that employee awareness, participation, and perceptions of SSCM performance are relatively consistent across the two major manufacturing regions. This suggests that SSCM implementation within the South African manufacturing sector may be influenced more by organizational practices and internal management initiatives than by geographic location. These findings provide additional contextual support for Hypothesis 1, indicating that SSCM practices and their perceived performance outcomes are observable across different regions of the manufacturing sector rather than being location specific.

RQ2. What challenges do manufacturing firms meet in implementing sustainable supply chain practices?

Table 22. Challenges in firms implementing SSCM practices

Table 22 identifies the main barriers affecting the implementation of sustainable supply chain management (SSCM) practices, employees were asked to indicate the challenges their firms experience when adopting sustainability initiatives.

	N	Sum
High costs	162	104
Lack of knowledge or expertise	162	58
Resistance to change	162	61
Lack of supplier collaboration	162	47
Regulatory challenges	162	20
Limited advanced technology options	162	100
Not sure	162	27
Valid N (listwise)	162	

Source: Author's Compilation

Interpretation:

Table 22 indicates that the most frequently reported barriers to SSCM implementation are high costs (64%) and limited access to advanced technology (62%), suggesting that financial and technological constraints represent the primary challenges faced by manufacturing firms. Other barriers include resistance to change (38%), lack of knowledge or expertise (36%), and limited supplier collaboration (29%), which highlight internal organizational and capability-related constraints affecting sustainability adoption. While regulatory challenges were reported by only 12% of respondents, indicating that policy requirements are perceived as less restrictive compared with operational and resource-related barriers. Additionally, 17% of respondents were unsure about the challenges faced by their firms, which may suggest limited employee

awareness or communication regarding sustainability initiatives. These findings indicate that SSCM adoption within South African manufacturing firms is influenced primarily by resource availability, technological capability, and organizational readiness rather than regulatory pressures. The results therefore provide empirical support for Hypothesis 2, which proposes that SSCM implementation is constrained by financial, technological, and organizational challenges.

RQ3. How do sustainable supply chain practices affect the performance and competitiveness of manufacturing firms? Questions from the Questionnaire: 7,8,12.

Adopting SSCM practices relates to perceived performance.

Compare Means Based on Promotion of SSCM

Checking whether those promoting SSCM report higher performance, from questionnaire questions:8,12.

Report

Table 23. Adopting SSCM practices relates to perceived performance

Table 23 examines whether the promotion of SSCM practices is associated with perceived sustainability performance, mean performance scores were compared across firms that actively promote SSCM practices and those that do not.

The company is performing in terms of sustainability goals within the supply chain			
The company actively promotes sustainable practices in the supply chain	Mean	N	Std. Deviation
Not Sure	.39	28	.832
No	1.24	33	.663
Yes	2.16	101	.880
Total	1.67	162	1.075

Source: Author's own compilation

Interpretation:

Table 23 shows that employees working in companies that actively promote SSCM practices reported the highest perceived performance score (Mean = 2.16), compared with those in firms that do not promote SSCM (Mean = 1.24) and respondents who were unsure (Mean = 0.39).

This pattern indicates a positive relationship between the promotion of SSCM practices and perceived sustainability performance. The results suggest that firms that actively integrate and promote sustainability initiatives within their supply chains are more likely to achieve stronger sustainability outcomes. These findings provide empirical support for Hypothesis 1, which proposes that effective implementation of SSCM practices contributes to improved organizational performance and competitiveness.

Correlation Between the Importance of SSCM and Performance**Table 24. Correlation Between the Importance of SSCM and Performance**

Table 24 examines whether the perceived importance of sustainable supply chain management (SSCM) is associated with company sustainability performance, a Pearson correlation analysis was conducted.

Correlations			
		Importance of SSCM to the future success of your company	Company Performance
Importance of SSCM to the future success of your company	Pearson Correlation	1	.512**
	Sig. (2: tailed)		.000
	N	162	162
Company Performance	Pearson Correlation	.512**	1
	Sig. (2: tailed)	.000	
	N	162	162

** . Correlation is significant at the 0.01 level (2: tailed).

Pearson Correlation (r) = 0.512 Significance (p: value) = 0.000

Source: SPSS, 2025

Interpretation:

Table 24 shows a moderate positive correlation between the perceived importance of SSCM for the future success of a company and perceived company sustainability performance ($r = 0.512$, $p < 0.01$). This statistically significant relationship indicates that employees who view sustainability as important for their company's future are more likely to report stronger sustainability performance within their organizations. Analytically, this finding suggests that organizational commitment to sustainability plays an important role in shaping performance outcomes within supply chains. Firms that place greater strategic importance on SSCM are therefore more likely to achieve improved sustainability performance. These findings provide empirical support for Hypothesis 1, which proposes that the implementation and prioritization of SSCM practices contribute positively to organizational performance and competitiveness.

RQ4. What are the key factors influencing the successful adoption and integration of sustainability within supply chains in the sector? Questions from the Questionnaire: 2,3,6,10,11.

Spearman Correlation: Involvement vs. Awareness and Experience. (Factors associated with involvement.)

Table 25a and b. Spearman Correlation

Table 25 and identifies the factors influencing employee involvement in sustainable supply chain management (SSCM), a Spearman correlation analysis was conducted to examine the relationships between employee awareness, years of experience, and involvement in SSCM activities.

Correlations					
			Awareness	Involvement in SSCM	Years of Experience
Spearman's rho	Awareness	Correlation Coefficient	1.000	.444**	:.065
		Sig. (2: tailed)	.	.000	.413
		N	162	162	162
	Involvement in SSCM	Correlation Coefficient	.444**	1.000	:.223**
		Sig. (2: tailed)	.000	.	.004
		N	162	162	162
	Years of Experience	Correlation Coefficient	:.065	:.223**	1.000
		Sig. (2: tailed)	.413	.004	.
		N	162	162	162
**. Correlation is significant at the 0.01 level (2: tailed).					

Variables	Correlation (Spearman's ρ)	Significance (p: value)	Interpretation
Awareness ↔ Involvement	0.444	0.000	Moderate, positive, and significant
Working Period ↔ Involvement	:0.223	0.004	Weak, negative, and significant
Awareness ↔ Working Period	:0.065	0.413	Not significant

Source: SPSS, 2025

Interpretation:

Table 25a and 25b show a moderate positive and statistically significant correlation between employee awareness of sustainability initiatives and involvement in SSCM activities ($\rho = 0.444$, $p < 0.01$). This suggests that employees who are more aware of sustainability initiatives within their organizations are more likely to participate in SSCM practices. A weak but significant positive relationship was also observed between years of experience and involvement ($\rho = 0.223$, $p < 0.01$), indicating that employees with longer work experience may show slightly higher engagement in sustainability activities. However, there is no significant relationship between awareness and years of experience ($\rho = 0.065$, $p = 0.413$), suggesting that employee

awareness of sustainability initiatives is not necessarily influenced by tenure. These findings indicate that awareness is a key factor influencing employee participation in SSCM activities, highlighting the importance of communication and organizational engagement strategies in promoting sustainability practices within manufacturing firms. The results therefore provide additional support for Hypothesis 1, which proposes that the effective implementation of SSCM practices contributes to improved organizational performance and sustainability outcomes.

Compare Means: Involvement based on Training

Table 26 test whether employees who received sustainability training are more involved in SSCM efforts.

Table 26. Compare Means: Involvement based on Training

Involvement in SSCM			
Provision of training or education	Mean	N	Std. Deviation
Not Sure	1.70	50	.763
No	1.60	35	.847
Yes	2.81	77	.974
Total	2.20	162	1.052

Source: SPSS,2025

Interpretation:

Table 26 shows that employees who reported receiving sustainability training demonstrated the highest level of involvement in SSCM activities (Mean = 2.81), compared with employees who did not receive training (Mean = 1.60) and those who were unsure whether training was provided (Mean = 1.70). This pattern indicates that sustainability training is associated with greater employee participation in SSCM practices. Analytically, the results suggest that training programs play an important role in developing employee awareness, skills, and engagement in sustainability initiatives within organizations. These findings highlight training as a key organizational factor influencing the successful adoption of SSCM practices, addressing RQ4 and providing additional support for Hypothesis 1, which proposes that effective SSCM implementation contributes to improved sustainability performance.

ANOVA: Involvement by Education Level

Table 27 determines whether education level influences employee involvement in sustainability. A one-way ANOVA was conducted.

ANOVA

Table 27. Involvement by Education Level

Involvement in SSCM					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19.843	4	4.961	4.916	.001
Within Groups	158.435	157	1.009		
Total	178.278	161			

Source: SPSS, 2025

Interpretation:

Table 27 shows a statistically significant difference in SSCM involvement across education levels ($F(4, 157) = 4.916, p = 0.001$), as the p-value is below the 0.05 significance threshold. This indicates that employee involvement in sustainability initiatives varies depending on their level of education. This finding suggests that employees with higher educational attainment are more likely to participate in SSCM activities, possibly because education enhances sustainability awareness, analytical skills, and understanding of environmental management practices. These results highlight education as an important factor influencing employee engagement in sustainability initiatives, addressing RQ4 and providing additional support for Hypothesis 1, which proposes that effective implementation of SSCM practices contributes to improved organizational performance.

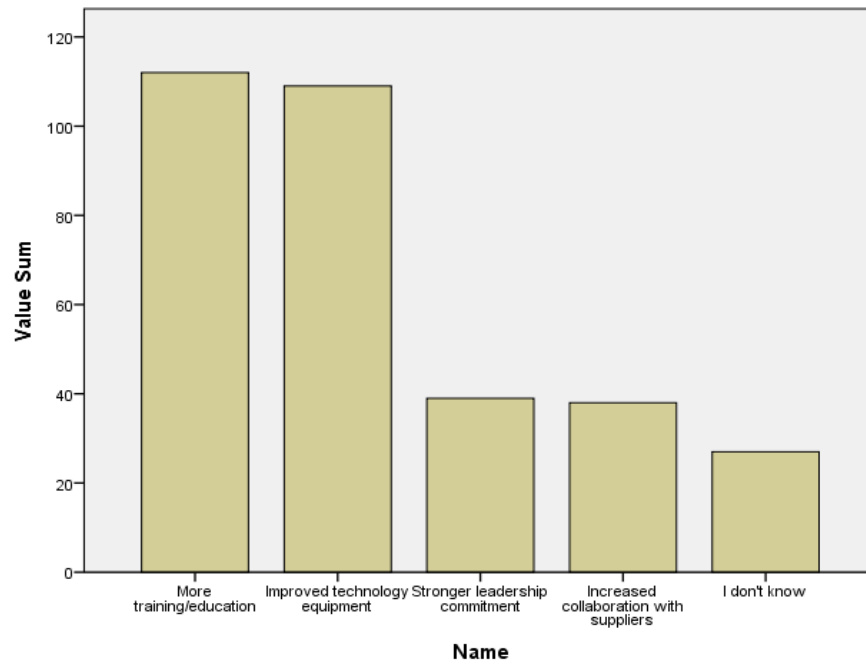


Figure 11. Recommended strategies to enhance the adoption of SSCM

Source: SPSS,2025

Among the 162 respondents, the two most frequently recommended strategies for enhancing SSCM adoption and effectiveness are:

1. More training and education: recommended by 112 respondents (69%)
2. Improved technology and equipment: recommended by 109 respondents (67%)

These findings indicate that building employee knowledge and upgrading technological infrastructure are seen as the most impactful strategies for supporting SSCM in the manufacturing sector.

However, other strategies were recommended less by respondents:

Stronger leadership commitment: 39 respondents (24%)

Increased collaboration with suppliers, 38 respondents (23%)

Additionally, 27 respondents (17%) reported "I don't know," suggesting either a lack of awareness of SSCM strategy options or limited involvement in decision-making processes.

Interpretation:

Table 28 shows that the most frequently recommended strategies for improving SSCM adoption are more training and education (69%) and improved technology and equipment (67%). These findings suggest that respondents perceive capacity building and technological capability as the most important factors for strengthening sustainability implementation within manufacturing supply chains. Other strategies received lower levels of support, including stronger leadership commitment (24%) and increased collaboration with suppliers (23%), indicating that while governance and collaboration are important, employees consider internal capabilities and technological readiness to be more immediate priorities. Additionally, 17% of respondents selected “I do not know,” which may indicate limited awareness or involvement in strategic sustainability decision-making within some organizations. These findings suggest that organizational capacity development particularly through training and technological investment is viewed as the most effective strategy for improving SSCM implementation. The results therefore address RQ5 by identifying the key strategic priorities perceived by employees for strengthening sustainability practices within the manufacturing sector.

4.2.1 Empirical Testing of Research Hypotheses (For Employees)**Employee Hypothesis Evaluation**

- *Methodological basis*

Although the employee sample was relatively large (N = 162), the hypotheses were evaluated using an empirical descriptive approach rather than predictive or causal statistical modelling. This decision was guided by the exploratory and perceptual nature of the employee survey, which focused on attitudes, experiences, and evaluations of SSCM practices rather than causal testing.

- *Analytical approach applied*

Employee responses were analysed using distributions, measures of central tendency, and observed associations across key SSCM constructs. Descriptive patterns were systematically examined to assess their alignment with the theoretical expectations of each hypothesis.

- *Decision logic (Accept / Reject)*

Hypotheses were accepted when employee response patterns demonstrated consistent alignment with the hypothesised relationships.

Hypotheses were rejected when empirical patterns showed weak, inconsistent, or no

alignment.

- *Interpretation of results*

Acceptance or rejection reflects descriptive empirical support, not statistical confirmation or causal inference.

The results indicate how employee perceptions and experiences relate to SSCM implementation within the organisational context.

- *Methodological justification*

This strategy ensured a link between the hypothesis evaluation method and the perceptual, ordinal nature of the employee data.

Table 28. Empirical Results of Hypothesis Testing for employee Data

	Description	Empirical result	Decision (Accept/Reject)
H1	Effective SSCM implementation improves efficiency, cost, and competitiveness	Companies promoting SSCM report higher performance; positive correlations found ($\rho = .512, p < .01$)	Accept
H2	Challenges include regulatory, resource, and supplier engagement constraints	High costs (64%), limited technology (62%), moderate resistance (38%)	Accept
H3	Circular economy integration enhances sustainability and resource optimization	Moderate awareness; integration emerging but limited by capacity	Reject
H4	Government support positively influences SSCM adoption	Weak evidence; no significant sector or location difference	Accept

Source: Author's own compilation)

4.3 Results for Industry Professionals

Table 29. Participants' occupation

Table 29 presents the professional background of the industry participants. Identifying respondents' occupations helps contextualise their perspectives on sustainable supply chain management (SSCM).

Response	Count	Percent
Academic/Researcher	7	46.7
Policy Advisor/Regulator	5	33.3
Consultant	2	13.3
Business Owner	1	6.7

Source: Author's own compilation.

Interpretation:

As shown in Table 29, most respondents were academics or researchers (46.7%), followed by policy advisors or regulators (33.3%). Smaller proportions consisted of consultants (13.3%) and business owners (6.7%). This distribution indicates that the perspectives captured in the study are primarily informed by individuals involved in research and policy development related to sustainability. The diversity of professional backgrounds strengthens the credibility of the findings, as it incorporates insights from theoretical, regulatory, and practical perspectives. In relation to RQ1, which investigates evidence of SSCM implementation in South African manufacturing, the presence of both policy and industry experts suggests that the responses reflect not only academic understanding but also regulatory priorities and practical industry experience. This diversity therefore enhances the ability of the study to capture a more comprehensive view of SSCM adoption within the sector.

Table 30. The level of involvement with sustainability within the manufacturing sector

Table 30 presents the level of involvement of industry professionals in sustainability activities within the manufacturing sector.

Response	Count	Percent
Very involved	8	53.3
Moderately involved	3	20.0
Extremely involved	3	20.0
Slightly involved	1	6.7

Source: Author's own compilation

Interpretation:

Table 30 presents the level of involvement of industry professionals in sustainability activities within the manufacturing sector. Most respondents indicated that they are very involved (53.3%), while 20% reported being extremely involved and another 20% moderately involved. Only 6.7% reported slight involvement. This high level of engagement strengthens the reliability of the responses, as most participants have direct experience with sustainability practices. In relation to RQ1, which examines evidence of SSCM implementation, the results suggest that sustainability initiatives are actively integrated into professional practice within the South African manufacturing sector. These findings also provide support for Hypothesis 1, which proposes that sustainable supply chain management practices are increasingly integrated into organisational operations and contribute to improved sustainability performance within manufacturing firms.

Table 31a and b. Examines the perceived importance of sustainability for future competitiveness in the manufacturing sector; respondents were asked to rate the role of sustainability within SSCM. The results are presented in Table 32a and b.

Response	Count	Percent
Very important	8	53.3
Extremely important	6	40.0
Moderately important	1	6.7

n	Mean	SD	Min	Max
15.0	4.33	0.62	3.0	5.0

Source: Author's own compilation

Interpretation:

Table 31 a and b shows that most respondents (93.3%) rated sustainability as “very important” or “extremely important,” with a high mean score of 4.33, indicating strong consensus among industry professionals. In relation to RQ1 and RQ3, this finding suggests that sustainability is increasingly viewed as a strategic driver of competitiveness rather than merely a regulatory or compliance requirement. Firms that adopt SSCM practices are perceived to be better positioned to improve operational efficiency, enhance their reputation, and access international markets. These results therefore provide support for Hypothesis 1, which proposes that the adoption of SSCM practices contributes to improved organisational performance and competitiveness within the manufacturing sector.

Table 32. Rate the current level of adoption of SSCM practices

Table 32 evaluates the current level of sustainable supply chain management (SSCM) implementation within the manufacturing sector; industry professionals were asked to rate the extent to which SSCM practices are currently adopted.

Response	Count	Percent
3	9	60.0
2	6	40.0

source: Author's own compilation

Interpretation:

Table 32 indicates that most respondents perceive the current level of SSCM adoption as moderate (60%), while 40% consider it low, and none rated it as high. This pattern suggests that although sustainability practices are recognised within the manufacturing sector, their implementation remains at a transitional stage rather than being fully embedded in organisational operations. Analytically, this gap between recognition and full adoption reflects a common pattern observed in emerging economies, where firms acknowledge the strategic importance of sustainability but face operational, financial, or technological constraints that slow implementation. In relation to RQ1, the findings therefore provide evidence that SSCM practices exist within the sector, but their integration is still evolving. These results also relate to Hypothesis 1, which proposes that SSCM adoption contributes to organisational competitiveness. The moderate level of adoption suggests that firms are beginning to integrate

sustainability into supply chain practices, although further development may be required for SSCM to generate its full competitive and performance benefits.

Table 33 and b. Presents primary drivers influencing the adoption of sustainable supply chain management (SSCM) practices in the manufacturing sector, respondents were asked to indicate the primary drivers motivating manufacturers to adopt SSCM.

Option	Count	Resp %
Environmental protection	14	93.3
Pressure from international markets	11	73.3
Corporate social responsibility (CSR)	7	46.7
Cost savings overtime	6	40.0
Regulatory requirements	5	33.3
Competitive advantage	4	26.7

Theme	Mentions
Cost and Funding	6
Market Demand and Trends	11

Source: Author's own compilation

Interpretation:

Table 33 a and b shows that environmental protection (93.3%) and pressure from international markets (73.3%) are the most significant drivers motivating manufacturers to adopt SSCM practices. In contrast, internal drivers such as competitive advantage (26.7%) and cost savings (40%) were mentioned less frequently. Analytically, this suggests that SSCM adoption within the manufacturing sector is largely externally driven rather than internally initiated. Firms appear to respond primarily to environmental concerns and global market expectations rather than adopting sustainability as a purely strategic initiative. In relation to RQ4, these findings indicate that external pressures particularly international market demands play a critical role in shaping the adoption of SSCM practices. This also provides support for Hypothesis 4, which proposes that institutional and external environmental factors influence the successful adoption and integration of sustainability practices within supply chains.

Table 34 and b. Identifies the key challenges preventing the wider implementation of sustainable supply chain management (SSCM) practices.

Option	Count	Resp %
High costs of implementation	15	100.0
Limited access to advanced technology	14	93.3
Unclear return on investment	9	60.0
Lack of expertise and knowledge	7	46.7
Lack of collaboration across supply chains	4	26.7

Theme	Mentions
Cost and Funding	15
Training and Skills	7
Technology and Infrastructure	14

Source: Author's own compilation

Interpretation:

Table 34 a and b indicates that the most significant barriers to SSCM adoption are high implementation costs (100%) and limited access to advanced technology (93.3%). Other barriers include unclear return on investment (60%), lack of expertise and knowledge (46.7%), and limited collaboration across supply chains (26.7%). Analytically, these findings suggest that although firms recognise the importance of sustainability, practical constraints limit their ability to implement SSCM practices. Financial limitations and technological capability gaps appear to be the most critical obstacles. In relation to RQ2, the results confirm that the adoption of SSCM is constrained by both internal challenges (such as limited expertise and technological capability) and external constraints (such as investment uncertainty and limited supply chain collaboration). These findings provide support for Hypothesis 2, which proposes that financial, technological, and organisational barriers significantly influence the implementation of SSCM practices within the manufacturing sector.

The following 3 tables 35,36 and 37 are merged to formulate a conceptual explanation of their results

Table 35. How effective the government support is

Response	Count	Percent
Slightly effective	9	60.0
Moderately effective	4	26.7
Very effective	1	6.7
Not effective at all	1	6.7

Table 36. regulatory framework supporting SSCM Practices

Response	Count	Percent
3	9	60.0
4	3	20.0
2	2	13.3
5	1	6.7

Table 37. Roles international sustainability standards play in influencing SSCM

Response	Count	Percent
Significant role	7	46.7
Critical role	6	40.0
Moderate role	2	13.3

Source: Author's own compilation

Interpretation:

The findings from Tables 35–37 indicate that institutional factors influence the adoption of sustainable supply chain management (SSCM), although their impact varies. Table 36 shows that most respondents perceive government support as only slightly effective (60%), suggesting that while policies may exist, their practical impact on encouraging SSCM adoption is limited. Similarly, Table 37 indicates that the regulatory framework is viewed as moderate, implying that regulations provide some guidance but may not strongly drive sustainability implementation. In contrast, Table 38 shows that international sustainability standards play a stronger role, with most respondents identifying them as having a significant or critical influence. This suggests that external market pressures and global supply chain requirements are stronger drivers of SSCM adoption than domestic policy incentives. Conceptually, these findings support

institutional theory, which explains that organisations often adopt sustainability practices in response to external pressures from international markets and industry standards. In relation to RQ4 and Hypothesis 4, the results indicate that institutional environments influence SSCM adoption, although international standards appear to be more influential than government support.

Table 38. Identifies the sustainability trends expected to shape supply chain practices in the manufacturing sector, respondents were asked to indicate the key sustainability areas likely to influence future supply chain strategies

Option	Count	Response_%
Circular economic practices	13	86.7
Water conservation efforts	13	86.7
Waste reduction and recycling	10	66.7
Ethical Sourcing and fair labour practices	9	60.0
Use of renewable energy sources	8	53.3

Source: Author's own compilation

Interpretation:

Table 38 indicates that circular economy practices (86.7%) and water conservation (86.7%) are perceived as the most important sustainability trends likely to shape supply chains in the coming decade. Other important areas include waste reduction and recycling (66.7%), ethical sourcing and fair labour practices (60.0%), and the use of renewable energy sources (53.3%). These findings suggest that future SSCM strategies will increasingly focus on resource efficiency, responsible sourcing, and environmental impact reduction. The prominence of circular economy practices and water conservation reflects growing concerns about resource scarcity and environmental sustainability within manufacturing supply chains. In relation to RQ5, the results indicate that strengthening SSCM adoption will require firms to prioritise circular production models, efficient resource management, ethical sourcing practices, and cleaner energy transitions. These findings also support Hypothesis 4, which proposes that institutional and

environmental factors influence the adoption and integration of sustainability practices within supply chains. By highlighting emerging sustainability priorities, the results provide direction for policy development, industry collaboration, and firm-level strategies aimed at improving long-term competitiveness and resilience within the South African manufacturing sector.

Table 39. Assesses the potential role of technological innovation in supporting sustainable supply chain management (SSCM), respondents were asked to evaluate how likely South African manufacturers are to adopt innovative technologies that enhance sustainability practices.

Response	Count	Percent
Moderately likely	6	40.0
Very likely	6	40.0
Slightly likely	3	20.0

Source: Author's own compilation

Relevant Research Question: Q11 links to RQ4 by assessing how likely manufacturers are to adopt innovative technology to enhance sustainability, to influence the successful adoption and integration.

Interpretation:

Table 39 shows that 80% of respondents believe manufacturers are either moderately or very likely to adopt innovative technologies, while 20% consider adoption slightly likely. Notably, none of the respondents selected “unlikely,” indicating a generally positive perception regarding the readiness of manufacturers to adopt technology-driven sustainability solutions. Analytically, this suggests that the manufacturing sector demonstrates growing openness to digital and data-driven technologies that can support sustainability initiatives, such as energy monitoring systems, resource optimisation tools, and supply chain traceability technologies. However, industry professionals also recognise that successful implementation will depend on overcoming practical challenges such as capital investment requirements, technological integration capabilities, and supplier participation. In relation to RQ4, the findings indicate that technological innovation is perceived as an important enabling factor for the successful adoption and integration of SSCM practices. These results also support Hypothesis 4, which proposes that external and organisational factors such as technological capability and institutional support play a critical role in influencing sustainability adoption within supply chains.

Table 40 a and b. Evaluates the perceived progress of sustainable supply chain management (SSCM) implementation within the manufacturing sector, industry professionals were asked to assess the current level of progress toward SSCM adoption.

n	Mean	SD	Min	Max
15.0	3.4	0.51	3.0	4.0
Response		Count	Percent	
Neutral		9	60.0	
Agree		6	40.0	

Source: Author's own compilation

Interpretation:

Table 40 a and b indicates that respondents generally perceive moderate progress toward SSCM implementation, reflected by a mean score of 3.4 (SD = 0.51) on a 1–5 agreement scale. Most responses cluster around neutral (60%) and agree (40%), suggesting that while progress is acknowledged, it is not yet viewed as fully developed. Analytically, this pattern indicates that SSCM adoption in the South African manufacturing sector is progressing gradually rather than rapidly. Industry professionals recognise emerging policies, initiatives, and pilot projects, but deeper integration across supply chains and supplier networks remains limited. The relatively low standard deviation (0.51) also indicates a shared perception among respondents that progress is occurring but remains incomplete. In relation to RQ1, these findings provide evidence that SSCM practices are being implemented within the sector, although at a developing stage. The results also support Hypothesis 4, which suggests that the adoption and integration of sustainability within supply chains are influenced by organisational and institutional factors that may slow the pace of full implementation.

Table 41a and b. Examines whether financial constraints hinder the adoption of sustainable supply chain management (SSCM), industry professionals were asked to assess whether the cost of implementing sustainable practices acts as a significant barrier.

Response	Count	Percent
Strongly agree	8	53.3
Agree	6	40.0
Neutral	1	6.7

N	Mean	SD	Min	Max
15.0	4.47	0.64	3.0	5.0

Source: Author's own compilation

Interpretation:

Table 41 a and b show strong agreement that cost is a major barrier to implementing SSCM practices, with 93.3% of respondents agreeing or strongly agreeing. The high mean score of 4.47 (SD = 0.64) indicates strong consensus among industry professionals that financial constraints significantly limit sustainability adoption. Analytically, this suggests that although sustainability is recognised as strategically important, high initial investment costs, technology upgrades, and operational adjustments may prevent firms from fully implementing SSCM practices. In relation to RQ2, these findings confirm that financial constraints remain one of the key challenges affecting SSCM adoption in the South African manufacturing sector. The results also support Hypothesis 2, which proposes that financial and resource-related barriers significantly prevent the implementation of sustainable supply chain practices.

Table 42a and b. Examines whether sustainability contributes to competitiveness in the manufacturing sector, industry professionals were asked whether the integration of sustainable practices enhances the global competitiveness of South African manufacturers.

Response	Count	Percent
Agree	7	46.7
Strongly agree	6	40.0
Neutral	2	13.3

N	Mean	SD	Min	Max
15.0	4.27	0.7	3.0	5.0

Source: Author's own compilation

Interpretation:

Table 42 a and b show strong agreement among respondents that sustainability enhances competitiveness, with 86.7% agreeing or strongly agreeing. The high mean score of 4.27 (SD = 0.70) indicates broad consensus that integrating sustainable practices can improve the global competitiveness of South African manufacturers. Analytically, this suggests that sustainability is increasingly viewed not only as a compliance requirement but also as a strategic tool for improving market positioning, reputation, and access to international markets. In relation to RQ3, the findings indicate that SSCM is widely perceived as contributing to competitive advantage within the manufacturing sector. The results therefore support Hypothesis 1, which proposes that the adoption of sustainable supply chain practices enhances organisational efficiency and competitiveness.

4.3.1 Empirical Testing of Research Hypotheses (For Industry Professionals)

Industry Professional Hypothesis Evaluation

- *Methodological basis*

The industry professional dataset (N = 15) was purposively sampled and consisted primarily of ordinal and frequency-based survey responses. Given the small sample size and data characteristics, parametric inferential statistical techniques were not appropriate and unlikely to yield reliable results.

- *Analytical approach applied*

Hypotheses were evaluated using a descriptive–empirical approach, drawing on mean ratings and frequency distributions. Descriptive patterns were systematically examined to assess the degree to which professional responses aligned with the theoretical expectations of each hypothesis.

- *Decision logic (Accept / Reject)*

Hypotheses were accepted when descriptive empirical patterns demonstrated clear alignment with the proposed theoretical relationships. Hypotheses were rejected when the observed patterns showed weak or insufficient empirical alignment.

- *Interpretation of results*

Acceptance or rejection reflects descriptive empirical support rather than statistical confirmation or causal inference. The results indicate how industry professionals' perceptions and experiences reflect the theoretical propositions under investigation.

- *Methodological justification*

This approach ensured coherence between the method of hypothesis evaluation, the size, structure, and measurement level of the industry professional data.

Table 43. Empirical Results of Hypothesis Testing for industry professionals

Hypothesis	Description	Empirical result	Decision (Accept/reject)
H1	Effective SSCM implementation improves efficiency, cost, and competitiveness.	Professionals rated sustainability as essential for competitiveness (mean = 4.33); evidence of growing strategic adoption.	Accept
H2	SSCM implementation faces regulatory, resource, and engagement constraints.	Cost barriers (100%), limited technology (93.3%), and unclear ROI (60%) identified as key obstacles	Accept
H3	Circular economy integration enhances sustainability and resource optimization	Circular economy and water conservation rated highest (86.7%), though full integration remains limited.	Reject
H4	Government support positively influences SSCM adoption.	Government support rated as “slightly effective	Accept

Source: Author’s Own Compilation

4.4 Results for Managers

Introduction

This section addresses the research questions by aligning them directly with the questionnaire items sent to managers and thematic findings based on their responses. The objective is to provide consistency between research design, data collection, and analysis, where each research question is answered with evidence. Reflexive thematic analysis (RTA), Developed by (Braun and Clarke, 2006; Braun and Clarke, 2019) is an important qualitative approach because it provides a systematic but flexible method for assigning and interpreting patterns of meaning in data. The analysis guided the interpretation of the qualitative data such that themes developed inductively. Quotations of direct managers are provided to emphasize key points, with literature relevant to the discussion being used to support the discussion.

Research Question One

RQ1: What evidence exists of sustainable supply chain management (SSCM) practices adopted in the South African manufacturing industry?

Relevant question from questionnaire:

Q9 (integration of sustainability in operations)

Q10 (supplier collaboration)

Q13 (measuring and monitoring SSCM)

Q14 (waste management)

Q15 (adapting to global sustainability trends)

Findings and linkages

Managers reported growing but uneven adoption of SSCM practices across manufacturing operations. Operational efficiency initiatives, such as energy efficiency improvements, route optimisation, and waste minimisation, were frequently mentioned as entry points for sustainability adoption. One manager explained:

“We reduced our environmental impact through trying to use energy-efficient manufacturing and prioritising efficient transportation.”

Another respondent emphasised that sustainability is gradually becoming embedded within operational processes:

“Sustainability has now been integrated into our daily processes, and we are gradually scaling up.” Supplier collaboration also emerged as an indicator of SSCM adoption. Managers noted that firms increasingly work with suppliers to improve sourcing practices and reduce environmental impacts across the supply chain. In addition, monitoring and evaluation mechanisms, including the introduction of Key Performance Indicators (KPIs), were highlighted as tools used to track sustainability performance. Waste management initiatives were another commonly reported practice. Several firms described programmes aimed at reducing waste or achieving “zero-to-landfill” targets. Managers also noted efforts to adapt to global sustainability trends, such as the adoption of renewable energy and carbon management strategies, although these initiatives were often constrained by financial and infrastructural limitations

Interpretation

Overall, the responses suggest that SSCM practices are present within South African manufacturing industry but remain uneven in scope and maturity. The strongest evidence of adoption relates to efficiency-driven initiatives and waste management practices, which are typically the first stages of sustainability implementation before firms transition to broader circular economy strategies. This pattern supports the argument by Geissdoerfer et al. (2017) that organisations often begin sustainability integration through operational efficiency improvements before adopting more systemic circular economy approaches. The emergence of supplier collaboration and performance monitoring mechanisms also indicates gradual progress toward more integrated SSCM practices. These developments reflect increasing organisational awareness of sustainability performance and the need to coordinate sustainability initiatives across supply chain partners. These findings align with international research suggesting that firms commonly pursue “efficiency-first” sustainability strategies, achieving short-term operational improvements before moving toward more comprehensive sustainability integration (Govindan et al., 2018). Consequently, SSCM adoption in South African manufacturing appears to be progressing, although full supply chain integration remains constrained by financial, technological, and organisational capacity limitations.

Research Question Two

RQ2: What challenges do manufacturing firms meet in implementing sustainable supply chain practices?

Relevant questions from questionnaire:

Q8 (challenges in implementation)

Q10 (supplier collaboration challenges)

Q11 (regulatory influence)

Q16 (barriers to adoption)

Findings and linkages

Managers identified several interrelated barriers to implementing sustainable supply chain management (SSCM). The most frequently mentioned challenge was financial constraints, particularly the high initial investment required for sustainability initiatives. One manager explained:

“The initial cost is high and difficult to justify at times.”

Technological and infrastructure limitations were also frequently highlighted. Some managers indicated that suitable sustainability technologies are not always readily available locally:

“A suitable technology is difficult to obtain or not locally available.”

Another recurring challenge related to supplier readiness. Managers reported that sustainability adoption across the supply chain is often slowed because some suppliers lack the resources or willingness to adopt sustainable practices.

“Our suppliers are not completely on board, resulting in chain-wide change difficult.”

Managers also highlighted regulatory challenges, noting that while certain policies such as Extended Producer Responsibility (EPR) encourage sustainable practices, frequent changes in reporting requirements can create administrative burdens and uncertainty:

“Frequent policy and reporting requirement changes make it difficult to keep up.”

Interpretation:

The findings suggest that SSCM adoption in South African manufacturing is constrained by a combination of financial, technological, supply chain, and institutional challenges. High upfront costs remain a significant barrier, particularly for investments in renewable energy, waste management systems, and sustainable production technologies. This observation aligns with Khan et al. (2024), who identify financial constraints as one of the primary obstacles to sustainability adoption in emerging economies. Technological limitations further reinforce these challenges. The limited availability of appropriate sustainable technologies within the local market means that firms often rely on imported solutions, which may be costly or poorly suited to local operational conditions. In addition, the lack of supplier readiness reflects broader structural challenges within supply chains, where smaller firms often lack the financial and technical capacity to adopt sustainability practices. Similar supply chain coordination challenges are highlighted by (Chauhan et al., 2022). Regulatory frameworks also play a dual role in SSCM adoption. While policies such as EPR create incentives for sustainability practices, regulatory complexity and frequent policy adjustments can impose administrative burdens on firms, particularly smaller organisations. Overall, these findings indicate that successful SSCM adoption requires supportive financial mechanisms, improved technological infrastructure, stronger supplier collaboration, and more stable policy frameworks to reduce uncertainty and facilitate long-term sustainability investments.

Research Question Three

RQ3: How do sustainable supply chain practices affect the performance and competitiveness of manufacturing firms?

Relevant questions from questionnaire

Q12 (role of customer demand)

Q13 (monitoring and KPIs)

Q15 (adapting to global trends)

Findings and linkages:

Managers consistently identified customer demand as a key factor linking sustainable supply chain management (SSCM) practices to competitiveness. One respondent noted:

“Much greater demand for sustainable products and traceable supply chains.”

However, respondents also highlighted the price sensitivity of the South African market, which limits the extent to which sustainability features can be expanded:

“Our customers want sustainable products but at the lowest possible price.”

Managers further indicated that firms increasingly use monitoring tools and key performance indicators (KPIs) to track sustainability performance, including metrics related to waste reduction, emissions management, and operational efficiency. These monitoring systems were reported to generate both operational improvements, such as cost savings, and reputational benefits in markets where sustainability acts as a differentiating factor.

Interpretation:

The findings suggest that SSCM contributes to competitiveness in two main ways. First, sustainability initiatives improve operational efficiency through practices such as waste reduction, energy conservation, and resource optimisation. Second, SSCM enhances firms' ability to respond to growing market and institutional expectations for environmentally responsible production. This dual benefit supports global research demonstrating that SSCM can generate “win–win” outcomes, where environmental improvements are accompanied by competitive advantages (Govindan et al., 2018). However, the South African context introduces an important constraint. Although demand for sustainable products is increasing, strong price sensitivity in local markets limits the extent to which sustainability can be translated into premium pricing or direct competitive advantage. Consequently, firms must balance sustainability innovation with cost efficiency to remain competitive. This suggests that SSCM adoption in South African manufacturing is most effective when sustainability initiatives simultaneously deliver environmental benefits and operational cost reductions.

Research Question Four

RQ4: What are the key factors influencing the successful adoption and integration of sustainability within supply chains in the sector?

Relevant questions from questionnaire:

Q11 (role of regulation)

Q12 (customer demand)

Q16 (barriers)

Findings and linkages

Managers identified several factors influencing the adoption and integration of sustainable supply chain management (SSCM). Regulation emerged as an important driver, with some firms adjusting their processes to comply with new environmental requirements. One manager explained:

“We had to register under the new waste management regulations and change our processes as a result.”

However, respondents also highlighted challenges related to policy instability and administrative complexity, noting that:

“The constant change in policy and reporting requirements makes it difficult to keep up the pace.”

Customer demand was also frequently identified as a driver of sustainability adoption, although managers noted that the ability to respond to this demand is often constrained by affordability considerations within the local market. In addition, internal organisational factors, including financial resources, supplier readiness, and management commitment, were identified as important enablers of sustainability integration.

Interpretation:

The findings indicate that successful SSCM adoption depends on a combination of external and internal factors. Regulatory frameworks such as waste management regulations and extended producer responsibility requirements create pressure for firms to adopt sustainability practices. However, unstable policies and complex reporting requirements may limit firms' ability to integrate sustainability strategies over the long term. Customer demand also plays a significant role in encouraging sustainability adoption, reflecting broader global trends in supply chain accountability. This observation supports Chauhan et al. (2022), who highlight institutional and market pressures as key drivers of sustainability adoption. At the same time, internal organisational readiness remains critical. Firms with adequate financial resources, supportive management structures, and capable supply networks are better positioned to integrate sustainability practices effectively. Consequently, successful SSCM implementation requires both supportive external frameworks and strong internal capabilities, allowing firms to respond to regulatory pressures while building the operational capacity needed for long-term sustainability integration.

Research Question Five

RQ5: What strategies can be recommended to enhance the adoption and effectiveness of SSCM in the manufacturing sector?

Relevant questions from questionnaire

Q17 (recommended strategies, supported by Q8–Q16 findings)

Q8(Challenges in implementation)

Q9(integration of sustainability in operations)

Q10(supplier collaboration)

Q11 (regulatory influence)

Q12(role of customer demand)

Q13(measuring and monitoring SSCM)

Q14(waste management)

Q15(adapting to global sustainability trends)

Q16 (barriers to adoption)

Findings and linkages:

Managers proposed several strategies aimed at overcoming the barriers previously identified and strengthening the adoption of sustainable supply chain management (SSCM):

First, respondents emphasised the need to accelerate renewable energy adoption and energy efficiency in manufacturing processes. One manager noted:

“The industry needs to transition to renewable energy in manufacturing to reduce carbon emissions and lower costs. But high costs and limited energy options in South Africa make it difficult.”

Second, managers highlighted the importance of strengthening supplier partnerships to ensure sustainability is implemented across the supply chain. However, they acknowledged that smaller suppliers often lack the capabilities required to meet sustainability standards:

“I believe in collaborating with suppliers to establish common sustainability objectives. The problem is that small suppliers might lack the capacity to fulfil large companies' sustainability demands.”

Third, respondents suggested developing circular economy strategies, particularly focusing on waste reduction and improved recycling systems:

“Waste reduction, particularly packaging, must be a top priority. The sector needs to invest in technology that monitors waste from manufacturing to disposal or recycling.”

Additional strategies included prioritising local sourcing to reduce transport emissions and support domestic supply chains, as well as strengthening collaboration between industry and research institutions to develop more sustainable materials and production processes.

Interpretation:

The proposed strategies indicate that improving SSCM adoption requires a combination of technological, organisational, and collaborative approaches. Investments in renewable energy and efficiency technologies address the financial and infrastructural barriers identified in RQ2, while stronger supplier partnerships help overcome supply chain coordination challenges. The emphasis on circular economy initiatives reflects the growing recognition that sustainability in manufacturing must extend beyond operational efficiency to include resource circularity and waste reduction, consistent with circular economy literature (Geissdoerfer et al., 2017). Similarly, prioritising local sourcing and strengthening research collaboration highlight the importance of knowledge exchange and innovation in developing sustainable production systems. Overall, the findings suggest that successful SSCM implementation requires coordinated action across firms, suppliers, research institutions, and policy frameworks. By combining technological investment, supplier development, and collaborative innovation, manufacturing firms can improve both the effectiveness and long-term integration of sustainability within their supply chains.

4.4.1 Empirical Testing of Research Hypotheses (For managers)

Manager Hypothesis Evaluation

- *Methodological basis*

The manager sample was small and purposively selected (N = 11), with data consisting of qualitative and descriptive responses on SSCM implementation, challenges, and strategic practices. Inferential statistical techniques were therefore methodologically inappropriate.

- *Analytical approach applied*

Hypotheses were assessed using a descriptive–empirical and interpretive approach, analysing recurring themes, reported initiatives, and logical consistency with SSCM theory.

- *Decision logic (Accept / Reject)*

Hypotheses were accepted when managerial responses showed clear alignment with the proposed theoretical relationships. Hypotheses were rejected where such alignment was insufficient or inconsistent.

- *Interpretation of results*

Acceptance or rejection indicates empirical and interpretive support, not statistical confirmation

or causal inference.

- *Methodological justification*

This approach ensured consistency with the exploratory, qualitative nature of the managerial data and the study’s mixed-methods design.

Table 44. Empirical Results of Hypothesis Testing for managers

Hypothesis	Description	Empirical result	Decision Accept/reject
H1	Effective SSCM implementation improves efficiency, cost, and competitiveness.	Managers reported efficiency-focused initiatives such as route optimisation, energy efficiency, waste minimisation, and KPI monitoring that produced operational improvements and competitive benefits.	Accept
H2	SSCM adoption faces regulatory, resource, and engagement constraints.	Strong evidence of financial barriers, limited technology availability, supplier misalignment, and regulatory uncertainty. Managers consistently cited high upfront costs, infrastructural gaps	Accept
H3	Circular-economy integration enhances sustainability and resource optimisation.	Waste reduction, “zero-to-landfill” goals, and growing interest in renewable energy were reported. However, circular-economy practices remained uneven and constrained by cost and capability limitations.	Reject
H4	Government support positively influences SSCM adoption.	regulation was viewed as both a driver (e.g., EPR) and a constraint due to policy instability and Government influence was present but inconsistent.	Accept

Source: Author’s Own Compilation

4.5 Discussion

4.5.1 Discussion of findings- for suppliers

*Evidence of SSCM Practices within the South African Manufacturing Sector (RQ1)
Sector and Firm characteristics.*

The results indicate that SSCM adoption among suppliers is influenced by sectoral and organizational characteristics. Table 2 shows that 60% of supplier respondents operate in the automotive sector, while 20% operate in food and beverages and 20% in textiles. This sectoral dominance suggests stronger exposure to global sustainability standards such as ISO 14001 environmental management systems, environmental audits, and supplier codes of conduct.

This finding aligns with Sarkis et al. (2021), who argue that internationally integrated automotive supply chains often drive sustainability practices across supplier networks. The results therefore suggest that suppliers embedded in globally connected industries experience stronger sustainability pressures compared with firms operating primarily in domestic markets. Firm size further explains the presence of SSCM practices. Table 3 shows that 80% of suppliers employ more than 100 employees, indicating that most firms in the sample are medium-to-large enterprises. According to Kamble et al. (2020), larger firms possess greater financial resources, technological capabilities, and managerial systems necessary for implementing sustainability initiatives. In contrast, smaller firms often face resource limitations that restrict investment in clean technologies or formal sustainability reporting.

Firm maturity also appears to influence SSCM adoption. Table 4 shows that 80% of firms have operated for more than ten years. Organizational longevity reflects accumulated knowledge and operational stability, which can support sustainability adoption. This observation is consistent with Ahi and Searcy (2015), who argue that organizational experience strengthens firms' ability to absorb and implement sustainability knowledge over time.

Geographical and Market Distribution

Regional location also plays a role in shaping SSCM adoption. Table 5 shows that 60% of suppliers are in KwaZulu-Natal, while 40% are based in Gauteng. Both provinces represent major industrial centres, but they differ in terms of infrastructure and institutional conditions. Gauteng has a highly developed industrial base and stronger regulatory enforcement, while KwaZulu-Natal benefits from logistical advantages linked to the Durban port (Scholvin, 2020). These differences suggest that the institutional and infrastructural environment influences the

pace of sustainability adoption. Similar conclusions are drawn by Bartos et al. (2024), who argue that regional regulatory environments significantly shape the implementation of sustainable supply chain practices. Customer structure also influences SSCM adoption. Table 6 indicates that 80% of suppliers serve more than six manufacturing customers, while 20% serve more than fifty customers. Exposure to multiple customers increases the likelihood that suppliers encounter diverse sustainability requirements, encouraging the diffusion of SSCM practices across supply chain networks. Overall, the results confirm that SSCM practices are emerging within the South African manufacturing supplier base. However, adoption remains uneven and is influenced by sectoral exposure, firm size, organizational maturity, and regional institutional conditions.

Challenges in implementing Sustainable Supply Chain Practices (RQ2)

The findings identify several barriers that constrain SSCM implementation among suppliers. As shown in Table 9, high implementation costs (70%) represent the most significant barrier to sustainability adoption. This result supports findings by Gonçalves et al. (2024), who identify financial constraints as a major obstacle to sustainability implementation in emerging economies. Many SSCM initiatives such as cleaner technologies, renewable energy adoption, and sustainable sourcing require substantial capital investment that small and medium enterprises may struggle to afford. Limited access to sustainable materials or technologies (60%) represents the second most significant challenge. This reflects structural limitations within South Africa's industrial ecosystem, where green technologies and sustainable inputs are not always readily available. Similar constraints are highlighted by Silva et al. (2024), who argue that weak green infrastructure can slow sustainability transitions in developing industrial contexts. Communication gaps between manufacturers and suppliers also appear to hinder adoption. Approximately 40% of respondents identified a lack of clear communication from customers regarding sustainability expectations. According to Beske-Janssen et al. (2023), effective buyer–supplier communication is essential for coordinating sustainability objectives across supply chains. Other barriers include regulatory constraints (30%), inconsistent demand for sustainable products (30%), and limited training or expertise (10%). Together, these findings indicate that SSCM adoption is constrained by a combination of internal resource limitations and external institutional factors.

Effects of SSCM Practices on Performance and Competitiveness (RQ3)

The results suggest that sustainability adoption may influence supplier competitiveness, although the relationship is mediated by organizational capabilities. Table 8 indicates that most

suppliers consider sustainability only “to some extent,” suggesting partial integration of SSCM practices rather than full strategic adoption. However, Table 12 demonstrates that suppliers perceive increasing sustainability demands from customers (mean = 3.8). This rising demand creates competitive pressure for suppliers to adopt sustainable practices to maintain business relationships. Similar conclusions are reported by Jahanbakhsh Javid et al. (2023), who argue that firms responding proactively to sustainability expectations can strengthen their reputation, customer loyalty, and market competitiveness. Despite these pressures, Table 13 indicates that many suppliers lack the internal resources or expertise required to fully implement sustainability practices. This capability gap limits the extent to which firms can translate sustainability initiatives into measurable performance improvements. The findings therefore suggest that while SSCM practices have the potential to enhance competitiveness, the realization of these benefits depends on the availability of internal organizational capabilities.

Drivers of Successful Adoption and Implementation of SSCM (RQ4)

External drivers

External stakeholder pressures play an important role in shaping SSCM adoption. Table 10 shows that customer sustainability requirements are inconsistent, with 50% of suppliers reporting that customers rarely request sustainability compliance. However, Table 12 indicates that 70% of respondents believe that customer demand for sustainability is increasing. This suggests that the South African manufacturing sector is currently undergoing a transition period in which sustainability expectations are emerging but not yet fully institutionalized across supply chains. Government support appears relatively weak. Table 14 indicates that 40% of suppliers disagree that regulatory incentives exist to support sustainability adoption. This finding aligns with Kapesa and Doraiswamy (2025), who note that South Africa’s sustainability policy environment remains fragmented and inconsistently implemented.

Internal Drivers

Internal organizational factors also influence SSCM adoption. Table 11 shows that 40% of firms have established sustainability policies, while another 40% are in the process of developing them. Internal policy frameworks therefore appear to be an important mechanism for integrating sustainability objectives into organizational strategies. However, internal capabilities remain a significant constraint. Table 13 indicates that many suppliers lack sufficient resources or

expertise to fully implement sustainability practices. This suggests that successful SSCM adoption requires the alignment of both external pressures and internal organizational capabilities.

Strategies to Improve SSCM Adoption and Performance (RQ5)

The results highlight several strategies that could support the wider adoption of SSCM practices. Table 15 indicates that training in sustainability best practices represents the most frequently identified support mechanism (90%). This finding emphasizes the importance of developing human and organizational capabilities for sustainability implementation. Government incentives (60%) and access to affordable sustainable technologies (50%) were also identified as important forms of support. Previous research suggests that financial incentives and technological support mechanisms can significantly accelerate sustainability adoption among small and medium enterprises (Allen et al., 2021). Industry collaboration (30%) and stronger regulatory frameworks (10%) were less frequently identified but remain important for creating systemic changes within supply chain networks. Collaborative governance approaches involving industry, government, and academic institutions may therefore play an important role in strengthening sustainability adoption across the manufacturing sector.

Comparison with the Literature

Efficiency, Cost, and Competitiveness (H1 – Accepted)

The findings of this study provide moderate empirical support for Hypothesis 1, which proposes that the adoption of sustainable supply chain management (SSCM) practices improves efficiency, cost management, and competitiveness. Evidence of this relationship is reflected in the emergence of internal sustainability policies and customer-driven compliance among supplier firms. These findings are consistent with earlier SSCM research. For example, Seuring and Müller (2008) argue that suppliers who align their environmental practices with customer sustainability requirements often experience improvements in operational efficiency and supply chain performance. Similarly, Porter and van der Linde (1995), suggest that environmental improvements can enhance productivity by encouraging firms to innovate and reduce resource waste. The results of this study support these arguments. Suppliers that reported stronger customer demand for sustainability practices (Table 12) also demonstrated greater evidence of sustainability policy development and responsiveness to environmental requirements. This suggests that customer-driven sustainability expectations can act as a catalyst for operational

improvements and competitive positioning within supply chains. However, the findings also reveal an important distinction from studies conducted in developed economies. While SSCM adoption is evident, most suppliers in this study reported implementing sustainability practices only “to some extent” (Table 8), indicating partial rather than full integration. This contrasts with studies such as Ahi and Searcy (2013), which report more advanced levels of sustainability integration among firms operating in developed economies. Therefore, this study contributes to the existing literature by demonstrating that even moderate levels of SSCM adoption can generate competitive and operational benefits in emerging market contexts. Unlike many studies that assume high levels of sustainability integration, the findings suggest that in developing economies such as South Africa, SSCM practices may evolve gradually, with performance improvements occurring even at intermediate stages of adoption.

Barriers to SSCM (H2 – Accepted)

The findings provide strong empirical support for Hypothesis 2, which proposes that sustainable supply chain management (SSCM) adoption is constrained by regulatory, resource, and supplier engagement challenges. The results show that the most significant barriers reported by suppliers are high implementation costs (70%), limited access to sustainable technologies or materials (60%), and communication gaps with customers (40%). These findings are consistent with previous SSCM literature. For example, Yu et al. (2022) identify cost and technological constraints as dominant barriers to sustainability adoption among suppliers, particularly in emerging economies where access to green technologies and financial resources is limited. Similarly, Vachon and Klassen (2007) emphasize the importance of effective buyer–supplier communication in aligning sustainability objectives across supply chains. When communication between supply chain partners is weak, sustainability initiatives are often implemented inconsistently or remain poorly coordinated. The findings also align with Seuring and Müller (2008), who identify financial constraints and relational challenges between supply chain partners as central challenges to SSCM implementation. The results of this study confirm that these structural barriers continue to influence sustainability adoption within supplier networks in the South African manufacturing sector. However, the findings diverge from the assumptions presented in Govindan et al. (2020), who suggest that government incentives and regulatory support mechanisms can help mitigate many of these barriers. In contrast, the present study indicates that suppliers perceive institutional support as relatively weak. As shown in Table 14, many respondents reported limited awareness or availability of regulatory incentives designed

to support sustainability adoption. This discrepancy suggests that while global SSCM models often assume the presence of strong institutional support mechanisms, such enabling conditions may not yet be fully developed or effectively implemented within the South African manufacturing context. The findings confirm the importance of financial and technological challenges identified in the literature while highlighting the continued weakness of institutional support structures in emerging economy supply chains.

Circular Economy Integration (H3 – Rejected)

The findings indicate that the integration of circular economy (CE) practices among supplier firms remains limited. Although some level of sustainability awareness is present (mean awareness score = 2.5), the results suggest that circular economy principles are not yet widely embedded within supplier operations. This limited adoption explains why Hypothesis 3, which proposed that circular economy integration enhances sustainability and resource optimization, is not supported by the empirical findings. These results are consistent with existing literature that highlights capability and infrastructure barriers to circular economy implementation. For example, Geissdoerfer et al. (2017) argue that the adoption of circular economy practices is often constrained by limited organizational readiness, insufficient infrastructure, and weak supporting systems within firms. Similarly, Masi et al. (2018) identify supplier capabilities, technical skills, and operational system maturity as critical determinants of circular economy adoption. However, the findings of this study also reveal an additional factor that receives less attention in much of the circular economy literature. While awareness of sustainability issues is emerging, the results indicate that communication gaps between manufacturers and suppliers also constrain circular economy adoption. A substantial proportion of suppliers reported uncertainty regarding customer sustainability expectations, suggesting that sustainability requirements are not always clearly communicated across supply chain relationships. This finding extends the existing literature by highlighting the relational dimension of circular economy adoption, where effective communication and coordination between supply chain actors become important enablers of sustainability implementation. In the absence of clear guidance from manufacturing customers, suppliers may struggle to translate sustainability awareness into concrete circular economy practices.

Government Support and Institutional Environment (H4) – Accepted

The findings provide partial support for Hypothesis 4, which proposes that government support and institutional frameworks influence the adoption of sustainable supply chain management (SSCM). Although suppliers acknowledge that regulatory environments can play an important role in promoting sustainability, the results indicate that institutional support is perceived as relatively weak or inconsistent. This finding partially aligns with previous studies that highlight the importance of government policies in driving sustainability adoption. For example, Testa et al. (2016) and Zhu and Sarkis (2007) argue that regulatory incentives and government programs can significantly encourage firms to adopt sustainable supply chain practices by creating compliance requirements and financial support mechanisms. However, the empirical results of this study reveal a different perception among suppliers in the South African manufacturing sector. Only 20% of respondents agreed that supportive government incentives are currently available, while 40% disagreed, indicating limited confidence in the effectiveness of existing institutional support mechanisms. These findings contrast with Govindan et al. (2020), who suggest that government incentives are increasingly becoming a major driver of SSCM adoption in global supply chains. In the context of South Africa, however, the results suggest that although regulatory frameworks may exist, they are not yet perceived by suppliers as strong or effective enablers of sustainability adoption. This discrepancy highlights a gap between policy intentions and supplier perceptions, suggesting that institutional mechanisms may require stronger implementation, clearer communication, or improved accessibility to effectively support SSCM adoption within the manufacturing sector.

4.5.2 Discussion of Findings-Industry Professionals

Evidence of Adoption and Professional Engagement (RQ1)

The demographic composition of respondents (Table 29), including academics, policy advisors, consultants, and business owners, reflects the multi-stakeholder nature of sustainable supply chain management (SSCM). The strong representation of academics (46.7%) and policy experts (33.3%) indicates that sustainability discussions in South Africa's manufacturing sector increasingly occur across research, policy, and industry environments, suggesting that SSCM is becoming institutionally embedded rather than remaining a purely operational issue. High professional engagement with sustainability initiatives (Table 31) further supports this trend. Most respondents reported active involvement in sustainability programmes, indicating that SSCM is increasingly integrated into professional practice.

This aligns with Mafini and Loury-Okoumba (2018), who note that sustainability awareness and engagement are growing among managerial and technical professionals in South African organisations. Similarly, the perceived importance of sustainability (Table 31a–b) highlights its strategic role in future competitiveness. Most respondents considered sustainability highly important, supporting findings by Mugoni et al. (2025) and Haman and Ahmed (2024), who argue that sustainability increasingly drives operational efficiency, innovation, and long-term competitiveness. In this context, SSCM is viewed not only as a compliance requirement but also as a mechanism for improving productivity, strengthening reputation, and accessing global markets. However, Table 33 indicates that SSCM adoption remains uneven, despite widespread recognition of its importance. Most respondents rated current adoption as moderate or low, revealing a gap between awareness and implementation. This finding is consistent with Kato and Manchidi (2025), who observe that in many emerging economies sustainability awareness often develops faster than practical implementation due to financial, technological, and organisational constraints. Overall, the findings suggest that SSCM within the South African manufacturing sector is progressing but remains at an intermediate stage of institutionalisation. While sustainability awareness and professional engagement are well established, limitations in capabilities and resources continue to constrain the full integration of SSCM practices across supply chains.

Barriers and Institutional Challenges (RQ2)

The findings from Tables 34a and 35b indicate that cost, technological limitations, and knowledge constraints are the primary barriers to the adoption of SSCM practices. All respondents identified high implementation costs (100%), while 93.3% cited limited access to advanced technology, and 60% expressed uncertainty regarding return on investment. These findings align with Nsowah and Phiri (2023), who report that South African manufacturers face cost–benefit challenges and technological infrastructure limitations when implementing sustainability initiatives. The strong agreement that cost is a major barrier is reinforced by Table 42 (mean = 4.47, SD = 0.64), indicating widespread recognition of financial constraints. From a Resource-Based View (RBV) perspective, these findings suggest that firms lack the necessary financial, technological, and knowledge resources required to implement SSCM effectively (Barney, 1991). In addition, the reported lack of expertise (46.7%) and limited collaboration across supply chains (26.7%) highlights broader capability gaps in skills development and industry coordination. Such challenges reflect institutional voids typical of emerging

economies, where supporting institutions, training systems, and public–private partnerships remain underdeveloped (Khanna and Palepu, 2010). From an institutional theory perspective, weak normative and coercive pressures may therefore slow the institutionalisation of sustainability practices within organisations (Özkan, 2025). Furthermore, perceptions of government support appear limited. As shown in Table 35, 60% of respondents rated government support as only slightly effective, while responses in Table 36 suggest moderate confidence in the regulatory framework. These findings indicate that institutional structures may exist but are not yet strong enough to actively drive sustainability adoption. This observation is consistent with Zhu and Zhang (2024) and Sharma et al. (2023), who emphasise that effective regulatory systems and supportive institutions are critical for integrating sustainability into manufacturing operations. Overall, the findings suggest an implementation gap, where policy intentions are present but limited enforcement and financial incentives reduce firms’ willingness to undertake costly sustainability investments.

SSCM and Competitiveness (RQ3)

The relationship between sustainability and competitiveness is evident in Tables 31 and 42, where most respondents perceive sustainability as an important driver of global competitiveness. In Table 42, 86.7% of respondents agreed or strongly agreed that integrating sustainability enhances the global competitiveness of South African manufacturers (mean = 4.27). Similarly, 93.3% of respondents in Table 31 viewed sustainability as highly important for future competitiveness. These findings align with studies by Shebeshe and Sharma (2025) and Opoku (2024), which suggest that SSCM can improve competitiveness by enabling product differentiation, reducing waste, and enhancing operational efficiency. The findings also support the argument by Mashat et al. (2024) that sustainability initiatives can strengthen stakeholder relationships, reduce operational risks, and enhance corporate reputation, thereby contributing to long-term organisational performance. However, the level of SSCM adoption remains uneven, as shown in Table 32, where most respondents rated adoption as moderate or low. This indicates that although industry professionals recognise the strategic importance of sustainability, many firms still face financial and institutional constraints that limit full implementation. This pattern reflects the observation by Mangla et al. (2024) that in many developing economies sustainability strategies are often implemented reactively in response to external pressures rather than being fully integrated into organisational strategy. Consequently, while SSCM is widely recognised as a source of competitive advantage, its practical impact on

competitiveness may remain limited until firms overcome the structural and resource constraints that hinder broader adoption.

Drivers and external influences of SSCM (RQ4)

The results in Tables 33a and 33b indicate that external market pressures are the most prominent drivers of SSCM adoption. International market pressure (73.3%) and environmental protection (93.3%) were the most frequently cited drivers. This aligns with findings by Abuzawida et al. (2023) and Yin (2024), who argue that international customers, global supply chain networks, and market regulations exert a “trickle-down” effect that compels suppliers in emerging economies to adopt sustainability practices. In contrast, competitive advantage (26.7%) and cost savings (40%) were mentioned less frequently, suggesting that many South African manufacturers have not yet fully integrated SSCM into their core competitive strategies. Instead, sustainability practices appear to be adopted reactively in response to external market expectations, consistent with the pressures described in institutional theory (Pamela, 1999).

Government and regulatory systems appear to play a supporting but relatively weak role in this process. As shown in Tables 35 and 36, only a minority of respondents rated government programmes and regulations as moderately effective, while most perceived them as weak or inconsistent. This reflects a governance gap identified in the literature by Ambe and Badenhorst-Weiss (2012) and Adebayo et al. (2023), who argue that fragmented policy frameworks and limited enforcement capacity hinder SSCM implementation in South Africa. While international sustainability standards (Table 38) are perceived as strong external drivers. Most respondents (86.7%) indicated that such standards play a significant or critical role in influencing SSCM practices. Standards such as ISO 14001, ISO 26000, and the UN Sustainable Development Goals (SDGs) therefore function as institutional benchmarks that encourage local firms to adopt globally recognised sustainability practices, particularly in export-oriented sectors, as noted by El-Garaihy (2024). Finally, perceptions regarding technological adoption (Table 39) suggest cautious optimism about the role of innovation in advancing SSCM. Approximately 80% of respondents indicated that firms are moderately or very likely to adopt technologies such as IoT monitoring, AI optimisation, and blockchain traceability to support sustainability initiatives. This supports the argument by Osintsev and Rakhmangulov (2025) that technological innovation enhances sustainable supply chains by improving efficiency, transparency, and data-driven decision-making. However, respondents also emphasised that widespread adoption remains constrained by financial costs and capability limitations, reinforcing the broader finding

that structural and resource constraints continue to slow the full integration of SSCM practices in the sector.

Emerging Trends and Future Opportunities (RQ5)

The thematic findings in Table 38 highlight the sustainability trends that industry professionals expect to shape SSCM in the next decade. The most frequently identified priorities were circular economy practices (86.7%) and water conservation (86.7%), followed by waste reduction (66.7%), ethical sourcing (60%), and renewable energy adoption (53.3%). These trends reflect growing recognition of resource efficiency and environmental responsibility within manufacturing supply chains. Kirchherr et al. (2025) argue that the circular economy represents a critical pathway for sustainable manufacturing in South Africa due to the country's resource intensity and water scarcity. Consequently, focusing on circularity and conservation is driven not only by environmental necessity but also by strategic considerations such as risk reduction, resilience, and cost efficiency.

The increasing emphasis on ethical sourcing and renewable energy further suggests a gradual shift from compliance-based sustainability toward value-driven strategies aligned with the triple bottom line framework (Elkington, 1997). However, the results in Table 40 indicate that overall progress toward SSCM remains moderate, with a mean score of 3.4, reflecting cautious optimism about the sector's trajectory. While awareness and initial adoption of sustainability practices are evident, systemic constraints such as financial limitations, technological capacity, and institutional support continue to slow full implementation. Achieving a higher level of SSCM maturity in South Africa will therefore require coordinated action across government, industry, and academia a collaboration that is reflected in the diverse professional representation within the respondent sample (Table 30).

Comparison with the Literature

The findings from industry professionals largely align with existing SSCM literature while also revealing contextual gaps within the South African manufacturing sector. The strong belief that sustainability contributes to future competitiveness supports the arguments of Carter and Rogers (2008) and Pagell and Wu (2009), who suggest that organisations integrating environmental and social considerations into supply chain strategies gain reputational and operational advantages. Similarly, respondents in this study viewed SSCM as a strategic tool for competitiveness rather than merely a compliance requirement. However, the moderate to low level of current SSCM adoption observed in the study indicates a gap between awareness and implementation. This observation supports Seuring and Müller (2008), who argue that awareness of sustainability

does not necessarily translate into adoption due to organisational and contextual constraints. In the South African context, this gap appears more pronounced, reflecting structural challenges such as limited financing and restricted access to advanced technologies, as noted by (Nhamo and Agyepong, 2020). The dominance of external drivers, particularly international market pressures and environmental protection, also aligns with the findings of Govindan et al. (2015), who highlight global supply chain expectations as important drivers of sustainability adoption. However, the relatively lower emphasis on competitive advantage and internal strategic motivations suggests that South African manufacturers often adopt SSCM reactively rather than proactively. This contrasts with findings from more industrialised economies where sustainability initiatives are frequently driven by innovation and brand differentiation strategies. The challenges identified by industry professionals particularly high implementation costs, technological limitations, uncertainty regarding return on investment, and knowledge gaps also reflect trends widely reported in the literature on sustainability adoption in developing economies. The strong consensus that cost remains a primary constraint reinforces findings by Zhu and Sarkis (2004), who emphasise financial limitations as a major barrier to implementing green supply chain initiatives. However, the perceived limited effectiveness of government support contrasts with Govindan (2020), who argues that policy incentives and regulatory frameworks are increasingly important for driving SSCM adoption. In the South African case, the findings suggest that policy frameworks may exist but remain insufficiently enforced or supported. This observation aligns more closely with Ambe and Badenhorst-Weiss (2011), who highlight the fragmented nature of South African supply chain governance and regulatory coordination. The importance attributed to international sustainability standards, such as ISO 14001, also supports global research demonstrating that such standards enhance environmental legitimacy and supply chain transparency (Heras-Saizarbitoria et al., 2011). Furthermore, the prominence of circular economy practices and water conservation as future sustainability priorities aligns with recent literature highlighting the increasing role of circular economy principles in driving sustainability transitions (Korhonen et al., 2018). However, the limited practical implementation of circular economy initiatives suggests that these concepts remain in the early stages of adoption within emerging economies, largely due to infrastructure and capability constraints. Overall, the findings confirm many core theoretical propositions within SSCM literature while also demonstrating that contextual economic, institutional, and technological factors shape the pace and depth of sustainability adoption in South African

manufacturing supply chains.

4.5.3 Discussion of Findings – Employee Perspectives

SSCM Implementation Evidence in South African Manufacturing RQ1a:

The findings show that most respondents (62.3%) believe their organisation promotes sustainable supply chain management (SSCM), while 20.4% indicated that their organisation does not promote SSCM and 17.3% were unsure. This suggests that SSCM practices are increasingly being recognised within South African manufacturing organisations. This finding aligns with (Kato and Manchidi, 2025), who reported growing sustainability practices in South African organisations. However, the uncertainty among some employees indicates that sustainability initiatives are not always fully communicated across organisational levels. Similar concerns were identified by Sethumadhavan et al. (2025), who found that inadequate internal communication can hinder SSCM implementation. From an institutional theory perspective, this suggests that while organisations may adopt sustainability practices due to external pressures such as regulations and stakeholder expectations, internal integration of these practices may occur more gradually (Encinas, 2024). Training also appears to play an important role in supporting SSCM implementation. Nearly half of the employees (47.5%) reported receiving sustainability-related training, while 52.5% either did not receive training or were unaware of it. Previous studies emphasise that employee training is a key mechanism for embedding sustainability within organisational practices (Carter and Rogers, 2008; Govindan et al., 2020). Where training is limited, employee awareness and engagement in sustainability initiatives may also remain weak. Correlation analysis further supports this interpretation. Significant positive relationships were found between awareness, involvement, and perceived company performance ($\rho = 0.444-0.673$, $p < 0.01$). These results indicate that employees who are more aware of sustainability initiatives are also more likely to participate in SSCM activities and perceive stronger sustainability performance. This finding is consistent with Huo et al. (2016), who highlight the importance of awareness and human capital in successful SSCM integration. Overall, the results reinforce the role of employees as key internal stakeholders whose awareness and participation contribute to the effective implementation of sustainability practices.

Industry and Location Impacts on Employee Awareness and Involvement RQ1b

ANOVA tests revealed no significant differences in awareness, involvement, or perceived firm performance across industry sectors or locations ($p > 0.05$). This finding suggests that employee attitudes and engagement with SSCM are relatively consistent across the manufacturing sector, regardless of sectoral or geographical differences. Such consistency may indicate the widespread diffusion of sustainability norms within the industry. From an institutional theory perspective, this uniformity may reflect the influence of coercive and mimetic pressures, where firms across different sectors experience similar regulatory requirements and societal expectations regarding sustainability.

The similarity in perceptions between firms located in Gauteng and KwaZulu-Natal further suggests that geographical context does not significantly influence employee perceptions of SSCM practices. This may indicate an increasing standardisation of sustainability practices across regional manufacturing activities. Many firms in these regions operate within larger supply chains, where sustainability policies and requirements are often determined at the corporate or supply chain level, potentially reducing regional differences. This finding aligns with Siddiqi et al. (2025), who argue that once sustainability practices become standardised within supply chains, geographical location may have a limited influence on their implementation. However, this uniformity may also reveal underlying challenges. When employees across sectors report similar levels of awareness and engagement, it may reflect broader systemic issues such as limited communication and insufficient training across the industry. As noted by Mafini and Loury-Okoumba (2018), achieving effective SSCM implementation requires not only policy adoption but also strong internal communication and employee engagement. Therefore, while the findings suggest institutional maturity in the adoption of SSCM practices, they also highlight the need for more targeted initiatives to strengthen employee awareness and engagement across the manufacturing sector.

SSCM Implementation Challenges RQ2

The study identifies financial and technological constraints as the most significant barriers to the implementation of SSCM, reported by 64% and 62% of respondents respectively. These challenges have long been recognised as key obstacles to SSCM adoption in emerging economies, where firms often lack the financial resources and technological capabilities required to invest in green technologies and sustainable operational practices. This finding is

consistent with the resource-based view proposed by Barney (1991), which suggests that firms require adequate resources and capabilities to effectively implement sustainability initiatives. Without sufficient financial and technological capacity, organisations may struggle to integrate SSCM practices into their operations. The lack of technological capability is also consistent with the findings of Khan et al. (2021), who highlight that the adoption of green technologies is essential for evaluating and improving sustainability performance within supply chains. Without access to such technologies, firms may find it difficult to measure environmental performance or implement cleaner production processes. In addition to these structural constraints, several internal organisational barriers were identified. Resistance to change (38%) and lack of knowledge or expertise (36%) indicate cultural and informational challenges that can hinder SSCM implementation. Resistance to change may reflect organisational cultures that are not aligned with the transformational requirements of sustainability initiatives (Garengo et al., 2024). Employees may perceive SSCM as disrupting established routines rather than as an opportunity for innovation and improvement. Similarly, limited knowledge and expertise highlight the need for greater training and awareness programmes within organisations. Challenges related to supplier collaboration (29%) further demonstrate the complexity of implementing SSCM across supply chains. Effective sustainability practices often require coordination between multiple actors within the value chain, and weak collaboration can limit the diffusion of sustainable practices among supply chain partners (Abdsharafat et al., 2024). Interestingly, regulatory challenges were reported by only 12% of respondents, suggesting that government regulations are not perceived as a major barrier to SSCM adoption. Instead, the findings indicate that internal operational constraints, such as limited resources, technological capability, and organisational readiness, play a more significant role. This highlights a broader pattern often observed in emerging economies, where firms may recognise the importance of sustainability but lack the necessary capabilities to fully implement SSCM practices.

Effects of SSCM on the Performance and Competitiveness in the manufacturing industry RQ3

The results indicate a positive relationship between SSCM adoption and organisational performance. Employees from companies that actively promote SSCM reported higher sustainability performance (Mean = 2.16) compared to those from companies that do not promote such practices (Mean = 1.24). This finding aligns with theoretical expectations that the implementation of SSCM can generate both competitive and environmental benefits (AlKhars

et al., 2024). Furthermore, the correlation between the perceived importance of SSCM and perceived company performance ($r = 0.512, p < 0.01$) suggests that organisations that prioritise sustainability internally are more likely to achieve stronger sustainability outcomes. These findings are consistent with the work of (Govindan, 2025), who found that firms focusing on sustainability are more likely to outperform competitors through improved efficiency, innovation, and stronger stakeholder trust. From an employee perspective, this reinforces the view that sustainability is no longer only an ethical consideration but also a key driver of organisational performance. This is particularly relevant in the South African manufacturing industry, where firms increasingly operate in global markets where sustainability factors influence supplier selection and purchasing decisions (Barman, 2025). Using the triple bottom line framework (Elkington, 1997), SSCM practices contribute simultaneously to economic, environmental, and social performance. The positive association between SSCM promotion and perceived performance therefore suggests that organisations integrating sustainability into their supply chain strategies are better positioned to create long-term value while reducing operational and environmental risks.

Key Factors Influencing SSCM Adoption and Integration RQ4

The correlation analysis indicates that employee awareness is a key factor influencing involvement in SSCM activities ($\rho = 0.444, p < 0.01$). This highlights the importance of communication and training in integrating sustainability into daily organisational practices. Employees who understand the purpose, benefits, and processes of SSCM are more likely to participate actively in sustainability initiatives. This finding aligns with stakeholder theory, which emphasises the role of employee participation and inclusion in achieving organisational sustainability objectives (Musonda et al., 2025). The results also reveal a weak negative correlation between years of experience and employee engagement in SSCM ($\rho = -0.223, p < 0.01$). This suggests that employees with longer tenure may be slightly less involved in sustainability initiatives, possibly due to resistance to change or stronger attachment to established work routines. Consequently, sustainability programmes may need to adopt more inclusive and participatory approaches that actively engage experienced employees and leverage their organisational knowledge. Training was also identified as an important determinant of employee participation. Employees who received sustainability-related training reported the highest level of involvement (Mean = 2.81), while those who did not receive training or were

unsure about it reported lower levels of engagement. This finding is consistent with Gezdur and Bhattacharjya. (2025), who found that employee training positively contributes to the successful implementation of SSCM practices. Training strengthens employees' understanding of sustainability objectives, builds internal capabilities, and encourages greater participation in sustainability initiatives across departments. Educational level was another significant factor influencing SSCM involvement ($F(4,157) = 4.916, p = 0.001$). Employees with higher levels of education were found to be more actively involved in SSCM activities, suggesting that knowledge and skills play an important role in sustainability adoption. This finding is consistent with the resource-based view, which emphasises human capital as a strategic resource that contributes to organisational competitiveness (Barney, 1991). Therefore, promoting employee education and professional development can be considered an important enabler for strengthening SSCM implementation within organisations.

Strategies to Enhance SSCM Adoption and Effectiveness RQ5

Employee recommendations further reinforce the importance of training and technological investment in enhancing SSCM adoption. Most respondents recommended increased training and education (69%) and improved technology and equipment (67%) as key strategies for strengthening sustainability practices. These recommendations correspond directly with the capability and technological limitations previously identified as major barriers to SSCM implementation. Increased training can help address gaps in awareness and employee engagement, thereby supporting the cultural transformation required for effective sustainability integration. As noted by Baveja (2024), training initiatives can foster a stronger sense of ownership among employees regarding sustainability outcomes. Similarly, investment in technology can improve operational inter-organisational coordination at the operational level. However, existing literature consistently highlights leadership support and collaboration among supply chain partners as key drivers of sustainability initiatives (Tshifhumulo et al., 2025). Therefore, a multi-faceted approach that combines internal capacity development, technological investment, visible leadership commitment, and stronger collaboration across supply chain partners is necessary to support the long-term integration of SSCM practices.

Comparison with literature

The findings of this study are largely consistent with previous research on sustainable supply chain management (SSCM), while also revealing some context-specific characteristics of the South African manufacturing sector. The positive relationship observed between SSCM awareness, employee involvement, and organisational performance supports the argument of

Seuring and Müller (2008) that the engagement of internal stakeholders is essential for the successful integration of sustainability. Similarly, the relationship between sustainability training and employee participation aligns with the findings of Gimenez and Tachizawa (2012), who identify capability development as a key driver of sustainability-oriented behaviour within organisations. The results also support earlier studies indicating that structural and infrastructural constraints can hinder the adoption of SSCM practices. Nhamo and Agyepong (2017), for example, highlight energy shortages and infrastructure limitations as major barriers to sustainable logistics development in Southern Africa. In contrast to Govindan (2020), who suggests that government incentives can play a strong role in encouraging SSCM adoption, the findings of this study indicate that such incentives are not widely perceived as effective in the South African manufacturing context. This suggests a potential gap between policy intentions and practical implementation within firms. At the same time, the positive association between SSCM practices and organisational performance reinforces findings from Pagell and Wu (2009) and Carter and Rogers (2008), who argue that integrating environmental and social considerations into supply chain management can contribute to improved organisational performance. However, the strong perception of cost as a major barrier in this study suggests that financial constraints may be more significant in emerging economies than in developed-country contexts commonly examined in SSCM literature. Overall, the study supports key theoretical propositions within SSCM research while also highlighting the importance of contextual factors in shaping sustainability adoption. By providing empirical evidence from the South African manufacturing sector, the findings extend existing literature and demonstrate that institutional conditions, resource constraints, and organisational capabilities can influence how SSCM practices are implemented in developing economies.

4.5.4 Discussion of Findings – Manager Perspectives

Evidence of SSCM Practices in the Manufacturing Sector RQ1

The findings indicate that South African manufacturing firms are adopting SSCM practices, although at varying levels of maturity. Managers most frequently reported operational efficiency initiatives such as route optimisation, energy efficiency, and waste management as the initial entry points for sustainability adoption. One manager noted: “We reduced our environmental impact through trying energy-efficient production and concentrating on efficient shipping.” These initiatives demonstrate that firms often begin SSCM implementation through practices that simultaneously improve environmental performance and operational efficiency. Supplier

collaboration also emerged as an indicator of SSCM adoption. Some managers described working with suppliers to reduce carbon emissions and improve ethical sourcing practices. In addition, performance monitoring systems, particularly the use of Key Performance Indicators (KPIs), were identified as mechanisms for tracking sustainability metrics such as energy consumption, waste reduction, and emissions. Waste reduction initiatives were also widely reported, with some firms pursuing “zero-to-landfill” goals, reflecting a growing alignment with circular economy principles.

Overall, the evidence suggests that SSCM implementation within South African manufacturing is genuine but uneven. Adoption is most visible in areas such as process optimisation, energy efficiency, and waste management, which correspond with early-stage sustainability maturity (Nazir et al., 2024). This pattern mirrors global trends in which firms initially prioritise operational efficiency improvements before progressing toward more systemic circular and regenerative practices (Govindan et al., 2018). Larger firms appear to demonstrate stronger supplier collaboration and sustainability monitoring, which may reflect greater resource availability and supply chain influence, consistent with the resource-based view (Barney, 1991). At the same time, SSCM adoption appears to be influenced by regulatory pressure, peer practices, and stakeholder expectations, indicating the growing institutionalisation of sustainability within the manufacturing sector. However, the findings also suggest that internal capabilities and leadership commitment remain essential for translating these external pressures into sustained organisational change. The increasing use of performance monitoring and supplier collaboration indicates a gradual transition from compliance-based sustainability toward more integrated SSCM practices within South African manufacturing.

Obstacles to SSCM Implementation RQ2

Financial constraints emerged as the most significant barrier to SSCM adoption. As one manager explained, “The initial cost is high and difficult to justify at times,” reflecting the tension between short-term financial priorities and long-term sustainability investments. Similar findings are reported by (Ogah and Asiegbu, 2022), who identify capital limitations as a major obstacle to SSCM adoption in sub-Saharan contexts. The high costs associated with renewable technologies, energy-efficient equipment, and advanced waste management systems discourage early investment, particularly for small and medium-sized enterprises. Technological and infrastructural limitations also emerged as important barriers. One respondent stated that “a

suitable technology is difficult to obtain or not locally available,” highlighting the limited availability of locally adapted sustainability technologies. This reflects broader systemic challenges within emerging economies, where firms often rely on imported technologies that may be costly or poorly suited to local industrial contexts. Supplier readiness was another frequently cited challenge. Managers reported that many smaller suppliers lack the financial and technical capacity required to meet sustainability requirements, making supply-chain-wide change difficult. These findings support previous research emphasising the interdependence of supply chain actors in achieving SSCM outcomes. Regulation was described as having a dual role. Policies such as Extended Producer Responsibility (EPR) encourage sustainable practices, yet frequent changes in regulatory requirements create uncertainty and administrative burdens. As one manager noted, “Frequent policy and reporting requirement changes make it difficult to keep up.” Such regulatory inconsistency can discourage long-term sustainability investments and reflects broader institutional instability. Overall, these findings demonstrate that SSCM implementation challenges are multidimensional, involving financial, technological, institutional, and supply chain coordination barriers. Effective SSCM adoption therefore requires not only firm-level commitment but also broader institutional support, industry collaboration, and skills development initiatives.

Impact of SSCM on Firm Performance and Competitiveness RQ3

Managers generally agreed that SSCM contributes to competitiveness through both operational efficiency and responsiveness to evolving customer expectations. One manager observed that “there is much greater demand for sustainable products and traceable supply chains,” highlighting the growing influence of sustainability expectations in supply chain relationships. However, managers also emphasised the strong price sensitivity of South African consumers: “Our customers want sustainable products but at the lowest possible price’s practices such as waste reduction, emissions monitoring, and KPI-based performance management were reported to generate both tangible operational benefits and intangible reputational advantages. These findings align with the framework proposed by Carter and Rogers (2008), which conceptualises SSCM as the integration of economic, environmental, and social objectives within the triple bottom line. The evidence therefore suggests that SSCM enhances firm performance in two ways: directly through improved operational efficiency and indirectly through increased stakeholder trust and brand credibility. However, the financial returns from sustainability investments may be moderated by local market conditions, particularly the limited willingness

of domestic consumers to pay price premiums for sustainable products. As a result, export-oriented firms operating in international markets may experience stronger competitiveness benefits due to higher sustainability expectations (Mehregan et al., 2023). These dynamics can also be interpreted through stakeholder theory (Freeman, 1984), which emphasises the influence of diverse stakeholder groups including customers, regulators, and supply chain partners on organisational decision-making. In contexts such as South Africa, where economic and environmental priorities coexist, SSCM allows firms to maintain legitimacy and respond to stakeholder expectations even when immediate financial benefits are limited.

Key drivers of SSCM adoption and integration RQ4

The findings indicate that SSCM adoption is influenced by a combination of external institutional pressures and internal organisational capabilities. Regulation emerged as a key external driver, although its effectiveness is often undermined by inconsistency in implementation. As one manager explained, “We had to register under the new waste management regulations and alter our processes as a result,” while another noted that frequent policy changes make it difficult to keep pace. This dual role of regulation can be explained through institutional theory DiMaggio and Powell (1983), which highlight how coercive pressures encourage organisational conformity. However, regulatory instability may simultaneously generate uncertainty that discourages long-term sustainability investments. Customer demand also plays an important role in driving sustainability adoption, particularly among business customers requiring traceable and responsible supply chains. However, affordability constraints limit the extent to which firms can fully integrate sustainability into their competitive strategies. As suggested by (Xia et al., 2024), market demand can only function as a strong driver of SSCM adoption when customers demonstrate willingness to pay for sustainable products. Internal organisational factors including financial capacity, supply chain coordination, and management commitment were also identified as critical enablers. Without leadership support and adequate internal resources, sustainability initiatives may remain symbolic rather than operational. This observation aligns with the resource-based view (Barney, 1991), which emphasises the importance of organisational capabilities in achieving competitive advantage through sustainability strategies.

Strategies for Increasing SSCM Adoption and Effectiveness RQ5

Managers proposed several strategies to strengthen SSCM adoption, reflecting both the barriers and opportunities identified in earlier findings. The most prominent recommendations included the expansion of renewable energy, stronger supplier collaboration, circular economy practices, local sourcing strategies, and increased collaboration with research institutions. The transition toward renewable energy and improved energy efficiency was widely identified as a priority. Managers recognised that renewable energy adoption could simultaneously reduce carbon emissions and operational costs, aligning with global decarbonisation initiatives and South Africa's Just Energy Transition strategy. Energy efficiency improvements also support the “win-win” logic of SSCM, where environmental improvements contribute to cost savings (Mahmood et al., 2024). Supplier collaboration was also considered essential for effective SSCM implementation. Managers emphasised the importance of establishing shared sustainability objectives across supply chains, although differences in supplier capabilities particularly among SMEs remain a significant challenge. This observation supports findings by (Pichle et al., 2023), which highlight the importance of value-chain collaboration in achieving sustainability outcomes. Managers also emphasised the need to promote circular economy practices, particularly waste reduction and recycling initiatives. Investments in digital technologies that monitor material flows from production to disposal were identified as potential tools for enabling circular systems. These approaches reflect broader global shifts toward circular supply chain models (Singh et al., 2023). Local sourcing strategies were also recommended as a means of reducing transport emissions while strengthening domestic supply chains. In addition to environmental benefits, local sourcing may enhance social legitimacy by supporting domestic economic development. Finally, managers highlighted the value of industry–research collaboration, particularly partnerships with universities and research institutions to develop sustainable materials and production technologies. Such collaborations can accelerate technological innovation and reduce the costs associated with sustainability adoption (Zaman et al., 2024).

Comparison with literature

The findings from managers reveal SSCM adoption patterns that are broadly consistent with international and emerging-economy studies. The emphasis on operational efficiency, waste reduction, and incremental sustainability improvements aligns with Govindan et al. (2018), who

note that firms in developing economies often begin with cost-saving sustainability initiatives before progressing toward more systemic integration. Similarly, the gradual institutionalisation of sustainability described by managers reflects early stages of sustainability transition identified by Geissdoerfer et al. (2017). The barriers identified by managers including high implementation costs, technological limitations, and supplier capability gaps also correspond with findings from previous research. (Khan et al., 2024) identify financial constraints as a major barrier in emerging economies, while (Chauhan et al., 2022) emphasise supply chain capability gaps as a structural challenge within Global South supply chains. However, the strong emphasis managers place on regulatory instability introduces an important contextual nuance. Earlier studies such as Seuring and Müller (2008) primarily emphasised external regulatory pressure as a driver of sustainability adoption, whereas the present findings indicate that frequent regulatory changes may also disrupt long-term sustainability planning in the South African context.

In terms of competitiveness, the findings support the “win-win” perspective described by Govindan et al. (2018), where sustainability initiatives enhance both operational efficiency and market differentiation. Nevertheless, managers highlighted the strong price sensitivity of South African consumers, which may limit the financial benefits of sustainability investments compared to more mature markets. Finally, the drivers of SSCM adoption external pressures, customer demand, and internal capabilities are consistent with established SSCM theory (Seuring and Müller, 2008; Pagell and Wu, 2009). However, the emphasis on local sourcing and research collaboration highlights context-specific strategies tailored to South Africa’s infrastructural and technological conditions, demonstrating a more locally grounded approach to sustainability integration.

4.6 National Environmental Management Act (NEMA), 1998

NEMA is thus the cornerstone of environmental governance in South Africa, laying down principles for sustainable development, environmental liability, and risk management. This Act obligates an organization to adopt all measures to avoid pollution and ecological deterioration, hence commanding environmental responsibility throughout the production and logistical activities of an entity. NEMA also requires environmental risk assessments, waste reduction strategies, and rehabilitation plans for manufacturing firms processes which will touch on supply chain operations directly. However, participants noted that inconsistent enforcement and the high administrative cost of EIAs tend to deter smaller suppliers from complying; this hinders

full-scale SSCM adoption.

4.7 National Waste Management Strategy, 2020 and Extended Producer Responsibility (EPR) Regulations, 2021

These frameworks achieve their goals through shifting the environmental responsibility upstream to the producer and importer by mandating waste minimisation, recyclability, and lifecycle accountability. The frameworks propose an orientation through a circular economy that obligates producers to track the lifecycle of products, offering information on the reduction of waste. This framework, therefore, supports the Circular Economy Model in the redesigning of products for longevity, reutilization, and recyclability. The suppliers interviewed nonetheless identified cost and data management challenges in complying with reporting obligations where the conditions of digital traceability systems are poor. Though the law is supportive of sustainability goals, compliance costs and the separation of information remain barriers.

4.8 Carbon Tax Act 2019

The Carbon Tax Act gives effect to the obligations of South Africa as stipulated in the Paris Agreement by assigning an economic cost to carbon emissions, aimed at ensuring the adoption of low carbon technology. This is applicable to large carbon emitting factories, energy producers, and the transport sector, in line with the "polluter pays" approach as cited by (Thoko et al., 2022). This piece of legislation directly impacts the supply chains, as organizations are compelled to consider costs of emissions during the manufacturing and supply chains. Although this law encourages investment in more efficient energy, other respondents felt that the carbon tax is economically stressful, especially in the absence of transitional support and affordable green finance as cited by some of the respondents.

4.9 Integrated Resource Plan (IRP), 2019

IRP: This is the framework for the long-term energy mix and planning strategy in South Africa. IRP is established as a shift from fossil fuels to renewable energy resources. According to a submission by Makgetla (2021), energy is viewed as an important element that influences the competitiveness of manufacturing and logistics sustainability. Reliable, low-carbon manufacturing and logistics operations are dependent upon an assured and varied energy supply. However, the persistent energy load shedding disrupts the IRP's aim for assured manufacturing, hence hindering green logistics chain infrastructure. Energy insecurity is a structural problem that continues to prevent SSCM.

4.10 Public Procurement Bill (2023)

The Draft Public Procurement Bill aims at bringing uniformity in the fragmented pieces of procurement legislation and embedding principles of sustainable procurement into the public sector contracting system. It would encourage the consideration of environmental and social criteria in the tender evaluation, making it therefore in line with ISO 20400 and best international practice. This framework provides a key opportunity to mainstream sustainability by using the power of government purchasing. Public procurement can incentivize suppliers to meet environmental and social standards, thus catalysing broader SSCM adoption. Participants have been quick to remind that the implementation remains at the nascent stage and there is much uncertainty around issues like evaluation criteria, preparedness of suppliers, and coordination across departments.

4.11 Comparison to International Guidelines on SSCM

compared to international frameworks like the European Union Green Deal of 2020, OECD Guidelines on Multinational Enterprises of 2011, or ISO 20400 Sustainable Procurement of 2017, the South African legislation is conceptually aligned, although its operational alignment is less strong. Thus, the EU Green Deal is specifically targeting climate policies, transition, or sustainable circles, whereas the policies of South Africa are still broken. There are still enforcement mechanisms to increase corporate responsibility and supply transparency, although these mechanisms are still weak in South Africa related to OECD Guidelines. In contrast to ISO 20400, which is targeting the whole life cycle, there is only partial alignment to the Public Procurement Bill or EPR Regulation.

4.12 Alignment with the National Development Plan 2030 NDP 2030

Details a transition towards a “green, inclusive and sustainable economy.” However, existing legal instruments only partially realise this vision. For example, as far as NEMA and EPR regulations support ecological objectives, this is undercut by weak integration with industrial competitiveness policies. The energy and procurement policies are also not fully in step with the low-carbon industrialization goals. Empirical findings from this study indeed confirm that policy misalignment, overlapping mandates, and short-term political priorities remain some of the major reasons why progress toward the NDP's sustainability targets has been slow. Therefore, a more integrated regulatory architecture is called for; one that links environmental, industrial, and social development strategies under a single SSCM policy framework.

4.13 Practical Implications

The findings provide several practical implications for enhancing sustainable supply chain management practices in the South African manufacturing sector. First, the high level of recognition among managers and employees of the strategic value of sustainability suggests that firms should go beyond compliance-driven approaches and institutionalize SSCM as part of core operational strategy. This can be addressed by infusing sustainability metrics into procurement, supplier selection, performance appraisals, and long-term planning. In addition, companies may also consider adopting more structured sustainability roadmaps oriented toward incremental improvements, such as energy efficiency, waste minimization, and process optimization, before scaling up toward more advanced practices like circular economy models and digital traceability systems. State regulation, subsidies, and incentives can make all the difference. The results show that inconsistent or insufficient policy frameworks are an important constraint to the adoption of SSCM today. Stronger, clearer, more stable regulatory standards—especially with respect to emissions, waste management, and energy use—would make it easier to create a more predictable environment in which companies could invest in sustainability. Targeted subsidies for renewable energy, green technologies, and low-carbon logistics could go a long way in reducing financial barriers that managers mentioned. Government incentives, such as tax deductions for certified sustainable operations or grants for technology upgrades, would also accelerate the rate of adoption, especially among small and medium-sized suppliers lacking access to capital. Training, certification, and technical support are some of the key capacity-building needs that emerge from this research. The study infers that most suppliers and internal departments lack the necessary knowledge to implement SSCM effectively. Practical interventions will involve industry-specific training programmes, mandatory sustainability induction for supply chain managers, and government-supported upskilling centres focusing on key areas like carbon accounting, waste optimisation, and digital supply chain tools. Certification schemes like ISO 14001, energy management standards, and responsible sourcing labels can help suppliers to meet global market expectations while improving local competitiveness. Tax breaks or fee reductions for achieving recognized sustainability certification would go a long way in further incentivizing participation, causing a cascading effect across supply networks. The results make further contributions beyond the realm of theoretical discourse. They offer specific guidelines for economic policy, industrial strategy, and corporate governance in South Africa. The results detail at what point policy interventions,

industry partnerships, and organisational reforms might best be targeted, given the constraints identified, to achieve the most significant impact. Thus, the value added by the research extends beyond a deeper academic insight into actionable pathways to strengthen sustainable supply chain practices both at the firm and national levels.

4.13.1 Contextual implications

The findings, which highlight pressures in SSCM adoption, therefore provide the best support for Institutional Theory (DiMaggio and Powell, 1983). While there is still a lack of support for local regulations, South African manufacturers would essentially be adopting sustainable practices in response to external forces like international demands from markets and global standards. This, in essence, points a maturity gap where there is full awareness but limited implementation due to financial, and technological constraints. Therefore, the South African context adds to global SSCM discussions by implying strategies that may have succeeded within developed economies have to be revised for local resource and infrastructure constraints that align with institutional pressures.

4.13.2 Practical and Strategic Implications of the SSCM Competitiveness Framework

The results of this study have significant implications across multiple levels and dimensions, providing both theoretical and practical contributions to sustainable supply chain management (SSCM) in South Africa, the Southern African region, and globally.

4.13.3 Local Implications (Firm and City Level)

At the local level, particularly within industrial hubs that is Durban and Johannesburg, the SSCM Competitiveness Index provides firms with an empirically validated tool to benchmark sustainability performance. Managers can use the framework to identify operational inefficiencies, prioritize resource allocation, and justify investments in sustainable technologies. Policymakers and municipal authorities are equipped with data-driven insights to design targeted interventions, including incentives, capacity-building programs, and regulations tailored to local industrial conditions. This localized approach ensures that SSCM adoption is both conceptually sound and practically feasible, considering the financial and technological constraints typical of South African manufacturing firms.

Regionally, the SSCM Competitiveness framework constitutes a practical and replicable tool for Southern African countries and other emerging economies facing similar resource and infrastructural constraints. By aligning with the Southern African Development Community

(SADC) and African Union (AU) sustainability and industrialization agendas, the framework can support regional policy harmonization, supply chain integration, and industrial competitiveness initiatives. SADC member states can benchmark SSCM practices across borders, identify common challenges, and implement collaborative sustainability programs, while the AU can inform continental strategies for responsible industrialization, green growth, and climate resilience. This regional perspective ensures that SSCM adoption not only strengthens individual firms but also contributes to sustainable economic development, environmental stewardship, and regional competitiveness.

4.14 Global Implications

Globally, this study contributes a novel perspective by contextualizing SSCM within an emerging-market environment, an area underrepresented in current SSCM literature dominated by developed economies. The findings enable international firms and researchers to compare sustainability performance metrics across diverse economic contexts, enhancing understanding of how resource constraints, technological limitations, and regulatory environments shape SSCM implementation. Furthermore, the framework supports global sustainability reporting and benchmarking standards by providing empirically derived, context-specific indicators, enriching international discourse on the business case for sustainability.

4.14.1 Vertical Implications (Within the Supply Chain)

Vertically, the framework offers actionable insights for suppliers, manufacturers, distributors, and retailers along various tiers of the supply chain. The framework would encourage vertical alignment in sustainability objectives that identify opportunities for operational efficiency, cost reduction, and value-added environmental performance. By facilitating a vertical alignment, business-to-business partnerships can solve problems through resources and shared accountability for environmental and economic outcomes. Companies can engage upstream or downstream entities to minimize wastes, emissions, and costs intelligently as part of strategic resource-building to ensure that sustainability initiatives are integrated throughout a supply chain.

4.14.2 Horizontal Implications (Across Firms in the Same Industry)

Horizontally, the SSCM Competitiveness Index enables peer benchmarking and industry-wide learning. Competitor firms can assess their sustainability performance relative to industry standards, identify gaps, and adopt best practices from high-performing organizations. This

promotes collective improvements, such as shared logistics solutions, joint investments in sustainable technologies, and coordinated approaches to environmental compliance. Horizontal collaboration strengthens overall industry sustainability, enhances competitiveness, and promotes a culture of corporate responsibility and continuous improvement.

Synthesis

In summary, the SSCM Competitiveness framework provides a multi-dimensional, empirically grounded tool that is actionable at local, regional, global, vertical, and horizontal levels. Its adoption empowers firms, policymakers, and industry associations to make informed decisions, justify sustainability investments, enhance operational efficiency, and strengthen competitiveness in line with both economic and environmental objectives. By bridging the gap between academic research and practical application, this study represents a significant advancement in understanding and operationalizing SSCM, particularly within emerging economies and contexts such as South Africa.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The background demonstrates that South Africa's manufacturing sector has developed through complex historical and economic phases that now shape its sustainability challenges. Durban and Johannesburg emerge as critical industrial hubs, each facing unique infrastructural and environmental pressures that influence the adoption of sustainable supply chain management. Despite supportive national policies and global expectations on sustainability, partial gaps remain in terms of consistent implementation across the sector. The chapter hence highlights the urgency and opportunity for strengthening sustainability practices within South African supply chains. This provides a general background to establish the rationale for the study and sets a foundation for investigating SSCM practices, challenges, and opportunities in these key metropolitan regions.

The literature has shown that SSCM has increasingly become an important focus for the manufacturing industry in South Africa, propelled by environmental, social, and economic imperatives. Although progressive firms like Woolworths and Nampak already demonstrate adoption through waste reduction, green procurement, and integration of renewable energy into operations, there are barriers identified in regulatory overlaps, resource constraints, and energy instability. Effective SSCM execution is said to significantly depend on leading, stakeholder collaboration, employee capacity-building, and alignment with policy frameworks; internally and externally, an enabling approach is thus crucial. Despite the progress made in economic, social, and environmental dimensions, SSCM still has lapses in social welfare monitoring, supplier engagement, and stringency of environmental compliance. In general, the development of SSCM in South Africa needs furtherance with an all-rounded, multivariate approach intertwined with technological innovation, cooperation among stakeholders, and specific contexts that will drive improvement in sustainability, competitiveness, and long-term industrial resilience. This study has utilized a mixed methods design to achieve a comprehensive understanding of SSCM practices in South Africa's manufacturing sector by effectively integrating quantitative surveys and qualitative interviews. The findings bring forth the level of sustainability initiative adoptions in the sector, including those challenges this sector has faced considering regulatory complexities, resource constraints, and energy disruptions, while pointing out opportunities for performance improvement, competitiveness, and stakeholder

engagement. Purposive sampling ensured that rich, contextual data are obtained from a sample comprising employees, managers, suppliers, and industry professionals. However, limitations in sample size and geographic coverage occurred. This study was able to enhance the reliability and validity of its findings, maintaining the credibility of the data, through ethical protocols and rigorous analysis to ensure that the findings reflect industry perspectives. Overall, this study puts forward a robust foundation for guiding policy, informing managerial practices, and providing impetus for further research in furthering SSCM in South Africa.

The survey results suggest that SSCM practices do exist among suppliers in South Africa's manufacturing sector, although their adoption is irregular and primarily driven by the demands of customers rather than internal strategic actions. Among the major constraints are high costs of implementation, limited availability of sustainable material supplies, and a lack of adequate internal capabilities that hinder the potential of sustainability efforts to improve performance. Suppliers' suggestions for improving SSCM adoption include targeted training, financial incentives, and access to sustainable technologies, indicating both a need for internal capacity building and supportive external frameworks. The findings reveal that South African industry professionals are very much aware of the strategic relevance of SSCM and its potential to enhance competitiveness. However, cost, technology, and institutional constraints make adoption spotty. Pressures from outside, such as international standards and market demands, facilitate implementation more than strategic initiatives internally, which leads to reactive instead of proactive sustainability practices. In the end, circular economy, resource conservation, and ethical sourcing have been identified as key opportunities, where coordinated action of government, industry, and academia is required to enhance SSCM maturity.

The findings indicate that employee awareness, training, and engagement are critical determinants of effective SSCM adoption, with higher knowledge and participation directly linked to improved sustainability performance and competitiveness. Addressing technological, financial, and communication gaps through targeted training, capacity building, and operational collaboration is essential to fully embed SSCM within South Africa's manufacturing industry. The findings indicate that SSCM in South African manufacturing is progressively institutionalized, with managers emphasizing operational efficiency, supplier collaboration, and circular economy practices as key entry points, yet adoption remains constrained by financial, technological, and regulatory challenges. Strategic investment in renewable energy, local sourcing, and industry–research partnerships, combined with strong leadership commitment, is

essential to advance SSCM integration and achieve long-term competitiveness and sustainability.

5.2 Research limitations

There are several limitations that need to be acknowledged in contextualizing the findings of the present study. Firstly, even though the study was able to collect data from several respondent groups, the sample sizes have been constraining factors in generalisability. The employee sample (N = 162) was sufficient for descriptive insight but was below the number that was targeted in the initial design. The supplier sample (N = 15), the managerial sample (N = 11), and the industry professionals (N = 15) were small, limiting the robustness of the statistical analyses and restricting opportunities for more advanced quantitative modelling. This is further constrained geographically because the study was limited to Durban and Johannesburg. These cities represent key manufacturing hubs and, therefore, provide meaningful insight into South Africa's industrial environment; the exclusion of other provinces could imply that regional variations in SSCM implementation might not be captured.

The methodological approach was constrained by practical considerations. The small quantitative sample size ruled out the use of more advanced inferential statistical techniques; a more robust mixed-methods design would have enhanced triangulation. Furthermore, participation by all types of respondents was voluntary, so self-selection bias might have had an impact on the data. Individuals with higher awareness or interest in issues of sustainability may be overrepresented in this study, which could distort perceptions of SSCM maturity and challenges. These limitations do not undermine the overall credibility of this study. Instead, the explicit statement of the limitations enhances the transparency and gives further reason to trust the research. Despite such constraints, the findings present valuable insights into SSCM practices in South Africa's manufacturing sector and set a clear foundation for future studies to expand the empirical scope. Subsequent studies could address these limitations by employing larger and more geographically diverse samples, incorporating more advanced quantitative techniques, and adopting comprehensive mixed methods designs to enhance empirical thoroughness.

5.3 Recommendations

Based on this study's results, the following recommendations are made:

5.3.1 Develop a national SSCM competitiveness index

A national SSCM competitiveness index can be developed to empirically demonstrate the firm case for SSCM in South Africa. The creation of this can and has to be facilitated either by universities or industry organizations. To make SSCM more attractive to the automotive and mining sectors in South Africa, there is a need to empirically demonstrate its firm case. Such an index could also incorporate indicators related to operational efficiency, waste reduction, emissions monitoring, energy efficiency, and supplier collaboration, which were identified in the findings as key SSCM practices currently emerging in South African manufacturing firms. By providing measurable benchmarks, the index could assist firms in translating sustainability awareness into practical strategies that improve competitiveness and operational performance.

5.3.2 Strengthen circular economy implementation through system-level coordination

The adoption of a circular economy requires a high degree of co-ordination at the system level. A circular economy can be adopted not exclusively by private companies. What needs to be done here can be jointly implemented by the companies, municipalities, and entities that recycle. This requires the adoption of a circular hub, a reverse logistics network, as well as a material tracking system. The key here should be investing in recycling infrastructure, technology incubators, or supply capabilities that can help accelerate a circular economy. This is particularly important because the study found that although sustainability awareness is increasing, the practical integration of circular economy practices remains limited. Strengthening recycling systems, waste reduction initiatives, and material recovery mechanisms can therefore support the broader adoption of circular supply chains in the manufacturing sector.

5.3.3 Prioritize regulatory frameworks through a Single Compliance Portal

Prioritize regulatory frameworks through a Single Compliance Portal The relevant industry associations should establish a single digital sustainability compliance portal that seeks to integrate requirements from NERSA, DEFF, DTIC, and other related bodies. Consolidating these regulations, together with consistent enforcement and long-term stability of policy, will

reduce uncertainty, compliance costs, and result in more predictable SSCM implementation across sectors. This recommendation responds to the study's finding that regulatory requirements currently play a mixed role in sustainability adoption: while regulations encourage environmental responsibility, frequent policy changes and unclear requirements can create administrative burdens for firms. A centralized portal could therefore improve transparency, coordination, and accessibility of sustainability policies and incentives.

5.3.4 Focus more on internal capacity development than location-based interventions

Focus more on Internal Capacity Development than Location-based Interventions: While Durban and Johannesburg are two geographically different cities, the SSCM maturity in both cases was found to be organization-driven rather than geography driven. For this reason, policymakers and industry stakeholders should directly strengthen their organizational capacity in terms of leadership, employee engagement, and resource availability rather than specifically designing location-based interventions. The findings also highlight the importance of employee training, internal communication, and leadership commitment in supporting sustainability initiatives. Strengthening organisational capabilities and improving employee awareness of sustainability practices can therefore enhance the effective implementation of SSCM across manufacturing firms.

5.3.5 Expand SSCM research across sectors, technologies, and behavioural dimensions

Expand SSCM Research across Sectors, Technologies, and Behavioural Dimensions Future studies should encompass sector-specific frameworks, the longer-term patterns of SSCM adoption, and the role of behaviour in the integration process. A focus on digitalisation, technology, and culture will promote SSCM success and increase the relevance of SSCM research in the context of expanding emerging economies. Future research should also examine the role of organisational capabilities, supplier readiness, stakeholder pressures, and internal sustainability policies in shaping SSCM adoption. Such research could help bridge the gap between sustainability awareness and practical implementation identified in this study.

5.3.6 Invest in digitalisation and blockchain to improve transparency and trust

Invest in Digitalisation and Blockchain to Improve Transparency and Trust Technological applications in digitalisation and blockchain can assist in improving the ability of manufacturers

to make their supplies traceable. At the same time, government-driven digital literacy initiatives and technological awards can help speed up the adoption trend in SMNs and therefore ensure that the transparent trend is achieved. Digital tools such as IoT monitoring systems, AI-based optimisation, and performance tracking platforms can also improve the measurement of sustainability indicators such as energy use, emissions, and waste reduction. However, given that the findings identified technological limitations and high implementation costs as key barriers, these initiatives should be supported through accessible technology funding and training programmes.

5.3.7 Promote comparative BRICS learning on SSCM

Academics, researchers and policy makers could seek comparative analyses of SSCM to learn from the experience of other BRICS country economies. In doing so, they would locate their own country, South Africa, in a global learning community, which would provide greater ease of application of best practices and an impetus to a global partnership for sustainable industrial development. Comparative research may also help identify strategies used by other emerging economies to overcome challenges like those identified in this study, including high implementation costs, limited technological access, supplier capability gaps, and institutional coordination challenges.

5.4 Analysis of Recommendations

Among the recommendations made, the most applicable to South African manufacturers regards capacity building to enable people, teams, and organizations to effectively execute sustainable supply chain practices. The need to enhance capacity building bears relevance to the condition identified in the research that a lack of expertise and cooperation is currently a hindrance to the adoption of sustainable practices. In terms of the spends required, it requires relatively lower investments, especially if contrasted with upgrading infrastructure.

The most supported recommendation from the research empirical evidence regards developing a framework on SSCM competitiveness. The research shows that there is a strong correlation between the adoption of sustainability and competitiveness on a global scale, but the current state does not have the proper tools to measure performance and benchmarking. In effect, having such a framework would enable the manufacturer to leverage their current awareness of sustainability into strategies to execute, measure SSCM, and boost competitiveness on both

domestic and global markets. In addition, the recommendations relating to supplier development, training, technology access, and leadership commitment are strongly supported by the discussion findings. Across suppliers, employees, managers, and industry professionals, the same broad pattern emerged: sustainability is widely recognised as important, but implementation remains uneven because of cost pressures, technological limitations, weak institutional support, limited supplier readiness, and insufficient internal capabilities. This means that the most effective recommendations are those that address both external system-level barriers and internal firm-level capabilities at the same time. Therefore, a combined approach involving regulation, capacity building, financing, collaboration, and innovation is likely to be the most practical route for strengthening SSCM adoption in South Africa.

6. NEW SCIENTIFIC FINDINGS

6.1 Employee Awareness as a Primary Driver of SSCM Engagement

This study demonstrates that employee awareness functions as a direct and primary driver of SSCM engagement, rather than a secondary or supporting factor. Higher levels of awareness are associated with increased participation in environmentally responsible practices, waste reduction, and sustainable operational activities.

Scientific contribution: This finding establishes that internal behavioural awareness directly drives SSCM implementation outcomes, independent of external pressures. It advances SSCM theory by introducing employee awareness as a core operational driver, thereby extending existing models that prioritise regulatory, stakeholder, or market-based influences.

6.2 Negative Influence of Employee Tenure on SSCM Participation

This study identifies a negative relationship between employee tenure and SSCM participation, where longer-tenured employees exhibit lower engagement with sustainability practices.

Scientific contribution: This finding challenges the dominant assumption that tenure enhances organisational commitment to sustainability initiatives. It demonstrates that tenure can act as a behavioural constraint due to resistance to change, thereby extending SSCM theory to include tenure-based behavioural dynamics as a determinant of sustainability adoption.

6.3 Dominance of Internal Organisational Capabilities Over Sectoral and Geographic Context

This study shows that internal organisational capabilities show a stronger influence on SSCM engagement than sectoral or geographic factors.

Employee awareness, leadership commitment, and resource allocation were found to be more influential than differences in location or industry conditions.

Scientific contribution: This finding refines SSCM and institutional perspectives by demonstrating that internal organisational readiness outweighs external contextual conditions. It establishes firm-level capability as the primary determinant of SSCM adoption, particularly in emerging-market environments.

6.4 Establishing a National SSCM Competitiveness Measurement Framework

This study demonstrates that SSCM adoption and performance can be systematically measured using integrated operational, environmental, and competitiveness indicators within an emerging-market context.

Scientific contribution: This finding introduces a measurable SSCM–competitiveness linkage at a national level, extending SSCM theory beyond firm-level analysis. It establishes the feasibility of a standardised competitiveness measurement framework, thereby advancing knowledge by linking sustainability practices directly to industrial and economic performance outcomes.

6.5 Financial and Technological Constraints as an Interacting Structural Barrier

This study identifies that financial and technological constraints operate as an interdependent and reinforcing factors, rather than as separate barriers to SSCM adoption. Limited financial capacity restricts access to sustainable technologies, while inefficient technologies increase costs and further constrain financial resources.

Scientific contribution: This finding advances SSCM theory by introducing a cycle of structural barrier model, where financial and technological constraints mutually reinforce each other. It shifts the understanding of SSCM challenges from isolated factors to interconnected system dynamics, particularly relevant in emerging economies.

7. SUMMARY

The South African manufacturing sector has emerged from its linked beginnings in the mining industry in the 19th century through history and modern sustainability pressures into a differentiated crucial sector. Durban and Johannesburg have a complementary role in the advancement of the manufacturing sector's transformation in South Africa towards sustainable supply chain management practices – Durban through its logistics-based advantages sustainably managed through its port function, while the other through its differentiated manufacturing capacity in technology. The paper seeks to explore the extent of SSCM practices in South African manufacturing sectors to determine ongoing practices, key challenges, impact on business performance, etc., for proposing improvements in its adoption. The study design comprehensively addressed mixed design, strategy of the study, and parameters of both inclusion and exclusion of the study, data collection and analysis techniques, including the use of SPSS for descriptive analysis, validity, reliability, and addressing the parameters of ethical aspects of the study. Conclusions from the mixed methods findings show that SSCM is in place, and its indiscriminating use finds its barriers in matters of financial, technological, and regulatory aspects, while the drivers for its adoption are from the external environment and are not motivated within.

REFERENCES

1. Abdsharafat, M., Saparauskas, Z.T., Rostamzadeh, R. and Saparauskas, J. (2024). EVALUATING BARRIERS OF CHANGE IN SUSTAINABLE SUPPLY CHAIN PERFORMANCE USING ISM-MICMAC METHODOLOGY. *Transformations in Business and Economics*, 23(3A), p.63A.
2. Abuzawida, S.S., Alzubi, A.B. and Iyiola, K. (2023). Sustainable supply chain practices: An empirical investigation from the manufacturing industry. *Sustainability*, 15(19), p.14395.
3. Adebayo, A., Daniel, I. and Adekunle, A. (2023). THE PARADIGM OF REVERSE DISTRIBUTION SUSTAINABILITY. A CASE OF SELECTED PRODUCTION FIRMS: AN APPROACH. *Environmental Engineering and Management Journal (EEMJ)*, 22(8).
4. Adeniran, A. (2021). AFRICA: Opportunities for a robust COVID-19 recovery grounded on SDG 16. *COVID-19 and the Crisis of Governance*, 14, pp.13-23.
5. Agyemang, O.S., Gbetey, C., Gatsi, J.G. and Acquah, I.S.K. (2019). Country-level corporate governance and foreign direct investment in Africa. *Corporate Governance: The International Journal of Business in Society*, 19(5), pp.1133-1152.
6. Agyepong, A.O. and Nhamo, G. (2017). Green procurement in South Africa: perspectives on legislative provisions in metropolitan municipalities. *Environment, development, and sustainability*, 19(6), pp.2457-2474.
7. Ahi, P. and Searcy, C. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. *Journal of cleaner production*, 52, pp.329-341.
8. Ahi, P. and Searcy, C. (2015). An analysis of metrics used to measure performance in green and sustainable supply chains. *Journal of Cleaner Production*, 86, pp.360-377.
9. Ahmad, M. and Wilkins, S. (2024). Purposive sampling in qualitative research: A framework for the entire journey. *Quality and Quantity*, pp.1-19.
10. Akinbami, O. M., Oke, S. R., and Bodunrin, M. O. (2021). The state of renewable energy development in South Africa: An overview. *Alexandria Engineering Journal*, 60(6), 5077-5093.
11. Ali, H., and Shoaib, M. (2023). A comprehensive literature review on green supply chain management: recent advances and potential research directions. *International Journal of Supply and Operations Management*, 10(1), 57-75.

12. AlKhars, M., Masoud, M., AlNasser, A. and Alsubaie, M. (2024). Sustainable practices and firm competitiveness: An empirical analysis of the Saudi Arabian energy sector. *Discover Sustainability*, 5(1), p.146.
13. Allen, S.D., Zhu, Q. and Sarkis, J. (2021). Expanding conceptual boundaries of the sustainable supply chain management and circular economy nexus. *Cleaner Logistics and Supply Chain*, 2, p.100011.
14. Ambe, I.M. and Badenhorst-Weiss, J.A. (2011). Managing and controlling public sector supply chains. *Supply Chain Management*, pp.73-92.
15. Ambe, I.M. and Badenhorst-Weiss, J.A. (2012). Supply chain management challenges in the South African public sector. *African Journal of Business Management*, 6(44), p.11003.
16. Anathi, S. (2023). Sustainable Supply Chain Management Practices: Challenges and opportunities: A focus on the South African manufacturing sector. *Acta Carolus Robertus*, 13(2), pp.3-10.
17. Anathi, S. (2024). Circular economy supply chain and sustainable sourcing: The incorporation of McArthur foundation's butterfly model into sustainable sourcing. *Studia Mundi–Economica*, 11(2), pp.43-53.
18. Andalib Ardakani, D., Soltanmohammadi, A. and Seuring, S. (2023). The impact of customer and supplier collaboration on green supply chain performance. Benchmarking: *An International Journal*, 30(7), pp.2248-2274.
19. Asif, M. S., Lau, H., Nakandala, D., Fan, Y., and Hurriyet, H. (2020). Adoption of green supply chain management practices through collaboration approach in developing countries–From literature review to conceptual framework. *Journal of Cleaner Production*, 276, 124191.
20. Assefa, S., Rorissa, A. and Alemneh, D. (2021). Digital readiness assessment of countries in Africa: Case study research. *Proceedings of the Association for Information Science and Technology*, 58(1), pp.400-404.
21. Atieh Ali, A.A., Sharabati, A.A.A., Allahham, M. and Nasereddin, A.Y. (2024). The relationship between supply chain resilience and digital supply chain and the impact on sustainability: Supply chain dynamism as a moderator. *Sustainability*, 16(7), p.3082.
22. Bag, S., Wood, L.C., Telukdarie, A. and Venkatesh, V.G. (2023). Application of Industry 4.0 tools to empower circular economy and achieving sustainability in supply chain operations. *Production Planning and Control*, 34(10), pp.918-940.

23. Bansal, N., Bhatnagar, M., and Taneja, S. (2023). Balancing priorities through green optimism: A study elucidating initiatives, approaches, and strategies for sustainable supply chain management. In *Handbook of Research on Designing Sustainable Supply Chains to Achieve a Circular Economy* (pp. 60-81). IGI Global.
24. Barman, A. (2025). Sustainability, Supply Chain Management, and Machine Intelligence: Overcoming Challenges and Shaping the Future. *Procedia Computer Science*, 258, pp.993-1002.
25. Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management*, 17(1), pp.99-120.
26. Bartos, K.E., Schwarzkopf, J. and Mueller, M. (2024). The role of trainings in improving supplier sustainability performance. *World Development*, 175, p.106482.
27. Baveja, A., Greeley, L. and McLaury, W. (2024). A participatory framework for bridging the conceptual and talent gaps in supply chain management education. *Decision Sciences Journal of Innovative Education*, 22(1), pp.33-49.
28. Beske-Janssen, P., Johnsen, T., Constant, F. and Wieland, A. (2023). New competences enhancing Procurement's contribution to innovation and sustainability. *Journal of Purchasing and Supply Management*, 29(3), p.100847.
29. Beske-Janssen, P., Schaltegger, S. and Liedke, S. (2019). Performance measurement in sustainable supply chain management: Linking research and practice. *Handbook on the Sustainable Supply Chain*. Cheltenham: Edward Elgar Publishing, pp.331-56.
30. Bhana, A., Suknunan, S. and Aliamutu, K.F. (2023). The Impact of Environmental Costs on Financial Performance: An Explorative Analysis of Two Plastic Companies. *Environmental Economics*, 14.
31. Bhorat, H., Lilenstein, K., Oosthuizen, M. and Thornton, A. (2023). Employment and Inequality Trends. *Tasks, Skills, and Institutions*, p.89.
32. Biau, D. J., Kernéis, S., and Porcher, R. (2008). Statistics in brief: The importance of sample size in the planning and interpretation of medical research. *Clinical Orthopaedics and Related Research*, 466(9), 2282–2288. <https://doi.org/10.1007/s11999-008-0346-9>.
33. Brandenburg, M., Warasthe, R., and Seuring, S. (2023). Impact pathways: improving supply chain sustainability by due diligence acts? Insights from a German case. *International Journal of Operations and Production Management*.
34. Braun, V. and Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative*

research in psychology, 3(2), pp.77-101.

35. Braun, V. and Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative research in sport, exercise, and health*, 11(4), pp.589-597.
36. Brixiová, Z., Kangoye, T., and Yogo, T.U. (2020). Access to finance among small and medium-sized enterprises and job creation in Africa. *Structural Change and Economic Dynamics*.
37. Burger, P. and Fourie, F. (2019). The unemployed and the formal and informal sectors in South Africa: A macroeconomic analysis. *South African Journal of Economic and Management Sciences*, 22(1), pp.1-12.
38. Cai, Y.J. and Choi, T.M. (2019). Extended producer responsibility: A systematic review and innovative proposals for improving sustainability. *IEEE transactions on engineering management*, 68(1), pp.272-288.
39. Carter and Rogers. (2008). "A framework of sustainable supply chain management: moving toward new theory." *International journal of physical distribution and logistics management* 38(5), pp.360-387.
40. Chauhan, C., Parida, V. and Dhir, A. (2022). Linking circular economy and digitalisation technologies: A systematic literature review of past achievements and future promises. *Technological Forecasting and Social Change*, 177, p.121508.
41. Chen, C. M. (2024). Unchaining supply chains: Transformative leaps toward regenerating social–ecological systems. *Journal of Supply Chain Management*, 60(1), 53-67.
42. Christopher, M. (2016). *Logistics and supply chain management: logistics and supply chain management*. Pearson UK.
43. Cohen, J. (2016). *Statistical power analysis for the behavioural sciences* (2nd ed.). Routledge.
44. Cooper, M. (2024). Exploring the role of stakeholder collaboration in sustainable supply chain management.
45. Craighead, C. W., Ketchen Jr, D. J., and Darby, J. L. (2020). Pandemics and supply chain management research: toward a theoretical toolbox. *Decision Sciences*, 51(4), 838-866.
46. Creswell, J.W. and Plano Clark, V.L. (2023). Revisiting mixed methods research designs twenty years later. *Handbook of mixed methods research designs*, 1(1), pp.21-36.
47. Dale, T. (2021). Brand heritage, perceived value, and loyalty: An exploration of Woolworths Holdings Limited (*Doctoral dissertation, The IIE*).

48. De Treville, S., Browning, T.R., Marewski, J.N. and Weiss, J. (2023): Toyota Production System practices as Fast-and-Frugal heuristics. *Journal of Operations Management*, 69(4), pp.522-535.
49. Deshpande, S., Hudnurkar, M. and Rathod, U. (2023). An exploratory study into manufacturing supply chain vulnerability and its drivers. *Benchmarking: An International Journal*, 30(1), pp.23-49.
50. Ding, B., Ferras Hernandez, X. and Agell Jane, N. (2023). Combining lean and agile manufacturing competitive advantages through Industry 4.0 technologies: an integrative approach. *Production planning and control*, 34(5), pp.442-458.
51. Dressler, A. and Bucher, J. (2018). Introducing a sustainability evaluation framework based on the sustainable development goals applied to four cases of South African frugal innovation. *Business Strategy and Development*, 1(4), pp.276-285.
52. Du Plessis, A. (2023). South Africa's Impending Water Crises: Transforming Water Crises into Opportunities and the Way Forward. In *South Africa's Water Predicament: Freshwater's Unceasing Decline* (pp. 143-170). Cham: Springer International Publishing
53. Du Venage, G. (2020). South Africa comes to standstill with Eskom's load shedding.
54. Egbulem, P.C., Khalil, K., Bamidele, R., Modupe, A., Omokeji, G.R. and Rabiou, U.A. (2024). The Impact of Technology on Work and Society: Nigerian Experience. *Open Access Journal of Social Sciences Research*, 2(2), pp.1-13.
55. El-Garaihy, W.H., Farag, T., Al Shehri, K., Centobelli, P. and Cerchione, R. (2024). Driving sustainability in supply chain management for a more inclusive and responsible future. *International journal of productivity and performance management*, 73(1), pp.43-84.
56. Elkington, J. (1997). The triple bottom line. *Environmental management: Readings and cases*, 2(1997), pp.49-66.
57. Encinas Bartos, K.M. (2024). Empirical exploration of supplier sustainability: Analysing influential factors and the impact of focal firms' SSCM measures in automotive supply chains. *Engineering and Mining Journal*, 221(1), pp.18-18.
58. Epoh, L.R. (2023) Modelling the relationship between green supply chain management practices, dynamic capabilities, and supply chain performance in the South African manufacturing sector (*Doctoral dissertation*).
59. Epoh, R.L., Langton, I. and Mafini, C. (2024). A model for green supply chain management in the South African manufacturing sector. *Cogent Business and Management*,

11(1), p.2390213.

60. Erero, J. L. (2023). Impact of loadshedding in South Africa: A CGE analysis. *Journal of Economics and Political Economy*, 10(2), 78-94.
61. Etikan, I., Musa, S. A., and Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, 5(1), 1–4. <https://doi.org/10.11648/j.ajtas.20160501.11>
62. Faber, J., and Fonseca, L. M. (2014). How sample size influences research outcomes. *Dental Press Journal of Orthodontics*, 19(4), 27–29. <https://doi.org/10.1590/2176-9451.19.4.027-029.ebo>
63. Fatoki, O. (2019). Drivers and barriers to sustainability manufacturing practices by small and medium enterprises in South Africa. *Academy of Entrepreneurship Journal*, 25(3), pp.1-12.
64. Field, A. (2024). *Discovering statistics using IBM SPSS statistics*. Sage Publications Limited.
65. Fritz, M.M.C., Silva, M.E. and Touboulic, A. (2022). October. Practicing sustainability in operations and supply chain management. In *Supply Chain Forum: An International Journal* (Vol. 23, No. 4, pp. 323-328). Taylor and Francis.
66. Gaglio, C., Kraemer-Mbula, E. and Lorenz, E. (2022). The effects of digital transformation on innovation and productivity: Firm-level evidence of South African manufacturing micro and small enterprises. *Technological Forecasting and Social Change*, 182, p.121785.
67. Garengo, P. and Betto, F. (2024). The role of organisational culture and leadership style in performance measurement and management: a longitudinal case study. *Production planning and control*, 35(2), pp.151-169.
68. Ge, S., O'Ceallaigh, C. and McGetrick, P.J. (2025). A review of best international life cycle assessment (LCA) practices in wood construction: Challenges for Ireland. *Cleaner Environmental Systems*, 16, p.100260.
69. Gebreeyesus, Alemayehu, A.G, A., Palladino, G. and Setti, M. (2020). Behavioural precursors in the innovation-decision process: The case of bioenergy in Ethiopia. *Energy strategy Reviews*, 30, p.100499.
70. Geissdoerfer, M., Savaget, P., Bocken, N.M. and Hultink, E.J. (2017). The Circular Economy—A new sustainability paradigm? *Journal of cleaner production*, 143, pp.757-768.

71. Gezdur, A. and Bhattacharjya, J. (2025). Innovators and transformers: enhancing supply chain employee training with an innovative application of a large language model. *International Journal of Physical Distribution and Logistics Management*, 55(4), pp.394-408.
72. Gimenez, C. and Tachizawa, E.M. (2012). Extending sustainability to suppliers: a systematic literature review. *Supply Chain Management: an international journal*, 17(5), pp.531-543.
73. Godfrey, L., Roman, H., Smout, S., Maserumule, R., Mpofo, A., Ryan, G. and Mokoena, K. (2021). Unlocking the opportunities of a circular economy in South Africa. In *Circular Economy: Recent Trends in Global Perspective* (pp. 145-180). Singapore: Springer Nature Singapore.
74. Gold, S., Seuring, S. and Beske, P. (2010). Sustainable supply chain management and inter-organizational resources: a literature review. *Corporate social responsibility and environmental management*, 17(4), pp.230-245.
75. Gonçalves, H., Magalhães, V.S., Ferreira, L.M. and Arantes. (2024). Overcoming barriers to sustainable supply chain management in small and medium-sized enterprises: a multi-criteria decision-making approach. *Sustainability*, 16(2), p.506.
76. Govindan, K., and Hasanagic, M. (2018). A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective. *International Journal of Production Research*, 56(1-2), 278-311.
77. Govindan, K., Rajeev, A., Padhi, S.S., and Pati, R.K. (2020). Supply chain sustainability and performance of firms: A meta-analysis of the literature. *Transportation Research Part E: Logistics and Transportation Review*, 137, p.101923.
78. Govindan, K., Soleimani, H. and Kannan, D. (2015). Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future. *European journal of operational research*, 240(3), pp.603-626.
79. Govindan, K. (2025). Applications of advances in operations research methods to achieve sustainable development goals (SDGs) in a supply chain management environment: review and future direction of research. *Annals of Operations Research*, 349(2), 425-450.
80. Gravetter, F.J., Wallnau, L.B., Forzano, L.A.B. and Witnauer, J.E. (2021). *Essentials of statistics for the behavioural sciences* (p. 648). Boston, MA, USA: Cengage.
81. Gualandris, J., Branzei, O., Wilhelm, M., Lazzarini, S., Linnenluecke, M., Hamann,

- R., Dooley, K.J., Barnett, M.L. and Chen, C.M. (2024). Unchaining supply chains: Transformative leaps toward regenerating social–ecological systems. *Journal of Supply Chain Management*, 60(1), pp.53-67.
82. H.H. and Vilhenac, E. (2019). Supply chain management practices and firms' operational performance. *International Journal of Quality and Reliability Management*, 34(2), pp.176-193.
83. Habib, A.M. (2025). *Exploring Sustainable Supply Chain Management in the Ethiopian coffee industry: an analysis of the critical factors, practices, and outcomes* (Doctoral dissertation, Liverpool John Moores University).
84. Hair, J. F. (2014). *A Primer on Partial Least Squares Structural Equation Modelling (PLS-SEM)* (3rd ed.). Sage.
85. Hajmohammad, S., Klassen, R. D., and Vachon, S. (2024). Managing supplier sustainability risk: an experimental study. *Supply Chain Management: An International Journal*, 29(1), 50-67.
86. Harrison, P. and Zack, T. (2012). The power of mining: the fall of gold and rise of Johannesburg. *Journal of contemporary African studies*, 30(4), pp.551-570.
87. Heras-Saizarbitoria, I., Casadesús, M. and Marimon, F. (2011). The impact of ISO 9001 standard and the EFQM model: The view of the assessors. *Total Quality Management*, 22(2), pp.197-218.
88. Huo, B., Ye, Y., Zhao, X. and Shou. (2016). The impact of human capital on supply chain integration and competitive performance. *International Journal of Production Economics*, 178, pp.132-143.
89. Jahanbakhsh Javid, N. and Amini, M. (2023). Evaluating the effect of supply chain management practice on implementation of halal agroindustry and competitive advantage for small and medium enterprises. *International Journal of Computer Science and Information Technology*, 15(2023), pp.8997-9008.
90. Ji, C. (2024). Talent Strategy and Future Development of High-tech Enterprises: Taking Huawei as an Example. *Highlights in Business, Economics and Management*
91. Johnsen, T., Howard, M., and Miemczyk, J. (2018). *Purchasing and Supply Chain Management: A Sustainability Perspective* (2nd ed.). Routledge.
92. Jum'a, L., Zimon, D., Sroufe, R. and Tyan, J. (2024). Sustainable supply chain management's impact on triple bottom line performance: Does the firm size matter? *Corporate*

- Social Responsibility and Environmental Management*, 31(5), pp.4673-4693.
93. Kafle, S.C. (2019). Correlation and regression analysis using SPSS. *The OCEM Journal of Management, Technology, and Social Sciences*, 1(1), pp.125-132.
 94. Kamau, E.W. (2023). *Influence Of Functional Level Strategies on Performance of Manufacturing Firms in Kenya* (Doctoral dissertation, Kca University).
 95. Kamble, S., Gunasekaran, A. and Dhone, N.C. (2020). Industry 4.0 and lean manufacturing practices for sustainable organisational performance in Indian manufacturing companies. *International journal of production research*, 58(5), pp.1319-1337.
 96. Kapesa, T. and Dorasamy, N. (2025). 1 Sustainable Development Opportunities and Challenges in Southern Africa. *Sustainable Development in Southern Africa: The Critical Role of Public Governance*, p.15.
 97. Karkour, S., Rachid, S., Maaoui, M., Lin, C.C. and Itsubo, N. (2021). Status of life cycle assessment (LCA) in Africa. *Environments*, 8(2), p.10.
 98. Kato, A.I. and Manchidi, N.H. (2025). Fostering Sustainable Manufacturing in Africa: A Sustainable Supply Chain Management Framework for a Green Future. *Administrative Sciences*, 15(7), p.271.
 99. Kaur, H. and Singh, S.P. (2019). Flexible dynamic sustainable procurement model. *Annals of Operations Research*, 273(1), pp.651-691.
 100. Kaziboni, L. (2018). The economic performance and competitiveness of manufacturing firms in Johannesburg, South Africa. *UNU-WIDER, SA-TIED Working Paper*, (14).
 101. Keeble, B.R. (1988). The Brundtland report: ' Our common future. *Medicine and war*,
 102. Khambule, I. (2025). 9 Promoting place-based regional development through Local Economic Development Agencies and Special Economic Zones in. *Contemporary South Africa and the Political Economy of Regional Development*, p.150.
 103. Khan, M., Ajmal, M. M., Jabeen, F., Talwar, S., and Dhir, A. (2023). Green supply chain management in manufacturing firms: A resource-based viewpoint. *Business Strategy and the Environment*, 32(4), 1603-1618.
 104. Khan, N.U., Shah, F., Ahmad, I., Shah, F.N. and Jalali, Q.M. (2024). Do Sustainable Supply Chain Performance Enhance Circular Economy: Mediation Analysis. *Policy Journal of Social Science Review*, 2(4), pp.476-491.
 105. Khan, S.A.R., Sharif, A., Panait, M. and Mardani, A. (2024). Technological innovation

and circular economy approaches: Leading toward sdg-12. *Environmental Technology and Innovation*, 36, p.103827.

106. Khan, S.A.R., Yu, Z. and Farooq, K. (2021). Green capabilities, green purchasing, and triple bottom line performance: Leading toward environmental sustainability. *Business Strategy and the Environment*, 32(4), pp.2022-2034.

107. Kirchherr, J. and Hartley, K. (2025). Is circular economy a failing sustainability paradigm? Not necessarily. *Journal of Industrial Ecology*.

108. Korhonen, J., Honkasalo, A. and Seppälä, J. (2018). Circular economy: the concept and its limitations. *Ecological economics*, 143, pp.37-46.

109. Kumar, A., Shrivastav, S.K., Shrivastava, A.K., Panigrahi, R.R., Mardani, A. and Cavallaro, F. (2023). Sustainable supply chain management, performance measurement, and management: a review. *Sustainability*, 15(6), p.5290.

110. Liu, Z. (2022), December. BMW Addresses Business and Financial Implications for Long-Term Sustainable Growth Based on a Competitive Value Approach. In 2022 *International Conference on Economics, Smart Finance and Contemporary Trade* (ESFCT 2022) (pp. 1392-1403). Atlantis Press.

111. Lozano-Oviedo, J., Cortés, C.E. and Rey, P.A. (2024). Sustainable closed-loop supply chains and their optimization models: a review of the literature. *Clean Technologies and Environmental Policy*, 26(4), pp.999-1023.

112. Ma, Y. (2024). The impact of sustainable supply chain management practices on business performance: A case study of Huawei. In *SHS Web of Conferences* (Vol. 181, p. 03015). EDP Sciences.

113. Maama, H., Doorasamy, M. and Rajaram, R. (2021). Cleaner production, environmental and economic sustainability of production firms in South Africa. *Journal of Cleaner Production*, 298, p.126707.

114. Mabe-Madisa, G.V. (2019). Trade and Investment in South Africa. In *Regional Development in Africa*. IntechOpen.

115. Mabotja, T. and Mavutha, W. (2024). Effect of Lean Six Sigma on order fulfilment process: evidence from manufacturing companies in Gauteng, South Africa. *International Journal of Research in Business and Social Science*, 13(3), pp.54-65.

116. Mabunda, N.E. (2022). December. Use of Photovoltaic Energy to Minimize the Impact of Load-shedding in South Africa. In 2022 *International Conference on Electrical, Computer*

and Energy Technologies (ICECET) (pp. 1-4). IEEE

117. Machingura, T. (2022). *The impact of the Lean-Green philosophy on Zimbabwean manufacturing industry* (Doctoral dissertation, University of Pretoria (South Africa))
118. Mafini, C. and Loury-Okoumba, W.V. (2018). Extending green supply chain management activities to manufacturing small and medium enterprises in a developing economy. *South African Journal of Economic and Management Sciences*, 21(1), pp.1-12.
119. Mahache, G.N., Mafini, C. and Langton, I. (2025). Dimensional impact of supply chain management on service delivery quality in South African municipalities. *Journal of Transport and Supply Chain Management*, 19, p.1157.
120. Mahajan, R., Lim, W.M., Sareen, M., Kumar, S. and Panwar, R. (2023). Stakeholder theory. *Journal of Business Research*, 166, p.114104.
121. Mahmood, S., Misra, P., Sun, H., Luqman, A. and Papa, A. (2024). Sustainable infrastructure, energy projects, and economic growth: mediating role of sustainable supply chain management. *Annals of Operations Research*, pp.1-32.
122. Makgetla, N.S. (2021). Mining and Minerals in South Africa. *The Oxford Handbook of the South African Economy*. Oxford: Oxford University Press. <https://doi.org/10.1093/oxford/9780192894199.013>, 13.
123. Mangla, S.K., Luthra, S., Garza-Reyes, J.A., Jabbour, C.J.C. and Brem, A. (2024). Sustainability and Industry 4.0: The role of social, environmental, and technological factors in the development of digital manufacturing. *Technological forecasting and social change*, 201, p.123223.
124. Mashat, R.M., Abourokbah, S.H. and Salam, M.A. (2024). Impact of internet of things adoption on organizational performance: a mediating analysis of supply chain integration, performance, and competitive advantage. *Sustainability*, 16(6), p.2250.
125. Masi, D., Kumar, V., Garza-Reyes, J.A. and Godsell, J. (2018). Towards a more circular economy: exploring the awareness, practices, and barriers from a focal firm perspective. *Production Planning and Control*, 29(6), pp.539-550.
126. Mateus, M. M., Cecílio, D., Fernandes, M. C., & Neiva Correia, M. J. (2023). Refuse derived fuels as an immediate strategy for the energy transition, circular economy, and sustainability. *Business Strategy and the Environment*, 32(6), 3915-3926.
127. Matt, D., Modrák, V., & Zsifkovits, H. (2020). *Industry 4.0 for SMEs: Challenges, opportunities and requirements*. Palgrave Macmillan.

128. Mehregan, E., Sanaei, S., Manna, M., Bozorgkhou, H. and Heidari, S. (2023). The role of SCM practices in competitive advantage and firm performance: a mediating role of supply chain innovation and TQM. *Tehnički glasnik*, 17(4), pp.516-523.
129. Miller, J.E. (2021). *Making sense of numbers: Quantitative reasoning for social research*. Sage Publications.
130. Mitchell, R.K., Agle, B.R. and Wood, D.J. (1997). Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts. *Academy of management review*, 22(4), pp.853-886.
131. Moonsamy, S., Underwood, S., Labadarios, G., Ramsundar, P., Sha, M., Botha, A. and Herselman, M., 1Next Generation Enterprises and Institutions (NGEI) cluster, Council for Scientific and Industrial Research (CSIR), Pretoria, South Africa; 2 National Department of Health.
132. Moutinho, R.A. (2022). How Supply Crisis Brings Resilience: The Case of Procter and Gamble (*Doctoral dissertation, Universidade de Lisboa (Portugal)*).
133. Mugoni, E., Shumbanhete, B. and Nyagadza, B. (2025). The Nexus Between Circular Economy (CE) and Sustainable Supply Chain Management (SSCM): A Systematic Literature Review and Mapping of Future Research Agenda. *Circular Economy and Sustainability*, pp.1-38.
134. Muller, M. (2023). Load shedding because of failures at the political-technological interface. *South African Journal of Science*, 119(9-10), pp.1-5.
135. Musonda, I., Zulu, S.L., Zulu, E. and Kavishe, N. (2025). Understanding clients' role in community stakeholder participation and influence on infrastructure sustainability—a stakeholder theory lens. *International Journal of Construction Management*, 25(4), pp.419-427.
136. Nagai, H., Nakazawa, E. and Akabayashi, A. (2022). The creation of the Belmont Report and its effect on ethical principles: a historical study. *Monash bioethics review*, 40(2), pp.157-170.
137. Naidoo, C. (2023). The Impact of Load Shedding on the South Africa Economy. *Journal of Public Administration*, 58(1), pp.7-16.
138. Naidoo, M. and Gasparatos, A. (2023). Consumer worldviews and perspectives on environmental sustainability initiatives in the South African supermarket sector. *Journal of Cleaner Production*, 413, p.137496.
139. Nazir, S., Zhaolei, L., Mehmood, S. and Nazir, Z. (2024). Impact of green supply chain

- management practices on the environmental performance of manufacturing firms considering institutional pressure as a moderator. *Sustainability*, 16(6), p.2278.
140. Nguyen, L.T. and Zuidwijk, R. (2025). Sustainable supply chain governance: A literature review. *Business Ethics, the Environment and Responsibility*, 34(2), pp.541-564.
141. Nimwal, S., Nimwal, E., and Nayak, K. A. (2023). Integration of Sustainability into Corporate Social Responsibility and the Fashion Industry: A Case Study on HandM. *Issue 1 Indian JL and Legal Rsch.*, 5, 1.
142. Niranjan, S., Garg, V., Gligor, D.M. and Hawkins, T.G. (2025). Enhancing supply chain sustainability performance: the pivotal role of emerging technologies. *Journal of Business and Industrial Marketing*, 40(2), pp.374-390.
143. NSOWAH, J. and PHIRI, M.A. (2023). Factors Influencing Adoption of Sustainable Supply Chain Management Practices Among Manufacturing Firms. *International Journal of Environmental, Sustainability, and Social Science*, 4(3), pp.822-831.
144. Nwaila, G.T., Bourdeau, J.E., Zhang, S.E., Chipangamate, N., Valodia, I., Mahboob, M.A., Lehohla, T., Shimaponda-Nawa, M., Durrheim, R.J. and Ghorbani, Y. (2024). A systematic framework for compilation of critical raw material lists and their importance for South Africa. *Resources Policy*, 93, p.105045.
145. Nwankwo, T.C., Ejairu, E., Awonuga, K.F., Usman, F.O. and Nwankwo, E.E. (2024). Conceptualizing sustainable supply chain resilience: Critical materials manufacturing in Africa as a catalyst for change. *International Journal of Science and Research Archive*, 11(1), pp.2427-2437.
146. Odello, J. (2024). Relationship between market orientation and innovation performance in technology startups in Kenya. *International Journal of Business Strategies*, 9(1), pp.75-86.
147. Odesola, O.T. and Aderemi, H.O. (2024). Green Supply Chain Management Practices in Nigerian Manufacturing Firms and Sustainable Development Goal 9. *SCMS Journal of Indian Management*, 21(2), pp.50-62.
148. Ogah, M. and Asiegbu, G. (2022). Sustainable Supply Chain Management in Sub-Saharan Africa. In *Management and Leadership for a Sustainable Africa, Volume 2: Roles, Responsibilities, and Prospects* (pp. 87-113). Cham: Springer International Publishing.
149. Olawumi, T.O. and Chan, D.W. (2018). A scient metric review of global research on sustainability and sustainable development. *Journal of cleaner production*, 183, pp.231-250.

150. Olojede, I.B. and ODEY, J.O. (2024). Political Breadcrumbs and its Implications for Sustainable Development in Nigeria. *Journal of African Sustainable Development*.
151. Onyekwelu, N.P., Ezeafulukwe, C., Owolabi, O.R., Asuzu, O.F., Bello, B.G. and Onyekwelu, S.C. (2024). Ethics and corporate social responsibility in HR: A comprehensive review of policies and practices. *International Journal of Science and Research Archive*, 11(1), pp.1294-1303.
152. Opoku, R.K. (2024). Green manufacturing, supply chain alertness, supply chain preparedness, and manufacturing performance in a developing economy. *Journal of Manufacturing Technology Management*, 35(8), pp.1486-1507.
153. Osintsev, N. and Rakhmangulov, A. (2025). Supply chain sustainability drivers: Identification and multi-criteria assessment. *Logistics*, 9(1), p.24.
154. Özkan, A.M. (2025). Sustainable Development and Institutional Theory. In *Integrating Organizational Theories with Sustainable Development* (pp. 59-80). IGI Global Scientific Publishing.
155. Pallant, J. (2020). *eBook: SPSS Survival Manual: A Step-by-Step Guide to Data Analysis using IBM SPSS*. McGraw-Hill Education (UK).
156. PAMELA, S.T. (1999). The institutionalization of institutional theory. *Studying organization: Theory and method*, p.169.
157. Panwar, R., and Niesten, E. (2020). Advancing circular economy. *Business Strategy and the Environment*, 29(6), 2890-2892.
158. Panya, K.O., Ochiri, G., Achuora, J. and Gakure, R.W. (2021). Sustainable supply chain management and its effects on the performance of sugar sub-sector in Kenya.
159. Patabandige, G. M. J., and Galahitiyawe, N. W. K. (2020). Role of supply chain transparency: traceability and visibility in achieving environmental performance. In *International Conference on Business Management, School of Business and Economics*
160. Pichler, A., Diem, C., Brintrup, A., Lafond, F., Magerman, G., Buiten, G., Choi, T.Y., Carvalho, V.M., Farmer, J.D., and Thurner, S. (2023). Building an alliance to map global supply Networks. *Science*, 382(6668), pp.270-272.
161. Porter, M.E. and Linde, C.V.D. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of economic perspectives*, 9(4), pp.97-118.
162. Qu, M.H., Suphachalasai, S., Thube, S.D. and Walker, M.S. (2023). South Africa carbon pricing and climate mitigation policy. *International Monetary Fund*.

163. Reyburn, P. (2020). Preliminary comments on the draft Public Procurement Bill. *African Public Procurement Law Journal*, 7(1), pp.46-54.
164. Rhaman, M.A. and Ahmed, H. (2024). Innovative approaches to sustainable supply chain management in the manufacturing industry: A systematic literature review. *Available at SSRN 5051065*.
165. Richardson, T., Orr, M., and Watanabe, N. (2022). An overview of Sustainable Development Goal 12. *The Routledge Handbook of Sport and Sustainable Development*, 289.
166. Robinson, R.S. (2024). Purposive sampling. In *Encyclopaedia of quality of life and well-being research* (pp. 5645-5647). Cham: Springer International Publishing.
167. Rogan, J., Fürstenberg, F. and Wieland, A. (2022). Shaping the Transition from Linear to Circular Supply Chains. In *Circular Economy Supply Chains: From Chains to Systems* (pp. 69-87). Emerald Publishing Limited.
168. Sarkis, J., Kouhizadeh, M. and Zhu, Q.S. (2021). Digitalization and the greening of supply chains. *Industrial Management and Data Systems*, 121(1), pp.65-85.
169. Saunders, M., Lewis, P. and Thornhill, A. (2009). *Research methods for business students*. Pearson education.
170. Schenck, C., Nell, C., Blaauw, D. and Grobler, L. (2023). Max-Neef's Fundamental Human Needs as Social Indicators for Sustainability: Examples of Waste Management in South Africa. In *Waste Management in Developing Countries* (pp. 135-155). Cham: Springer International Publishing.
171. Schilling, L., and Seuring, S. (2024). Linking the digital and sustainable transformation with supply chain practices. *International Journal of Production Research*, 62(3), 949- 973.
172. Scholvin, S. (2020). Articulating the regional economy: Cape Town, Durban, and Johannesburg as gateways to Africa. *African Geographical Review*, 39(2), pp.162-174.
173. Sethumadhavan, R., Sajimon, P.P., Selvakumar, P., Kadu, S.G., Chandel, P.S. and Gupta, S. (2025). Environmental Sustainability and Employee Participation. In *Green Leadership Strategies for Increased Employee Engagement and Performance* (pp. 275-298). IGI Global Scientific Publishing.
174. Seuring, S. and Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of cleaner production*, 16(15), pp.1699-1710.
175. Shah, A., Soomro, M. A., Zahid Piprani, A., Yu, Z., and Tanveer, M. (2023). Sustainable supply chain practices and blockchain technology in garment industry: An empirical

study on sustainability aspect. *Journal of Strategy and Management*.

176. Shahparvari, S., Soleimani, H., Govindan, K., Bodaghi, B., Fard, M. T., and Jafari, H. (2021). Closing the loop: Redesigning sustainable reverse logistics network in uncertain supply chains. *Computers and Industrial Engineering*, 157, 107093.
177. Sharma, S.K., Srivastava, P.R., Kumar, A., Jindal, A. and Gupta, S. (2023). Supply chain vulnerability assessment for manufacturing industry. *Annals of Operations Research*, 326(2), pp.653-683.
178. Shebeshe, E.N. and Sharma, D. (2025). Impact of sustainable supply chain management practices on competitive advantage and organizational performance in the manufacturing sector. *International Journal of Productivity and Performance Management*, 74(3), pp.995-1025.
179. Shevchenko, A., Montabon, F., Pagell, M., and Wu, Z. (2022). 19. Sustainability in supply chain management. *Handbook of Research Methods for Supply Chain Management*, 352.
180. Siddiqi, R.A., Codini, A.P., Ishaq, M.I., Jamali, D.R. and Raza, A. (2025). Sustainable supply chain, dynamic capabilities, eco-innovation, and environmental performance in an emerging economy. *Business Strategy and the Environment*, 34(1), pp.338-350.
181. Siems, E., Seuring, S. and Schilling, L. (2023). Stakeholder roles in sustainable supply chain management: a literature review. *Journal of Business Economics*, 93(4), pp.747-775.
182. Silva, V.L., Silvestre, B.S., Bonet Fernandez, D.F. and Jordão, T. (2024). Sustainable supply chain management (SSCM): challenges in the XXI century. *RAUSP Management Journal*, 59(2), pp.74-77.
183. Singh, R., Khan, S. and Dsilva, J. (2023). A framework for assessment of critical factor for circular economy practice implementation. *Journal of Modelling in Management*, 18(5), pp.1476-1497.
184. Sivakumar, K., Dhyankumar, C.T., Cherian, T.M., Manikandan, N. and Thejasree, P. (2023). Requirements for the adoption of industry 4.0 in the sustainable manufacturing supply chain. In *Industry 4.0 Technologies: Sustainable Manufacturing Supply Chains: Volume II- Methods for transition and trends* (pp. 185-201). Singapore: Springer Nature Singapore.
185. Sokhetye, A.(2023) Sustainable Supply Chain Management Practices: Challenges and opportunities: A Focus on the South African Manufacturing Sector. *Acta Carolus Robertus*, 13(2), pp.3-10.
186. Stanley, L. and Wise, S. (2010). The ESRC's 2010 framework for research ethics: fit

for research purpose? *Sociological Research Online*, 15(4), pp.106-115.

187. Statistics, L. (2018). *Multiple regression analysis using SPSS statistics*. Lund Research Ltd [online]

188. Stats SA. (2020). “The most important economic sectors in South Africa for the further development and growth.” statistics report 2019 under *Trading economies*.

189. Suganya, G., Selvakumar, J.J. and Pachiyappan, S. (2024). Enablers and Outcomes of Supply Chain Collaboration for Sustainable Growth. *International Research Journal of Multidisciplinary Scope*, 5(01), pp.535-556.

190. Sweet, S.A. and Grace-Martin, K. (1999). *Data analysis with SPSS* (Vol. 1). Boston, MA, USA: Allyn and Bacon.

191. Teece, D.J., Pisano, G. and Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic management journal*, 18(7), pp.509-533.

192. Teferi, E.T., Assefa, T.T., Tilahun, S.A., Wassie, S.B., Minh, T.T. and Béné, C. (2024). Bridging the gap: Analysis of systemic barriers to irrigation technology supply businesses in Ethiopia. *Agricultural Water Management*, 303, p.109004.

193. Testa, F., Annunziata, E., Iraldo, F. and Frey, M. (2016). Drawbacks and opportunities of green public procurement: an effective tool for sustainable production. *Journal of cleaner production*, 112, pp.1893-1900.

194. Thokoa, R.L., Naidoo, V., and Herbst, T.H. (2022). A review of service quality: Case of the National Treasury of South Africa. *Africa's Public Service Delivery and Performance Review*, 10(1), p.567.

195. Thomas, F.B. (2022). The role of purposive sampling technique as a tool for informal choices in a social Sciences in research methods. *Just Agriculture*, 2(5), pp.1-8.

196. Tshifhumulo, R., Heyns, G.J. and Kilbourn, P.J. (2025). Supply chain risks in the South African manufacturing sector. *Journal of Transport and Supply Chain Management*, 19, p.1189.

197. Vachon, S. and Klassen, R.D. (2007). Supply chain management and environmental technologies: the role of integration. *International journal of production research*, 45(2), pp.401-423.

198. Walsh, K., Theron, R. and Reeders, C. (2021). Estimating the economic cost of load shedding in South Africa. In Paper submission to *Biennial Conference of the Economic Society of South Africa* (ESSA) (Vol. 22).

199. Web of Science (2025) *Web of Science Core Collection database*. Available at:

<https://www.webofscience.com> (Accessed: 03 April 2025).

200. Wiseman, K. (2024). Environmental assessment and planning in South Africa: the SEA connection. In *Perspectives on strategic environmental assessment* (pp. 155-166). CRC Press.
201. Wu, N., Liu, M., and Zhang, J. (2023). Rhetorical strategies for the construction of a corporate identity: A case study based on Huawei annual reports. *Pragmatics and Society*, 14(5), 777-800.
202. Xia, S., Ling, Y., De Main, L., Lim, M.K., Li, G., Zhang, P. and Cao, M. (2024). Creating a low carbon economy through green supply chain management: investigation of willingness-to-pay for green products from a consumer's perspective. *International Journal of Logistics Research and Applications*, 27(7), pp.1154-1184.
203. Yang, M., Chen, L., Wang, J., Msigwa, G., Osman, A.I., Fawzy, S., Rooney, D.W. and Yap, P.S. (2022). Circular economy strategies for combating climate change and other environmental issues. *Environmental Chemistry Letters*, 21(1), pp.55-80.
204. Yawar, S. A., and Seuring, S. (2023). Inside the world of stepsiblings: Linking global production networks to sustainable supply chain management. *Business Strategy and the Environment*.
205. Yin, W., (2024). Exploring the drivers of supply chain sustainability: An internal and external configuration perspective. *Business Strategy and the Environment*, 33(6), pp.5873-5885.
206. Yu, Z., Waqas, M., Tabish, M., Tanveer, M., Haq, I.U. and Khan, S.A.R. (2022). Sustainable supply chain management and green technologies: a bibliometric review of literature. *Environmental Science and Pollution Research*, 29(39), pp.58454-58470.
207. Zaman, S.I., Khan, S.A. and Kusi-Sarpong, S. (2024). Investigating the relationship between supply chain finance and supply chain collaborative factors. *Benchmarking: An International Journal*, 31(6), pp.1941-1975.
208. Zhu, Q. and Sarkis, J. (2007). The moderating effects of institutional pressures on emergent green supply chain practices and performance. *International journal of production research*, 45(18-19), pp.4333-4355.
209. Zhu, Q., Sarkis, J., and Lai, K.H. (2013). Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices. *Journal of Purchasing and Supply Management*, 19(2), pp.106-117.
210. Zhu, Y. and Zhang, Z. (2024). Supply chain digitalization and corporate ESG

performance: evidence from supply chain innovation and application pilot policy. *Finance Research Letters*, 67, p.105818.

211. Zulu, B.M. and Singh, S.B. (2023). The National Development Plan (NDP) in South Africa: An Inspiration to Shape Communities by 2030. In *African Development and Global Engagements: Policy, Climate Change, and COVID-19* (pp. 7-29). Cham: Springer International Publishing.

APPENDIX 2: Research Questionnaire

Title: Sustainable supply chain management in the South African manufacturing industry (exploring the challenges and opportunities) employees

Dear Participant,

I am conducting research on *Sustainable Supply Chain Management in the South African Manufacturing Industry*, with a focus on exploring the challenges and opportunities within this sector. Your valuable insights will help inform the study and contribute to a deeper understanding of the current landscape and future opportunities for sustainable practices. I would be grateful if you could take a few minutes to complete the questionnaire. It is anonymous, and all responses will be kept confidential.

Questions for Employees

*** Indicates required question**

1. Demographic Information 1. Which department are you under in your company? *

Mark only one.

- Logistics Production/Operations Quality Control
- Research and Development Sales/Marketing
- Finance
- Other:

2. How long have you been working in this company? *

Mark only one.

- Less than 1 year 1-3 years
- 4-6 years
- 7-10 years
- 10 years +

3. What is your level of education? *

Mark only one.

- Matric
- National Diploma bachelor's degree Honours Degree master's degree

4. Which sector does your company primarily operate in? *

Mark only one.

**Automotive Textiles
Food And Beverages Metals and Mining Other:**

5. Where is your company based? *

Mark only one.

- Gauteng Province
- Kwa Zulu Natal Province

6. How aware are you of your company's sustainability initiatives in its supply chain operations?

Mark only one.

1 2 3 4 5

7. In your opinion, how important sustainability is supplying chain management to the future success of your company? *

Mark only one.

1 2 3 4 5

Not Extremely Important

8. Does your company actively promote sustainable practices in the supply chain, such as reducing waste or using eco-friendly materials? *

Mark only one.

Yes No

Not Sure

9. What challenges (if any) do you think your company faces in implementing sustainable supply chain practices? (Please select all that apply) *

Check all that apply.

High costs

Lack of knowledge or expertise Resistance to change

Lack of supplier collaboration Regulatory challenges

Limited advanced technology options Not sure

None

Other:

10. How involved are you, or your department, in contributing to the company's sustainability efforts in the supply chain? *

Mark only one.

1 2 3 4 5

Not Extremely involved

11. Has your company provided any training or education in sustainability practices in the supply chain? *

Mark only one.

Yes No

Not Sure

12. How well do you think your company is performing in terms of its sustainability goals within the supply chain? *

Mark only one.

Poorly

Below average Average

Above average Excellent

I am not sure

13. What kind of support or resources would you like to see from the company to improve its sustainability in the supply chain? *

Check all that apply.

More training/education

Improved technology equipment

Increased collaboration with suppliers Stronger leadership commitment

I don't know.

Questions for Industry Professionals

Part 1: Demographic Information *

1. What is your occupation?

Mark only one.

Academic/Researcher Consultant

Analyst

Policy Advisor/Regulator

- **Industry Association Representative**
- **Other:**

2. What is your level of involvement with sustainability or environmental initiatives within the manufacturing sector? *

Mark only one.

- **Not involved**
- **Slightly involved**
- **Moderately involved**
- **Very involved**
- **Extremely involved**

Part 2: Sustainable Supply Chain Management (SSCM) *

3. How important is sustainability in supply chain management to the future competitiveness of the South African manufacturing industry?

Mark only one.

- **Not important**
- **Slightly important**
- **Moderately important**
- **Very important**
- **Extremely important**

4. How would you rate the current level of adoption of sustainable supply chain practices in the South African manufacturing sector? *

Mark only one.

1 2 3 4 5
Very Very High

5. What are the primary drivers for manufacturers to adopt sustainable supply chain practices? (Select all that apply) *

Check all that apply.

- **Regulatory requirements**
- **Cost savings overtime**
- **Environmental protection**
- **Competitive advantage**
- **Pressure from international markets**
- **Corporate social responsibility (CSR)**

6. What are the key barriers preventing the adoption of sustainable supply chain practices in the manufacturing sector? (Select all that apply) *

Check all that apply.

- **High costs of implementation**
- **Lack of expertise and knowledge**
- **Limited access to advanced technology**
- **Weak regulatory enforcement**
- **Insufficient customer demand**
- **Lack of collaboration across supply chains**
- **Unclear return on investment**

7. In your opinion, how effective is the government in promoting and supporting sustainability initiatives within the manufacturing supply chain? *

Mark only one

- **Not effective at all**
- **Slightly effective**

- Moderately effective
- Very effective
- Extremely effective

8. How would you rate the regulatory framework governing sustainability in the supply chain within this country? *

Mark only one.

1 2 3 4 5

- Very Very Strong

9. What roles do international sustainability standards (e.g., ISO 14001, UN Sustainable Development Goals) play in influencing supply chain management in the South African manufacturing industry? *

Mark only one.

- No role
- Small role
- Moderate role
- Significant role
- Critical role

Part 3: Sustainability Trends and Opportunities *

10. Which sustainability trends do you believe will have the greatest impact on supply chains in the manufacturing industry over the next ten years? (Select all that applies)

Check all that apply.

- Circular economic practices
- Use of renewable energy sources
- Carbon footprint reduction initiatives
- Waste reduction and recycling
- Ethical Sourcing and fair labour practices
- Water conservation efforts

11. How likely are South African manufacturers to adopt innovative technologies to enhance sustainability in their supply chains (e.g., IoT, AI, blockchain)? *

Mark only one.

- Not likely at all
- Slightly likely
- Moderately likely
- Very likely
- Extremely likely

12. The South African manufacturing sector is making good progress toward sustainable supply chain management. *

Mark only one.

- Strongly disagree
- Disagree
- Neutral Agree
- Strongly agree

13. The cost of implementing sustainable practices is a significant barrier for manufacturers in South Africa. *

Mark only one.

- Strongly disagree
- Disagree
- Neutral

- Agree
 - Strongly agree
- 14. The integration of sustainable practices will enhance the global competitiveness of South African manufacturers. ***

Mark only one

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Questions for suppliers

1. what is your company's primary sector?

Mark only one

- Automotive Textiles
- Food and Beverage Chemicals/Pharmaceuticals
- Metals and Mining
- Other:

2. What is the size of your company? *

Mark only one

- 1-50 employees
- 51-100 employees
- 101-200 employees
- 201-300 employees
- 300+ employees

3. How long has your company been in operation? *

Mark only one.

- Less than 1 year
- 1-5 years
- 6-10 years
- 10 years +

4. Where is your company based? *

Mark only one

- Gauteng Province
- Kwa Zulu Natal Province

5. How many companies do you supply within the manufacturing sector? *

Mark only one.

- 1-5
- 6-10
- 11-20
- 20-50
- 50+

Part 2: Sustainable Supply Chain Management (SSCM) *

6. How aware are you of your customers' (manufacturing companies) sustainability requirements in the supply chain?

Mark only one.

- Not aware at all
- Slightly aware
- Somewhat aware

Very aware

Extremely aware

7. To what extent does your company consider sustainability (e.g., reducing environmental impact) when working with manufacturing customers? *

Mark only one

Not at all

To a small extent

To some extent

To a great extent

To a very great extent

Part 3: Challenges in Sustainable Supply Chain Management

8. What challenges does your company face in implementing sustainable practices while supplying them to manufacturing companies? (Select all that apply)

Check all that apply.

High implementation costs

Lack of clear communication from customers

Limited access to sustainable materials or technology

Inconsistent demand for sustainable products

Lack of expertise or training in sustainability

Regulatory constraints

Other:

9. How often do your customers ask you to meet specific sustainability criteria (e.g., use of eco-friendly materials, and reduced carbon footprint)? *

Mark only one.

Never

Rarely

Sometimes

Often

Always

10. Does your company have internal policies or initiatives aimed at improving sustainability? *

Mark only one.

Yes

No

In Development

11. Customers are increasingly demanding that suppliers adopt sustainable practices. *

Mark only one.

Strongly disagree

Disagree

Neutral Agree

Strongly agree

12. My company has the resources and expertise to meet sustainability requirements set by customers. *

Mark only one.

Strongly disagree

Disagree

Neutral Agree

- Strongly agree
- 13. The South African regulatory department provides sufficient support and incentives for suppliers to adopt sustainable practices. ***
- Mark only one.**
- Strongly disagree
- Disagree
- Neutral Agree
- Strongly agree
- 14. What kind of support would help your company better implement sustainable supply chain practices? (Select all that apply) ***
- Check all that apply.**
- Government incentives
- Industry-wide collaboration
- Access to affordable sustainable materials or technology
- Training in sustainability best practices
- Stronger regulatory framework
- Managers questions**

Part 1: Demographic Information *

- 1. What is your current job title or role within the organization?**
- 2. How long have you been working in the manufacturing industry? ***
- Mark only one.**
- Less than 1 year
- 1-3 years
- 4-6 years
- 7-10 years
- 10 years +
- 3. What is the size of your company in terms of the number of employees? ***
- Mark only one.**
- 1-10 employees
- 11-50 employees
- 51-100 employees
- 100+ employees
- 4. Which manufacturing sector does your company operate in? ***
- Mark only one.**
- Automotive
- Clothing and Textiles
- Food and Beverage
- Metals and Mining
- Other:
- 5. Where is your company based? ***
- Mark only one.**
- Gauteng Province
- Kwa Zulu Natal Province
- 6. what is your level of education? ***
- Mark only one.**
- Matric
- Diploma

- Bachelor's Degree
- Honor's Degree
- master's degree

7. What is your company's annual turnover? *

Mark only one.

- Less than R10 million
- R10 million –
- R50 million
- R50 million – R100 million
- More than R100 Million
- I am not sure

8. What are the key challenges your company faces when implementing * sustainable practices in your supply chain? Please elaborate on any specific operational, financial, or organizational constraints.

9. How has your organization integrated sustainability into its supply chain * operations? Please provide examples related to sourcing, production, distribution, or other areas.

10. How does your company collaborate with suppliers to ensure sustainability * across the entire supply chain? What challenges do you encounter in this collaboration?

11. How has the regulatory department influenced your company's approach to * sustainable supply chain management? Are there any specific regulations that have posed challenges or opportunities?

12. What role does customer demand play in your company's decision to adopt * or expand sustainable supply chain practices?

13. How has your company addressed the issue of waste management in its * supply chain operations.

14. How has your organization adapted to global trends in sustainability, such * as reducing carbon emissions, using renewable energy, or promoting circular economy practices?

15. What strategies do you believe the manufacturing industry should prioritize * to foster greater sustainability across supply chains?