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Sustainable Supply Chain and Business Efficiency: The Impact of Strategy, Digital Transformation, Supply Chain Resilience, and Green Human Resource Management

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Abstract

This study examines how sustainable supply chain practices affect business performance, where operational performance is one of the mediating variables. Particularly, it aims to explore how supply chain strategy (SCS), digital transformation (DT), supply chain resilience (SCR), and green human resource management (GHRM) collectively lead to organisational outcomes. The literature review showed that traditional supply chain models have been subject to major inefficiencies that are a result of recent disruptions in the world and pressure on the environment. Among the most important thematic areas, there will be the role of SCS as a comprehensive plan of monitoring activities, digital transformation, and integration of advanced technologies such as AI and ERP, and flexibility and recovery as the issues SCR is concerned with. In addition, the review examines the way in which GHRM integrates environmental values in recruitment and training to facilitate employee sustainable commitment. Besides, the study was a primary research study that used a quantitative research methodology to test hypothesised connections between quantifiable variables. Evidence was gathered based on a five-point Likert scale, with 101 valid responses to the questionnaire. The results were processed with the assistance of the two-step Partial Least Squares Structural Equation Modelling (PLS-SEM) of SmartPLS that comprised the testing of the measurement model, including the reliability and validity, as well as testing of the structural model. According to the analysis, it is possible to note that the most considerable positive impact is that of Supply Chain Strategy (0.369, $p = 0.001$) and then Green HRM ($\beta = 0.183$, $p = 0.041$). Remarkably, the direct effects of digital transformation and supply chain resilience on the operational performance were not statistically significant in this sample. However, operational performance was observed to be a strong and influential source of efficiency in the business ($\beta = 0.560$, $p = 0.001$). The validation of the hypothesis of indirect effect testing established that SCS and GHRM are effective in positively influencing the efficiency of the business by first increasing its

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operational reliability and flexibility. The result that improved operational outcomes are followed by high efficiency at the business level indicates that OP can be used as the endogenous mediator.

CHAPTER 1: INTRODUCTION

Research Background

Recent disruptions, environmental pressures, and digitalisation exposed major inefficiencies in traditional supply chain models, requiring firms to adopt sustainable supply chain strategies to increase business efficiency. Raj et al. (2020) stated that the pandemic and its aftermath exposed the need for a strong supply chain strategy, as many businesses faced disruptions due to raw material shortages and shifts in consumer demand. As per IBM (2023), it was reported in one of the survey conducted in the year 2023 that around 44% of the organisation had to make major structural changes due to supply chain footprint and its challenges, and 49% said supply chain disruptions had caused planning problems. As observed in Figure 1 of Archive Market Research (2025) below, the global supply chain management market is predicted to reach USD 48.90 billion by 2032, with an expected CAGR of 11.2%, driven by faster digitalisation and a growing reliance on cross-border networks.

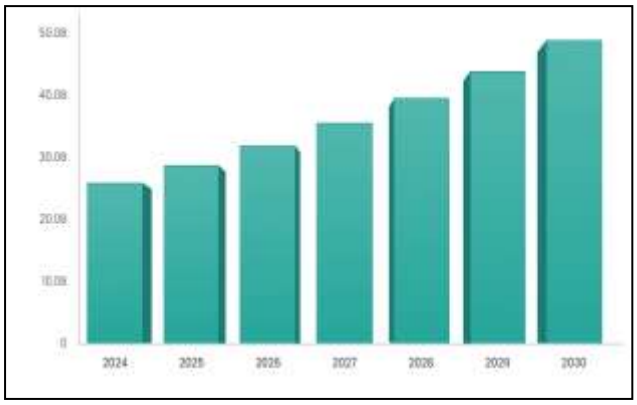

Figure 1 Supply Chain Market

Source (Archive Market Research, 2025)

A sustainable supply chain is one that fully integrates ethical and environmentally friendly practices in its competitive and successful model. End-to-end supply chain transparency is critical, and sustainability efforts should not be limited to sourcing raw materials and the supply chain up to final delivery, but also to product delivery, returns, and recycling (SAP, 2024). Further, Rennie (2024) defined supply chain strategy (SCS) as an overarching plan for the planning, design, execution, control, and monitoring of supply chain activities. It directs effective operations and initiates initiatives that deliver key performance indicators. Likewise, Digital transformation (DT), as opposed to manual, fragmented processes, enables organisations to incorporate advanced technologies. As per Mhaskey (2024), these technologies include artificial intelligence (AI), enterprise resource planning (ERP) systems, big

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data analytics, and Internet of Things (IoT) to improve transparency, coordination, and decision-making in the supply chain. Similarly, when efficiency-focused supply chains strive to reduce costs, supply chain resilience (SCR) focuses on flexibility, adaptability, and recovery, enabling firms to respond to shocks associated with demand instability, global crises, or operational failures.

Further, Green Human Resource Management (GHRM) incorporates environmental values into recruitment, training, performance appraisal, and reward systems, unlike traditional human resource management, which focuses on productivity and cost control. Agyabeng et al. (2021) stated that GHRM promotes environmentally responsible and cost-effective practices in the supply chain by promoting awareness and skills, as well as commitment of employees towards sustainability. In combination with supply chain resilience, digital transformation, and GHRM, supply chain strategy drives better operational performance (OP) through cost efficiency, quality, flexibility, and delivery reliability (Oteri et al., 2023). Improved operational performance, in turn, can be viewed as one of the primary mechanisms by which organisations can achieve greater business efficiency (BE) and long-term sustainable performance.

The correlation between these variables is both strategic and operational since the direction of the supply chain is determined by the strategic decisions conducted, and operational practices determine whether they are effectively implemented and performed or not. Effective supply chain policies can inform long-term decision-making and efficient resource allocation, while digital transformation results in transparency, speed, and accuracy in supply chain activities (Li, Chen, and Guo, 2025). Supply chain resilience provides operational continuity and flexibility during disruptions that reduce losses and risks. Simultaneously, Saeed et al. (2019) noted that GHRM enhances employees' willingness to engage in sustainability initiatives, thus enabling responsible and efficient working practices. Collectively, these factors contribute to better operational performance, serving as a critical mediating mechanism by streamlining resource use, minimising waste, enhancing productivity, and, eventually, converting sustainable supply chain operating practices into increased business efficiency.

Although sustainability-based supply chain practices have increasingly gained significance, there have been very few empirical studies on how strategic, technological, resilience, and human resource factors interact to drive business efficiency through operational performance. Hence, the study is required to deliver an integrated insight into the way these dimensions collectively contribute to sustainable business performance in contemporary organisations. Thus, globalisation is occurring at a fast rate, as climate policies, and pressure of stakeholder are forcing organisations to re-architecture their supply chains into integrated sustainability and efficiency-based operational designs.

Problem Statement

Although organisational investment in sustainable supply chain practices has increased, most firms remain weak at converting these efforts into sustained

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operational performance and measurable business efficiency. In practice, supply chain strategy, digital transformation, supply chain resilience, and green human resource management are often implemented separately, leading to disjointed decision-making and suboptimal performance. Organisations often implement digital technologies without a plan to integrate them into a strategic supply chain, invest in resilience after disruptions occur, or apply green HR practices symbolically rather than embed them as operational processes (Gill Ahmad and Kazmi, 2021; Amjad et al., 2021). Consequently, managers do not have explicit, evidence-based guidance on how to put together sustainability practices to enhance cost efficiency, quality, flexibility, and delivery reliability.

Moreover, operational performance has frequently been viewed as an objective rather than a process by which sustainable supply chain efforts impact business efficiency. This presents a practical challenge for organisations seeking to rationalise sustainability investments based on actual performance results. Studies like (Xie et al., 2019; Shad et al., 2019) have highlighted that, without a cohesive strategy, companies cannot achieve the full benefits of sustainability-oriented supply chains, at least in terms of operations and competitive edge. This problem becomes especially clear in emerging, diverse industrial settings, where limited resources, low digital maturity, and poor cross-functional coordination become obstacles to implementation. The lack of a coordinated operational model prevents practitioners from understanding how the supply chain strategy, resiliency, digital transformation, and green human resource management work together to enhance business efficiency. There is also lack of cohesive operational structures thereby restricting the capacity of organisations to convert sustainability initiatives into uniform efficiency based performance outputs.

Thus, the main problem this research aims to address is the absence of an integrated, empirically validated approach to explain how sustainable supply chain practices can be operationalised and aligned to achieve business efficiency, with operational performance as the key connecting mechanism.

Research Aims and Objectives

Research Aim

This study aims to examine the impact of sustainable supply chain practices, specifically supply chain strategy, digital transformation, supply chain resilience, and green human resource management, on business efficiency, with operational performance acting as a mediating variable.

Research Objectives

To examine the impact of supply chain strategy on operational performance and business efficiency.

To assess the influence of digital transformation on operational performance and business efficiency.

To analyse the supply chain resilience role in improving operational performance and business efficiency.

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To evaluate the influence of green human resource management practices on operational performance.
To examine the mediating role of operational performance in the relationship between business efficiency and sustainable supply chain practices.

Research Significance

This research is important to academia, industry, and practitioners as it enhances the theoretical and practical implementation of sustainable supply chain management. Academically, the research can contribute to the current literature by formulating and executing an integrated framework that connects the supply chain strategy, digital transformation, and supply chain resilience, with green human resource management to business efficiency through the mediating factor of operational performance. The collective study of these variables, as opposed to studying them individually, fills an important knowledge gap in sustainability and supply chain research and provides additional insight into how sustainable practices produce higher efficiency outcomes. The findings can also be used in further research and the formulation of future theories in the field of sustainable operations and strategic supply chain management.
On the industry side, the study can provide evidence-based information on how organisations can enhance efficiency and achieve sustainability objectives. The findings can assist the firms in recognising the strategic significance of integrating digital technologies, resilience planning, and green human resource approaches in the supply chain operations. It can help in informed decision-making when it comes to the priorities of investment, process redesign, and sustainability initiatives. Finally, to practitioners such as supply chain managers and policymakers, the work offers practical recommendations towards the development of resilient, digitally empowered, and environmentally conscious supply chains. These results can help practitioners convert sustainability strategies into operational and efficiency gains to support competitive advantage in the long term and the sustainability of business performance. The research eventually enhances the process of managerial decisions by clarifying the way in which sustainability-oriented supply chain capabilities are transformed to quantifiable efficiency gains.

Research Structure

This research is structured into six sections as discussed below.
Section 1: This section discusses the research background, problem statement, aim, and objective of the research with its significance.
Section 2: The literature review section critically analyses the existing literature available, key concepts, findings, and identifies gaps.
Section 3: The methodology section explains the chosen techniques and tools with justifications, used for gathering the data.
Section 4: The results/findings section presents the data that was collected.
Section 5: In the discussion section, the interpretation of the findings was done.
Section 6: The last conclusion section summarises the key findings and offers recommendations.

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CHAPTER TWO: LITERATURE REVIEW

Introduction

This chapter of research dissertation is based on the review and synthesis of the previous and existing research. As per Snyder (2019), a well-executed and compelling review as a means of research establishes a solid base on which further knowledge and theory development are possible. This section is a critical review of the literature on sustainable supply chain management and business efficiency. It offers both theoretical and empirical backgrounds to explore how supply chain strategies, digital transformation, supply chain resilience, and green human resource management affect business efficiency, with Operational performance as a mediating variable.

Supply Chain Strategy and Operational Performance

Supply chain strategy (SCS) is commonly understood as a core process under which organisations align supply chain operations with business objectives, competitive priorities, and sustainability goals. Tien, Anh, and Thuc (2019) argued that a successful supply chain strategy offers long-term guidance via integrating procurement, product creation, logistics, and distribution choices into a cohesive structure that benefits organisational performance. A study indicates that strategically aligned supply chains promote operational performance through the creation of cost efficiency, quality consistency, flexibility, and dependability in delivery (Anwar et al., 2021). In addition, a well-defined supply chain strategy helps organisations respond in advance to market changes and mitigate risks, which can make operations more stable and competitive in the long run.

Some researchers underline that strategic planning and coordination among the partners of the supply chain minimise the inefficiency and redundancy of operations (Shehkhar, 2023; Tarigan, Siagian, and Jie, 2021). To illustrate, lean and agile supply chain models have been proven to lower operational costs and improve customer responsiveness. Additionally, collaborative strategies also enhance information exchange and process integration with partners, leading to increased flexibility and reliability in performance delivered by partners. Moreover, the supply chain strategic alignment facilitates the process standardisation of long-term capacity plans and minimises uncertainty and enhances coordination between functional units (Anwar et al., 2025). This kind of alignment allows organisations to align demand and supply decision-making more efficiently and comes with increased stability of operations, shorter lead times, and stability in performance that occur irrespective of the dynamism of market environments.

On the contrary, critics, like Kale et al. (2024), have claimed that much of the strategy-related literature places excessive emphasis on cost efficiency and tends to ignore dynamic, uncertain environments in which modern supply chains operate. As a result, all-efficiency-based strategies may be rigid in the face of disruption. The sustainability concept has been introduced to the supply chain strategy in recent literature, implying that environmentally and socially responsible operations could be combined with high operational performance. Research indicates that long-term strategic orientation allows companies to achieve a balance between economic goals

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and environmental responsibility through a more effective use of resources and reduced waste (Bhutto, 2024; Challoumis, 2024).

However, studies are inconsistent on this issue, with some showing that a sustainability-focused strategy leads to a rise in the cost of operation, especially in resource-constrained settings. Even though the topic of supply chain strategy has been widely discussed, it is evident that there has been limited research in empirical studies that examines the interactive effect of strategy on other sustainability-focused drivers. Additionally, as a mediating mechanism, operational performance is not often analysed. Strategic alignment also helps companies to align demand planning, capacity utilisation, and supplier coordination and minimise variability in operations. This coherence promotes predictability in the processes, reduces cycle time, and develops compliance in execution in the functions of the supply chain. This highlights the relevance of holistic models in linking supply chain strategy to business effectiveness through operational performance.

Digital Transformation in Supply Chains

Digital transformation (DT) has become one of the key sources of efficiency and competitiveness in modern supply chains, with organisations becoming more complex, global, and uncertain about the market. As Mhaskey (2024) emphasised, the developments of the modern digital technologies like artificial intelligence (AI), enterprise resource planning (ERP) systems, big data analytics, and the Internet of Things (IoT) altered the manner in which the operations of the supply chains are planned, followed, and controlled. The reviewed literature suggests that the digital transformation has the potential to enhance supply chain visibility due to the possibility of gathering real-time data and exchanging information with supply chain partners (Alonge et al., 2024). This then enhances the levels of coordination and operational responsiveness.

Research indicates that digital technologies enable more accurate demand forecasting and recording of stock, fewer excess stocks, lower operational costs, and improved services. As an example, Badmus (2024) stated that the trends of customer demands and supplier effectiveness can be detected with the help of AI-based analytics and large data analytics, and help companies to make informed decisions at a faster pace. Likewise, the ERP systems combine different functional areas within the supply chain and lead to process standardisation and reducing manual errors (Agbelusi et al., 2024). Consequently, the digital transformation is directly connected to improvements in operational performance dimensions, such as cost effectiveness, flexibility, quality, and delivery reliability.

The literature, however, also points out that the advantages of digital transformation are not always delivered. Researchers such as Koczerga (2024) also proposed the idea that the implementation of digital technologies might fail to lead to performance unless these technologies are implemented with strategic plans and organisational preparedness. High implementation cost and the absence of technical expertise and employee resistance to change may limit the extent of the effectiveness of the digital initiatives, particularly among small and medium-sized businesses. Additionally,

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excessive dependence on digital systems may bring new risks, including cybersecurity breaches, and system barriers have the potential to impact supply chain sustainability and operational effectiveness in a negative way. As noted by Alquraish (2025), the digital transformation trend was critical to improving the ability of supply chains to be more resilient and sustainable. Digital technology increases transparency and traceability and assists organisations in monitoring the effect on the environment and maintaining the criteria of sustainability.

Despite these developments, much of the existing literature is technology-centric and focuses on adoption rates, rather than analysing how digital transformation interacts with strategic, human, and resilience-related variables. Although the literature on the subject is vast, empirical studies are missing on the role of digital transformation in an integrated sustainable supply chain model. The moderating effect of the operation performance is not well researched. In addition to automation, digital transformation promotes the use of data to make decisions and cross functional integration. Predictive analytics and real-time dashboards would be used to help improve operational control and allow them to respond proactively to demand variability and process inefficiencies in interrelated supply networks. This introduces a need to conduct intensive research in linking digital transformation to business efficiency as per the operational performance.

Supply Chain Resilience and Business Performance

Resilience is an increasingly significant concept of research in supply chain because of the increasing number of global disruptors such as pandemics, geopolitical tensions, natural disasters, and demand instabilities. Diaz (2024) defines supply chain resilience as the capability of a supply chain to predict, adapt, and recover during disruptions, including natural disasters, pandemics, or other unforeseen situations. The existing literature is highly inclined towards establishing the fact that resilient supply chains can prove beneficial in terms of business performance in the context of minimising vulnerability and increasing reliability. A study by Deloitte (2024) established that the supply chains of the firm that are robust provide operations with stability, faster recovery speeds, and allow the businesses to retain their services in case of any disruption. The most important drivers of resilience are regarded as flexibility, redundancy, risk diversification, and good collaboration with suppliers and logistics partners. Such abilities enable the business to continue with the production process, meet the demands of customers, and protect its bottom line, that can improving the overall performance of the business. This has contributed to the growing view of resilience as a strategic resource, as opposed to an operational response mechanism.

Moreover, Riad, Naimi and Okar (2024) noted that digital technologies, such as data analytics, artificial intelligence, and real-time visibility systems, also strengthen resilience in supply chains by enabling the detection of risks and the ability to make decisions before time. Resilience is incorporated in the strategic planning process to help in long-run competitiveness, increase confidence, and ensure the preservation of market share. It is resilience that not only neutralises the short-term disturbance but also supports long-term organisational performance and business survivability in

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highly volatile and turbulent foreign markets. However, the literature contains critical arguments about the trade-offs of the supply chain resilience. Scholars like Dzreke and Dzreke (2025) argued that redundancy, buffer stock, and alternative suppliers' influx can make business operations more expensive and less efficient in the short-term. This has resulted in conflicting empirical findings; some studies claim positive performance effects, and others indicate that returns to high resilience investments diminish (Matos et al., 2020). Recent studies have started considering the combination of resilience and digital technologies and sustainability efforts, proposing that digital visibility and sustainable supplier relationships improve adaptive capacity (Abourokbah, Mashat, and Salam, 2023).

Despite this advancement, the literature is still fragmented and usually context-dependent, and it is difficult to make broad generalisations across industries and regions. Despite ample evidence connecting supply chain resilience to business performance, scarce literature exists to explore resilience in an integrated, sustainable supply chain. Also, the mediation of operational performance has not been studied well. Strong organisational learning is also enhanced by having resilient supply chain which in turn inculcates the risk awareness to planning routines. This learning orientation enhances recovery rate and makes a long lasting performance without inefficiencies of the operations. This underlines why effective empirical research linking resilience and business performance in terms of operational performance is required.

Green Human Resource Management and Sustainable Operations

The concept of Green Human Resource Management (GHRM) has also become a growing theme in sustainability and operations management literature as organisations have acknowledged the importance of human capital in goal realisation in relation to both environmental and operations. As per Molina et al. (2024), GHRM is defined as the alignment between traditional human resource practices (such as training and performance appraisal) and environmental policies and objectives. It includes green recruitment, training, performance appraisal, reward systems, and employee involvement.

Available literature reveals that GHRM helps organisations to integrate sustainability in the organisational culture and day-to-day operations that help to achieve sustainable performance in the long run. Moreover, Susita and Murdiono (2024) claimed that green recruitment and training enhance the environmental awareness, skills, and competencies of employees. It enables them to adopt green work practices that promote efficiency in operations. As an illustration, waste minimisation, energy conservation, and resource optimisation training programmes can help minimize the cost of operation and increase the efficiency of the processes. Similarly, reward systems and performance appraisal rewarding environmentally responsible behaviour are also used to encourage employees to engage in sustainable initiatives, making them more committed to organisational operations that are sustainable.

In contrast, the GHRM practices have been critically perceived and reflected in the literature as well. Huo et al. (2020) suggested that GHRM initiatives may not produce

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an effect unless they are supported by top management and are strategically aligned. In such a situation, green practices have no significant impact on employee behaviour and cannot affect the results of operations. Additionally, GHRM sometimes necessitates huge investment in training and system redesign, which small and medium enterprises may find difficult due to limited resources. Recent studies demonstrated GHRM as a tool to support sustainable supply chain activities by collusion, creativity, and enhancement preserved among employees. (Eyo, Odimarha, and Ejairu, 2024; Holloway, 2024). The GHRM practices have also been associated with enhanced quality, flexibility, and responsiveness operational performance indicators, which are the major demands of sustainable supply chain management.

But empirical evidence is not consistent and varies across industries and national settings. Despite the growing academic interest in GHRM, most of the existing researches examine it separately instead of examining it in its connection with other supply chain attributes such as digital transformation and resilience. When employees are motivated to carry out sustainability programmes, operational practises will be improved constantly. Green engagement increases compliance, innovativeness, and accountability that help organisations to meet environmental objectives without disrupting operational consistency and productivity. There is also a limited understanding of the mechanisms through which GHRM influences business performance and efficiency.

Operational Performance and Business Efficiency

The operational performance has been regarded as one of the most imperative determinants of organisational success as well as a direct business efficiency contributor. Dimensions that are traditionally utilised to measure operational performance in both operations and supply chain management encompass cost efficiency, quality, flexibility, responsiveness, and reliability of delivery. These dimensions are used to show how well an organisation is using its resources and simultaneously satisfying its customers. Oteri et al. (2023) highlighted that strong operational performance makes firms produce at a higher level of productivity, waste minimisation, and stable operation costs, leading to business efficiency and sustainability. Cost control has been cited as one of the cornerstone components of operational performance. Olaniyi and Pugal (2024) noted that effective cost management through efficient processes, inventory optimisation, and waste reduction allows organisations to improve margins without compromising service quality. Companies with greater cost efficiency are in a stronger position to invest in innovation and sustainability initiatives, thus enhancing long-term competitiveness. However, researchers warned that excessive cost minimisation can negatively impact flexibility and resiliency, suggesting that the operation should be balanced (Kamalahmadi et al., 2022).

Quality performance is another business efficiency motivation aspect since the result of quality output will reduce rework, returns, and complaints by customers. The increase in productivity and customer satisfaction is always associated with quality improvement initiatives such as standardisation of processes and continuous

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improvement programs through research (Koval, Nabarese, and Chromjaková, 2019). Consistency of delivery and responsiveness enhances business efficiency by enabling firms to satisfy customers' expectations and respond positively to changing market needs. The responsive and flexible operations minimise lead times and boost service levels, which subsequently lead to customer loyalty and revenue stability. Despite the established theoretical framework, the available literature gives conflicting evidence as to whether operational performance is directly related to business efficiency. Caiado et al. (2019) indicated that operational measures do not always come with financial outcomes, particularly in cases where operational investments are not in tandem with the strategic objectives. This brings out the importance of shaping the notion of the operational performance not merely as an outcome but as a process whereby the strategic and sustainability-focused practices affect the business efficiency.

Recent research postulates that a supply chain strategy, digital transformation, resilience, and green human resource management are determinants of business efficiency that are mediated by operational performance. According to Sankala (2024), operational performance is one of the essential business efficiency drivers, and its operational moving requires its alignment with strategic alignment and harmonisation with the entire organisational capacity. This serves to reinforce the fact that the integrated empirical research on the operational performance is an important channel through which the sustainable practices within the supply chains help the efficiency of long-term business. Despite the extensive body of work on operational performance and business efficiency, the two are typically discussed as a pair of variables in the literature. Empirical studies that describe operational performance as a mediating variable in which sustainable supply chain practices influence business efficiency are lacking. The findings have also not been consistent or exhaustive across sectors and contexts, which diminishes the ability to generalise. Operational performance is a conversion process, which handles strategic intention into actual efficiency benefits. In the absence of proper operational implementation, sustainability investments can only be symbolic and do not create quantifiable economic value. This highlights the need to engage in a combined empirical study, which tests the mediational role of operational performance in the context of sustainable supply chain systems.

Sustainable Supply Chain Practices and Business Efficiency

Sustainable supply chain practices have become relevant because organisations are increasingly struggling to manage economic performance and build a balance between environmental and social responsibilities. Nweje and Taiwo (2025) demonstrated that sustainable supply chain management considers environmental stewardship, ethical sourcing, and operational efficiency throughout the chain of supply, the procurement and production, distribution, returns, and recycling. Sustainability-oriented supply chain has ceased to be viewed as an expenditure but as a strategic asset, which is leveraged to enhance the efficiency and competitiveness of businesses over time. Further, Ezekwu (2025) highlighted that sustainable supply chain practices contribute to making businesses more efficient by reducing resource utilisation, wastes and

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shortening operations. Environmentally responsible sourcing and production processes, such as energy-saving production and waste reduction, have been linked to reduced operating costs as well as improved asset utilisation. These efficiencies assist organisations to maximise resource use without interfering with regulatory and stakeholder expectations. Sustainable logistics, such as green transportation and optimised distribution networks, improve cost efficiency and performance of delivery. As a strategy, sustainability-based supply chains promote organisational reputation and customer confidence, thus indirect business efficiency through improved market positioning and customer retention. Researchers like Tarigan et al. (2021) have claimed that firms with sustainable supply chain approaches are more likely to get more coordination and collaboration with suppliers and partners. It contributes to enhanced information sharing, minimised disruptions, and enhanced stability of the operations. This collaborative approach supports efficient processes and credible supply chain flows, which increases productivity and service levels. Quite to the contrary, the literature reports severe difficulties and conflicting results, too. As an example, Cousins et al. (2019) observed that sustainable supply chain operations may increase the costs of operations at the beginning because of the investments in green technologies, development of suppliers, and employee training. These are short-term financial stress factors that can diminish the perceived business efficiency, particularly among organisations with resource limitations.

Recent research has emphasised operational performance as the process by which sustainable supply chain practices determine business efficiency. Kumar et al. (2020) stated that cost control, quality, flexibility, and delivery reliability have been identified as ways in which sustainability efforts are translated into quantifiable efficiency improvements. However, most of the literature addresses sustainability and efficiency as direct outcomes without considering the interdependencies among strategic, technological, and human resource issues. The literature on the positive relationship between sustainable supply chain practices and business efficiency is fragmented and has not been integrated into a single empirical model. The integrated sustainability practises improve the standardisation of the processes and their coordination at different stages of the supply chain as well. The duplication is minimised, the use of resources is enhanced, and scalable efficiency enhancement across organisational boundaries is supported by this integration explicitly. This necessitates thorough investigations that explore the roles of multiple sustainability-based practices in jointly improving operational performance and business efficiency, and that provide clearer guidelines for researchers and practitioners.

Theoretical Frameworks

Resource-Based View (RBV)

Barney (1991) was the first to propose the Resource-Based View (RBV). RBV argues that the ability of an organisation to maintain a competitive advantage and high performance is based on the presence and utilisation of inimitable, non-substitutable, rare, and valuable (VRIN) resources (Tifani et al., 2020). The main strength of RBV is that it attempts to answer the question why different firms in the same industry may

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have different performance results. It provides a strong explanatory approach to the heterogeneity of performance and long-term effectiveness through mobilisation of internal assets, which include capabilities, knowledge, systems and human capital. Another benefit of RBV is that it can be applied in a range of organisational settings and strategic problems- operations and supply-chain management. The theory emphasised the intangible assets which include technological expertise, supplier relationships, and individual capabilities of employees which are requisite in sustaining operational excellence and sustainability. However, there are notable shortcomings of RBV, with critics stating that it presumes a static viewpoint and provides a responsible record of how businesses adapt their resources in dynamic and unpredictable environments (Kero and Bogale, 2023). Further, RBV fails to capture the role of external factors like market turbulence, disruptions, and institutional pressures, which are relevant in modern global supply chains. Despite constraints, RBV could be highly valuable in the current study. The concept of sustainable supply chain can be conceptualised as a strategic organisational resource with references to the supply chain strategy, digital transformation, resilience capabilities, and green human resource management. These resources increase the scope of operational performance, like cost-efficiency, flexibility, quality, and delivery reliability; all of this increases business efficiency when used appropriately. RBV also describes the means in which sustainability-based supply chain capabilities can take the form of strategic resources when incorporated into organisational routines, as it allows firms to use the internal resources to achieve a greater operational performance and efficiency benefits in the long run. Operational performance in this respect is a procedure through which internal resources are transformed into efficient products, and this is the reason why RBV is a proper theoretical framework in this study.

Dynamic Capability Theory

Dynamic Capability Theory, which is a developed extension of RBV pioneered by Teece, Pisano, and Shuen (1997), is concerned with a firm's capacity to integrate, build, and redesign internal and external capabilities in response to a swiftly evolving environment. The major advantage of this theory is that it lays emphasis on adaptability, learning, and innovation, and as such, it is more appropriate to use it to examine organisational performance in the face of uncertainty. The ability to sense opportunities, seize resources, and transform operations is a dynamic capability that enables a company to keep up with a volatile and complex supply chain environment.

The other positive aspect of the Dynamic Capability Theory is that it applies to technological change and resilience. It details what organisations can continue to do to transform their working processes through the use of digital technologies, strategic flexibility, as well as responsive human resource practices. However, the theory is not without its limitations as it faced criticism regarding its conceptual ambiguity and difficulty in empirical testing (Posen et al., 2023). The theory also does not provide instructions on operational terms of developing such capabilities systematically, causing discrepancy on empirical findings.

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In the context of the current research, Dynamic Capability Theory is useful to describe how organisations adjust to disruptions and sustainability pressures. Dynamic capabilities entail supply chain resilience, digital transformation, and green human resource management, which enable companies to modify operations and restructure processes to stay in operation during change. Dynamic Capability Theory emphasises the significance of constant reorganisation of supply chain, technological and human resources so that organisations are able to maintain operational effectiveness and efficiency in the face of uncertainty in the environment and faster changes in the market. The success of these adaptive capabilities in operation is a moderating measure of operational performance. Therefore, Dynamic Capability Theory supplements the RBV because it determines what organisations possess, in addition to how they are continually realigned to facilitate the efficiency of their businesses in a consistent supply chain.

Conceptual Framework

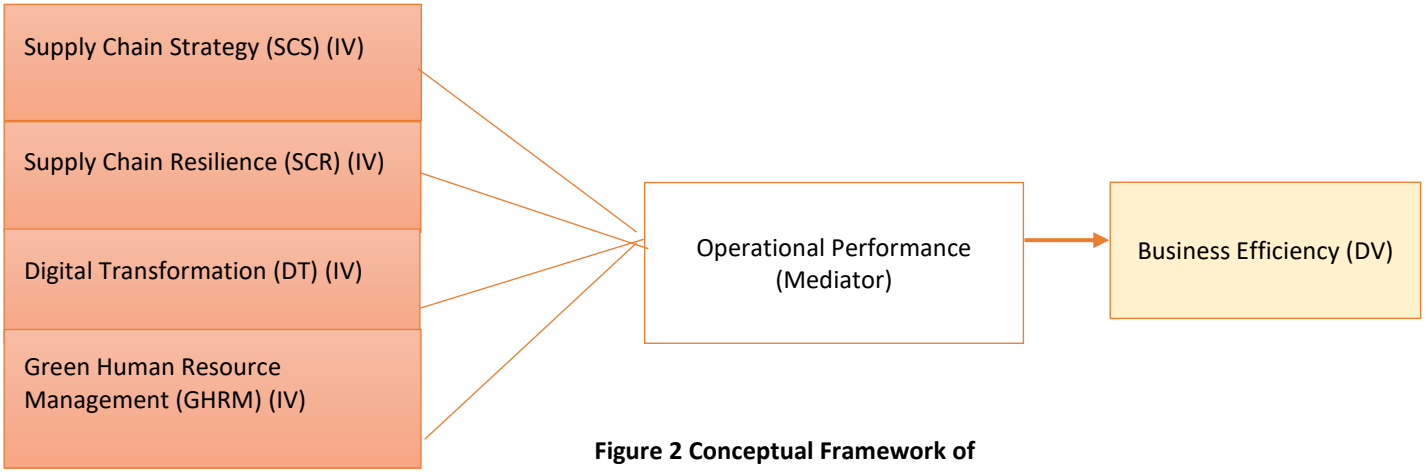

Figure 2 Conceptual Framework of Research
Source: Author's own

This conceptual framework outlines how sustainable practices in the supply chain impact business effectiveness by connecting different variables. The independent variables, such as supply chain strategy (SCS), supply chain resilience (SCR), digital transformation (DT), and green human resource management (GHRM), are the methods that numerous businesses apply to make their supply chains better. These do not have a direct relationship to each other, but rather they are complementary to each other and interrelate. SCS is focused on the alignment of the supply chain with the overlay of business and strategic perspective of the firm, as compared to SCR, which is focused on the system capacity to respond to sudden challenges and disruptions. Moreover, DT allows becoming more efficient and faster as it incorporates advanced technologies, including AI, IoT, ERP, and big data.

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Finally, GHRM also incorporates a sustainability perspective into the strength of its workforce by focusing on green recruitment, training, and employee engagement.

The Operational Performance (OP) is the Mediator that affects these independent variables. This means that operational performance capabilities (such as responsiveness, flexibility, quality, and cost efficiency) are strengthened by strategy, resiliency, and immense utilisation of technology and green HR practices. This model further reveals that sustainable supply chain practices can be a major source of competitive advantage that can help organisations to become more efficient and adaptable. It stresses the necessity of establishing resilience, strategic alignment, and digital capability during times of uncertainty, operational excellence, which may play a part in long-term organisational expansion and sustainability.

Literature Gap

Irrespective of the fact that the literature on sustainable supply chain management and organisational efficiency has been vast, there is still a significant gap. To a large extent, existing studies have demonstrated a tendency to concentrate on individual factors, such as supply chain strategy, digital transformation, supply chain resilience, and green human resource management. This strategy inhibits an overall comprehension of the interrelation between these practices that focus on sustainability and how they can mediate organisational performance. As a result, the synergies between strategic, technological, resilience, and human resource aspects of the supply chain are under-investigated.

Moreover, although operational performance is widely recognised as a critical determinant of business efficiency, there is a lack of research that explicitly examines its role in mediating sustainable supply chain practices and organisational effectiveness. The majority of research is inclined toward a direct relationship, disregarding the processes by which strategic, technological, and human resource efforts influence business outcomes. Additionally, operational performance has been more of a direct outcome rather than a mediating mechanism.

Empirical literature has few studies that have been conducted to examine the transmission channel by which operational performance dimensions like cost efficiency, quality, flexibility and delivery reliability can be used as a transmission channel through which sustainable supply chain practices can influence business efficiency. This is a theoretical gap, considering that it limits a process-level interpretation of value creation. Lastly, there is a critical shortage of integrated, empirically proven models, especially in emerging and diverse industries, where digital maturity, available resources, and organisational capabilities stand in stark contrast to those of developed economies. This limits the generalisability of the findings.

To address these gaps, the current study hypothesises and empirically tests an integrated framework that examines the combined effects of supply chain strategy, digital transformation, supply chain resilience, and green human resource management on business efficiency, with operational performance as a central

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mediating variable. The approach enhances theory and practice by offering a more holistic, mechanism-based view of sustainable supply chain performance.

Chapter Summary

In summary, this chapter has discussed the major theories and empirical research on sustainable supply chain practises and efficiency in the business. It determined the functions of strategy, digital transformation, resilience and green HRM and operational performance is one of the key mediating processes and it formed clear research gaps addressed by this study explicitly.

CHAPTER THREE: RESEARCH METHODOLOGY

Introduction

Research methodology is the systematic method that is implemented to plan, design and conduct research to respond with ease and reliability towards research aim and objectives. The significance of research methodology is that it enhances validity, reliability and credibility of the findings (Kapur, 2019). Considering that, this section provides justification for tools and techniques that were used to collect data about analysing the impact of sustainable supply chain practices. It focused on specifically supply chain strategy, digital transformation, supply chain resilience, and green human resource management, on business efficiency, with operational performance (as a mediating variable). This includes sections on research philosophy, research approach, research design, data collection, sample size and technique, data analysis and ethical considerations.

Research Philosophy

The beliefs of how a research study produces, studies and perceives knowledge is the research philosophy. The main philosophies of research include positivism, interpretivism, realism and pragmatism (Saliya, 2023). The philosophy of research adopted in this study was positivism. The study was intended to be a primary quantitative study aimed at testing hypothesised relationships between clearly defined variables. This philosophical stance was appropriate for the present study because it focused on exploring the effects of a supply chain strategy, digital transformation, supply chain resilience, and green human resource management on operational performance and business efficiency. Those constructs were treated as measurable variables, and relationships of interest were studied objectively and statistically.

Park, Konge and Artino (2020) stated that positivism assumes that reality is objective and can be measured through observable facts using scientific methods. Further, positivism and its main concerns with generalisation and testing were consistent with the theoretical construction of the study, thus it was the foundation of the study. The study was designed to confirm existing theoretical assumptions about sustainable supply chain practices and their impacts on organisational outcomes, and it did not focus on subjective insights or individual experiences. The use of structured data collection guaranteed uniformity among the respondents and assisted in the minimisation of researcher bias, which is a fundamental requirement of the positivism.

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The philosophy enabled the examination of operational performance as a mediating process through which strategic, technological, and human resource-based practices were transformed into business efficiency by studying cause-and-effect relationships. On the contrary, an alternative philosophy considered was interpretivism, which centres on subjective meanings and the social construction of reality (Pervin and Mokhtar, 2022). However, interpretivism was not selected because the objectives of this study did not involve exploring individual perceptions or situational narratives. Thus, positivism was considered the most suitable research philosophy, as it effectively supported the research's quantitative nature, variable-based structure, and explanatory purpose.

Research Approach

A research approach is a rational structure that defines how a study would be carried out and how theory would relate to data collection and analysis. The two-research approaches frequently employed are deductive and inductive (Kumar and Ujire, 2024). Considering this, the study adopted a deductive research approach and was conducted as primary quantitative research. A deductive approach was considered appropriate, as the study was to test existing theoretical relationships among supply chain strategy, digital transformation, supply chain resilience, green human resource management, operational performance, and business efficiency. The existing literature assumes that sustainable supply chain practices performs a critical role in supporting organisational performance (Baah and Jin, 2019). Thus, the aim of the study was not to create a new theoretical framework, but to either prove or disprove these relationships on a empirical basis. By taking a deductive method, the researcher generalised the hypotheses of the preceding studies and the theoretical constructs that were applicable in sustainable supply chain management and operational performance. These hypotheses were then tested statistically with the numerical data that was gathered and it was possible to objectively test the cause effect relationships. The chosen methodology was appropriate, because the study aimed at not only quantifying the strength and direction of the relationship between the distinctly defined variables, but also measuring the mediating position of the operational performance in transferring the sustainable supply chain practices into the efficiency of the business. The structured instruments were deployed, and this provided uniformity in data collection and added to the overall generalisability of results. On the other hand, an alternative inductive approach was considered but not selected because it involves qualitative exploration and theory development based on subjective interpretations (Yuwono and Rachmawati, 2023). This methodology could not be in line with explanatory, hypothesis-based aims in this study. Consequently, the deductive method was most appropriate since it was in alignment with the objective of the study which was to test the theoretically developed relationships to an empirical ground.

Research Design

Research design is the plan that defines the framework, how research is conducted and analysed to answer the research questions. The research design that is common

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are quantitative, qualitative and mixed methods research design (Asenahabi, 2019). This study employed primary quantitative research as its research design. The quantitative nature of design was selected because the study was aimed in exploring and testing the relationship between measurable variables, including supply chain strategy, digital transformation, supply chain resilience, green human resource management, operational performance, and business efficiency. These constructs were developed as measurable variables and operationalised using a structured questionnaire with standardised measurement items. Quantitative design allowed obtaining numerically measured data built on a comparatively considerable sample size and statistically analyse the patterns, strengths, and directions of the relationships between the variables.

The primary focus of this research design was to objectively measure the effect of sustainable supply chain practices on the business efficiency, both in the direct and indirect ways through operational performance as a mediating mechanism. The quantitative design was also most appropriate as the purpose of the research was to find out the hypothesised cause-and-effect relationships rather than to explore subjective experiences or the perceptions. The cross-sectional survey design ensured the uniformity of data collection, reduced researcher-bias and enhanced the reliability and generalisability of research outcomes. Furthermore, the design aligned with the empirical testing of an empirical theoretical framework, using available literature about sustainable supply chain management and operational performance. Conversely, an alternative qualitative research design was considered but not selected as the qualitative methods are attributed to an exploratory insights and contextual understanding rather than hypothesis testing and statistical validation (Lim, 2025). Thus, quantitative research design was the most appropriate one since it facilitated the research objective, which was the empirical exploration of the impacts of sustainable supply chain practice on the operational performance and business efficiency with the assistance of quantifiable and systematic evidence.

Data Collection

Data collection is defined as an activity of collecting data that is relevant to study objectives to produce valid and reliable evidence that can be analysed (Taherdoost, 2021). The primary data collection was employed in the given study since it was necessary to examine the relationship among the supply chain strategy, digital transformation, supply chain resilience, green human resource management, operational performance, and business efficiency using the original data. The primary data collection option was appropriate because it allowed the researcher to gather first-hand, context-specific information directly from respondents who were well informed on supply chain and operative practice in their respective organisations.

Data were collected using a structured questionnaire, which was designed based on established measurement scales adapted from earlier studies. All items were measured on a five-point Likert scale with strong disagreement and strong agreement to capture respondents' perceptions in a consistent and quantifiable manner. Koo (2025) highlighted that Likert-type scale captures human sentiments in a standardised

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manner which enables respondents to express their opinions. The questionnaire was distributed online to the professionals in the supply chain, operations and management functions ensuring relevance to the study variables. A total of 101 usable responses was received and included in the final analysis. The questionnaire approach to gathering primary data facilitated standardisation, reduced researcher bias and simplified statistical analysis of the relationship between variables. Such a methodology was useful in testing hypothesised relationships, operational performance as a mediating variable between sustainable supply chain practices and business efficiency. Thus, the research relied on the primary data collection method, which was appropriate since it provided valid quantitative estimates required to address the objectives of the research empirically.

Sample Size and Technique

Sample Size

Sampling refers to the process of choosing participants in a research study among a large population based on the criteria of the research study (Rahman, 2023). In this research, 101 usable responses to questionnaires were obtained and analysed. This sample size was considered enough for the study due to the use of Partial Least Squares Structural Equation Modelling (PLS-SEM), which is suitable for studies with relatively small to medium sample sizes and complex models. According to RVSPK, Priyanath and Megama (2020) the PLS-SEM can be reliably used with a sample size that exceeds the ten times rule where the minimum sample size must be at least 10 times the maximum number of structural paths directed towards any construct. The maximum number of paths directed to one construct in this research was four hence this required a minimum of 40 responses. Thus, the resulting sample size of 101 was observed to exceed this threshold and was considered sufficiently large enough to assure stables path estimates, acceptable statistical power, and significant inferences between the study variables.

Sampling Technique

A non-probability purposive sampling was employed in this research. The reason why purposive sampling was selected was that the study required the respondents to possess relevant knowledge and experience, as far as the supply chain strategy, operations, digital transformation, and sustainability practices are concerned. Ahmad and Wilkins (2025) demonstrated that purposive sampling allows the researcher to target the participants who have a certain, detailed knowledge or experience pertinent to the topic of the research. The validity and relevance of the gathered information were maintained by a selective sample of the target respondents, who were selected on the basis of their roles in supply chain management, operations, logistics, or managerial roles of their organisations. The recruitment process was carried out through professional networks and online platforms, such as LinkedIn, in addition to direct email recruitment of persons in relevant positions, which made it direct and easier to reach the potential respondents.

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The questionnaire link was shared to the research participants through internet media channels; therefore, effective distribution of the questionnaire and allowing respondents to participate in the questionnaire who are working in a diverse range of organisations and industrial sectors. Such an approach helped to access qualified professionals who could offer insights that would be consistent with the aim of the study. The reasons behind using purposive sampling were related to practical aspects, including limitations on full sampling frames, and the benefit provided by enlisting experts knowledgeable in the domain. Therefore, the information-based data collection process contributed to the efficient promotion of research goals that were aimed at operational performance and business efficiency in the framework of sustainable supply chain practices.

Data Analysis

A process of checking, cleaning, converting, and modeling data with the aim of finding useful information, hinting at conclusions, and assisting decision-making is the process of data analysis (Alem, 2020). The analysis of data in the given study was conducted by the help of the Partial Least Squares Structural Equation Modelling (PLS-SEM) with the assistance of SmartPLS software. PLS-SEM was selected as suitable because it suits complex models with multiple latent constructs, as well as mediating relationships and relatively small sample sizes (Akter et al., 2017). The analysis was performed using a twostep process that has been extensively suggested in the PLS-SEM literature. The measurement model was tested in the first step to determine the reliability and validity of the constructs. It included the consideration of the indicator loading, internal consistency reliability with Cronbach alpha and composite reliability, as well as convergent validity with the Average Variance Extracted (AVE). Both the Fornell-Larcker and the Heterotrait-Monotrait (HTMT) ratios were used to evaluate discriminant validity, means each construct was empirically different.

The second step was assessment of the structural model to test the relationship that was hypothesised between the constructs. The path coefficients were tested using bootstrapping where resamples were 5,000 to provide t-values and p-values to test the hypothesis. To understand the level of explanatory power of the model on endogenous constructs that are Operational Performance and Business Efficiency, the coefficient of determination (R^2) was explored. The indirect effects also were to be analysed to reveal the mediation effect of Operational Performance on the sustainability of supply chain practices and the efficiency of the business. The overall data analysis methodology provided an opportunity to have a strict and systematic study of not only the measurement properties, but also of the structural relationships, and to receive strong empirical findings in line with the purposes of the study.

Ethical Considerations

Ethical considerations are a cornerstone of research methodology, as they ensure that studies are conducted ethically and with respect for participants' rights, dignity, and well-being (Alhabsi, 2024). The research was conducted by following ethical

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guidelines and principles as before data was collected, the subjects were thoroughly and clearly informed about the purpose of the research, the nature of the involvement, and the purpose of the data. The recruitment was done voluntarily, and informed consent was obtained before all the respondents filled the questionnaires. The participants have been given assurance that there would be no negative impact of withdrawing from research at any point. Anonymity and confidentiality helped in protecting the privacy of the participants. No personal information, including the results of individual respondents, was noted; all information were then analysed only in aggregate form. The data obtained were to be used in the academic field only and were stored in a password-protected USB device and accessible only to the researcher thus adhering to the relevant data-protection laws and the ethical principles of conducting research. In addition, precaution was taken to exclude fraud and harm. The questions in the questionnaire were framed in a way that they were neither too intrusive nor irrelevant to the professional situations, hence reduced the limit of possible discomfort. In this regard, ethical concerns were adequately taken into account, and the research was performed with honesty, transparency, and respect to the participants.

CHAPTER FOUR: DATA ANALYSIS

Part 1 - Results and Analysis

This chapter discusses empirical results of the research, which were obtained using the Partial Least Squares Structural Equation Modelling (PLS-SEM) performed in SmartPLS. The two step process suggested in the literature where the evaluation of measurement model is made according to reliability and validity before the structural model is assessed is followed in this chapter. It is a model of six reflective latent variables, including Supply Chain Strategy (SCS), Supply Chain Resilience (SCR), Digital Transformation (DT), Green Human Resource Management (GHRM), Operational Performance (OP), and Business Efficiency (BE). A total of 101 usable questionnaire responses were used to gather data. All constructs were operationalised through various items with a five-point Likert scale and could be considered reflective in SmartPLS. The results of the measurement and structural model analysis are provided in the following subsections.

Measurement Model Evaluation

The measurement model was assessed on the reliability of the indicators, the internal consistency reliability, convergent and discriminant validity. The findings of the PLS algorithm with respect to the entire model, outer loadings and path coefficients, as well as direction of the relationships among constructs, are presented in Figure 1. As one will observe, all indicators it has a positive loading to their intended constructs, and most of the loadings are above the widely recommended threshold of 0.70. Very few of the items (such as SCS3, SCS5 and SCR6) have loadings between 0.60 and 0.70, however, since they aid content validity and their inclusion does not significantly impair the reliability and validity of the constructs, they were included.

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Practically, this implies that everything continues to have a large percentage of variance with its latent variable and as such is theoretically meaningful (Wang et al., 2023). All the indicators of DT, GHRM, OP and BE have high loadings that imply that the items are good manifestations of the underlying latent variables and signify that there is a low level of measurement error. Collectively, these results indicate that reflective scales employed in the present research are satisfactory and have a good basis to test the relationships between the variables in a structural form in the second step of the PLS-SEM analysis. The general trend of findings thus represents sufficiency of the measurement model and warrants to continue with the postulated framework.

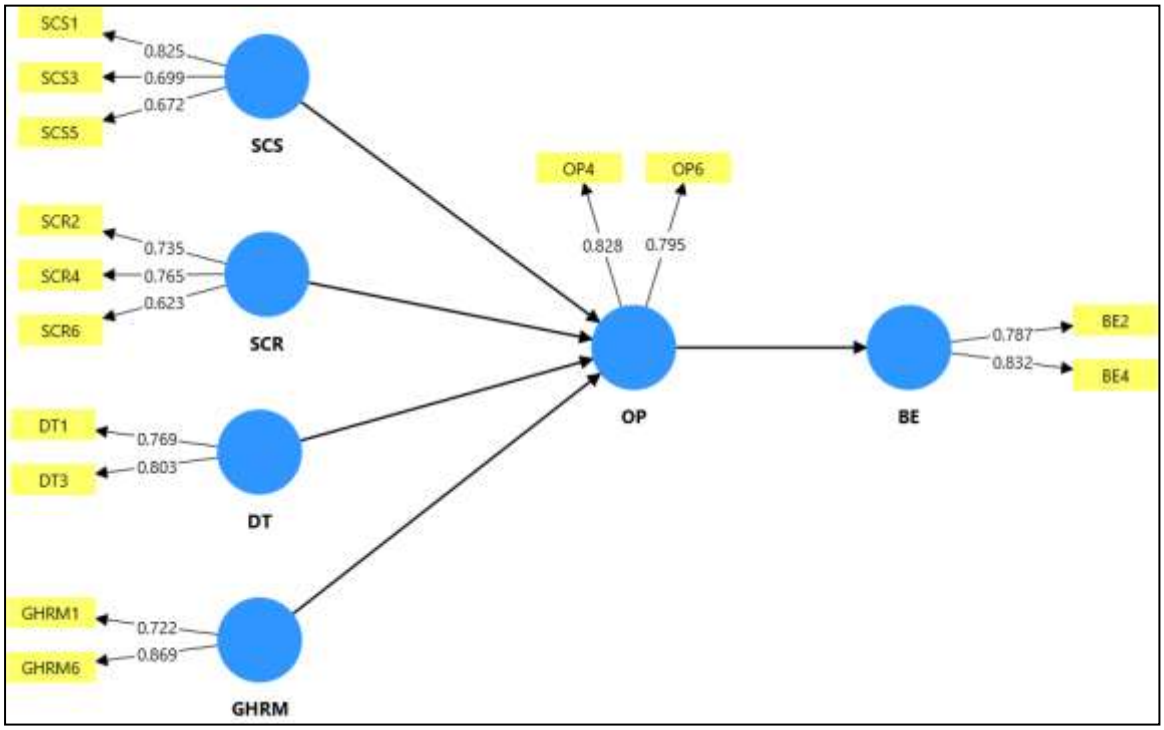

Figure 3 SmartPLS algorithm results for the full structural model.
Source: Author's own

The composite reliability and the Cronbach alpha statistics generated by the SmartPLS were used to measure internal consistency reliability. In the case of all six constructs, both indices achieved or surpassed the suggested minimum of 0.70, which is well satisfying as regards reliability. This implies that the items in any scale are homogeneous and they constantly represent the same concept. Combined with the large outer loadings, these findings are also a good basis to prove that the measurement instrument is usable to measure the study constructs.

Stability of the measurement model was also determined by the consistency in performance of indicators across constructs besides assessing reliability and validity of the measurement models. The reflective method of measurement ensured that the

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observed indicators reflected their latent variables making construct integrity. The feature of not having excessively high inter-item correlations was also an indicator of the fact that multicollinearity was not a factor of concern, and this fact proved the strength of the model estimation.

The adequate outer loadings in the majority of indicators proved the fact that the measurement items reflected the theoretical areas of the supply chain strategy, digital transformation, resilience, green human resource management, operational performance, and business efficiency successfully. The indicators that had slightly lower loading were retained because of their conceptual relevance, thus there was content validity of constructs and theoretical completeness. The deletion of such items would have posed a threat to the reduction of the construct domain and interpretability. Additionally, the findings of the internal consistency indicated that the respondents have a unified interpretation of questionnaire items, which implies the clarity and relevance of the measurement tool. This gives the data more credibility and enhances the testing of causal relationships of the structural model. The results of the reliability also suggest that the instrument may be re-used or modified to other similar studies that may be empirical in nature in the context of sustainable supply chain research.

Generally, the measurement model analysis shows that the constructs were operationalised in the best way and the data were appropriate in terms of testing the hypothesis. A good measurement framework should be aligned, and structural relationships may be embedded by unreliable or invalid constructs. Thus, the validated operational performance measurement model offers a valid foundation of the research on the mediating role of operational performance and the influence of sustainable supply chain practises on business efficiency.

The Evaluation of Convergent validity was done through the Average Variance Extracted (AVE). In the case of SCS, SCR, DT, OP and BE the AVE values exceeded the suggested value of 0.50 which shows that the contribution of the respective latent construct towards the underlying indicators is more than half. AVE in GHRM was slightly lower, however, it did have one moderate-loading item; the fact that reliability indices were acceptable and theoretical significance of the construct were significant made GHRM stay in the model. Altogether, the convergent validity of the measurement model can be evaluable as sufficient to be used in the framework of the current study.

This analysis establishes that measurement scales employed are conceptual and have statistical strengths. The acceptable indicator loadings, reliability scores and the validity measures all show that the constructs represent sustainable supply chain dimensions well to the extent that other results of the structural model are based on reliable and valid measurements.

Discriminant Validity

The Fornell -Larcker criterion was used to investigate discriminant validity (Anwar, 2025). Table 1 gives the square root of the value of the AVE (on the diagonal), and the relationship between the latent constructs (off-diagonal elements). In order to establish discriminant validity, the square root of AVE of each construct must exceed

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its correlations with any other construct within the model. This is met by all constructs in the analysis as indicated in Table 1. As an illustration, the square root of AVE of BE is 0.81 that is greater than its correlations with DT (0.132), GHRM (0.150), OP (0.558), SCR (0.248) and SCS (0.328).

The same themes can be noted with the other constructs suggesting that none of the correlations among the different constructs is greater than the corresponding square root of AVE. Such tendency is a great testimony to the idea that every latent variable describes a different distinct feature of the field of study and is empirically distinguishable against the rest of the constructs. That is, the constructs, in spite of being connected in theoretically significant terms, are not redundant or overlapping to the point of posing a threat to the interpretability of the structural model. The acceptable Fornell-Larcker findings thus confirm the fact that the discriminant validity has been achieved and that the measurement model as a whole is strong enough to continue with the testing of the structural relationships.

Construct	**BE**	**DT**	**GHRM**	**OP**	**SCR**	**SCS**
BE	0.810					
DT	0.132	0.786				
GHRM	0.150	0.333	0.608			
OP	0.558	0.239	0.410	0.812		
SCR	0.248	0.228	0.418	0.405	0.710	
SCS	0.328	0.327	0.413	0.517	0.415	0.735

Table 1 Fornell–Larcker criterion (square root of AVE on the diagonal**).**

Besides the Fornell-Larcker test, the Heterotrait-Monotrait ratio of correlations (HTMT) was also used to test discriminant validity (Nagwovuma, Maiga and Nakakawa, 2024). The values in all HTMT were lower than the conservative cut-off of 0.85, which also further confirms that the constructs are empirically different with each other. A combination of the indicator reliability, convergent and discriminant validity tests evidence proves that the effect that measurement model works reasonably well, and it can be used to measure the structural relationships between the constructs.

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Path coefficients - Mean, STDEV, T values, p values

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	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
DT -> OP	0.027	0.050	0.091	0.292	0.770
GHRM -> OP	0.183	0.186	0.089	2.046	0.041
OP -> BE	0.560	0.565	0.070	8.032	0.000
SCR -> OP	0.178	0.190	0.100	1.776	0.076
SCS -> OP	0.369	0.370	0.085	4.359	0.000

Figure 4: Additional SmartPLS measurement model output.

	BE	DT	GHRM	OP	SCR	SCS			
BE	0.81						0.81	0.81	TRUE
DT	0.132	0.786					0.786	0.786	TRUE
GHRM	0.15	0.333	0.608				0.608	0.608	TRUE
OP	0.558	0.239	0.41	0.812			0.812	0.812	TRUE
SCR	0.248	0.228	0.418	0.405	0.71		0.71	0.71	TRUE
SCS	0.328	0.327	0.413	0.517	0.415	0.735	0.735	0.735	TRUE
	0.81	0.786	0.608	0.812	0.71	0.735			

Figure 5: Additional SmartPLS measurement model output.

	BE	DT	GHRM	OP	SCR	SCS			
BE	0.81						0.81	0.81	TRUE
DT	0.132	0.786					0.786	0.786	TRUE
GHRM	0.15	0.333	0.608				0.608	0.608	TRUE
OP	0.558	0.239	0.41	0.812			0.812	0.812	TRUE
SCR	0.248	0.228	0.418	0.405	0.71		0.71	0.71	TRUE
SCS	0.328	0.327	0.413	0.517	0.415	0.735	0.735	0.735	TRUE
	0.81	0.786	0.608	0.812	0.71	0.735			

Figure 6: Additional SmartPLS measurement model output.

The discriminant validity confirmation is essential to the assurance of the fact that every construct focuses on distinct conceptual dimension of the proposed framework. According to the results of this study, the discriminant validity between supply chain strategy and digital transformation, resilience, green human resource management,

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operational performance, and business efficiency are found to be empirically different, despite their theoretical relationship.

This difference is especially significant due to the integrated aspect of sustainable supply chain practises. Although these constructs are supposed to work together practically, they are empirically distinct enough to ensure that the effects that are found in the structural model are not due to overlapping. The findings indicate that the respondents could easily distinguish between strategic, technological, human and operational aspects in their assessment of the organisational practises.

Dying of discriminant validity increases the interpretability of the path coefficients and increases the confidence maintenance of the hypothesis test. It makes it possible to make meaningful conclusions about the stronger or weaker impact of the practises on the operational performance and business efficiency. In the absence of discriminant validity, it would be difficult to determine the individual contribution of any one of the sustainability-oriented drivers.

Additionally, the conceptual framework is supported by the attained discriminant validity that substantiates the theoretical premise that operational performance is a unique mediating construct. This supports the process-oriented approach to the investigation, in which operational performance is a channel of transmission, but which is not equated with the strategic or efficiency performance.

Generally, the discriminant validity test proves that the model is empirically well-grounded and the relationships between the constructs can be discussed in a reliable way. This lays a strong ground in evaluating the structural models and then discussing the findings obtained.

The established discriminant validity depicts that each construct portrays a different theoretical construct. Such separation enhances trust in the model by making the relationships among the variables free of inflated values and hence the structural path estimates are more credible and understandable.

Structural Model Evaluation

Since the measurement model has been proven to be sound, the second step is to test the structural model. Structural analysis is concerned with the strength and importance of the postulated relationships among the latent variables, and the extent of variance accounted in the endogenous constructs (Hair and Alamer, 2022). The endogenous variables in this study are the Operational Performance (OP) and Business Efficiency (BE), whereas the exogenous predictors are Supply Chain Strategy (SCS), Supply Chain Resilience (SCR), Digital Transformation (DT) and Green Human Resource Management (GHRM).

To achieve the standard errors, t-statistics and p-values of each path coefficient, a bootstrapping with 5,000 resamples was applied as suggested by the PLS-SEM literature in the determination of estimating stability and significance. It is a non-parametric resampling process that does not involve the assumption of multivariate normality and hence it is appropriate to the sample size and the distributional properties of the data. The bootstrapping results of the structural model, which display

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the estimated path coefficients with their respective t-values are given in Figure 5 and the main statistics of all hypothesised paths are given in a concise form in Table 2.
Besides the significance of paths, the coefficient of determination (R 2) of OP and BE is also evaluated in the evaluation of the structural model, as it shows the percentage of the variance in these constructs that is jointly predicted by their predictors. The combination of these indicators gives a clear picture of the predictive ability of the model and the extent, in which the hypothesised relationships are supported by the empirical data.

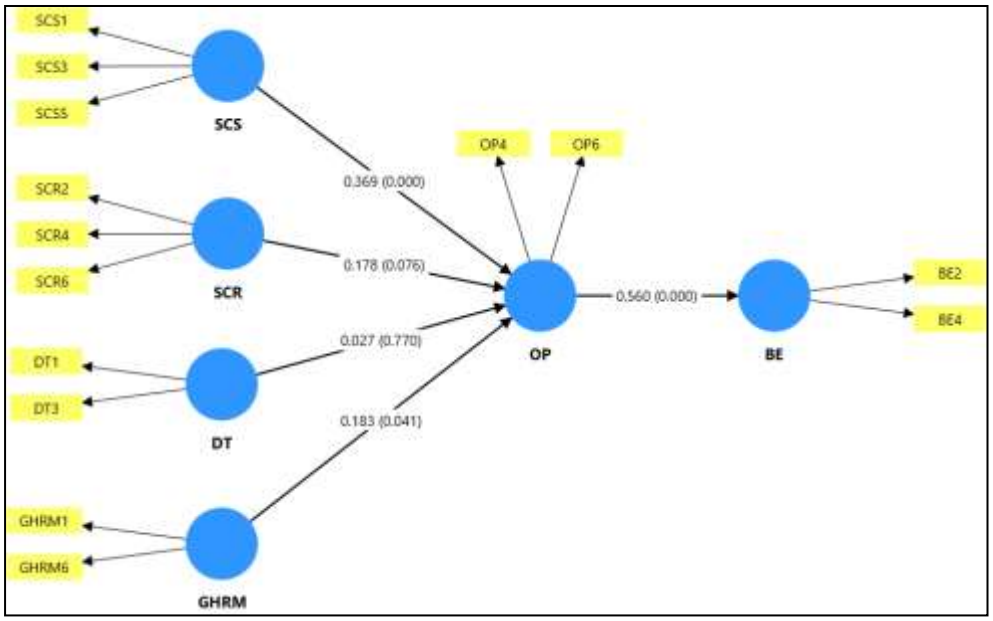

Figure 7: SmartPLS bootstrapping results for the structural model.
The operational performance model includes four antecedents of Operational Performance (SCS, SCR, DT and GHRM) and one critical outcome of the same, which is Business Efficiency. Within this construct, Supply Chain Strategy, Supply Chain Resilience, Digital Transformation and Green Human Resource Management are identified as exogenous variables that will have direct impact on Operational Performance, which will further be an endogenous mediator that will result in better Business Efficiency. Therefore, the model does not only reflect the immediate impact of each strategic, technological and human-resource factor on operational results, but also the way these operational result spreads further downstream in the shape of efficiency gain at the organisational level.
Table 2 contains the initial sample estimates (β), along with the t -value, p -value and decision of each hypothesis. Such statistics enable one to evaluate the magnitude as well as the statistical significance of each of the paths and also offers an unequivocal foundation of either accepting or rejecting the proposed relationships. Combined, the structural findings provide a comprehensive picture of the contribution made by the four antecedent constructs and the mediating nature of Operational Performance to

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explain variance in Business Efficiency in the firms involved in the study. This makes it easy to test the theory as well as informing the managers on the most effective drivers.

Path	β	t-value	p-value	Decision
SCS → OP	0.369	4.359	0.000	Supported
SCR → OP	0.178	1.776	0.076	Not supported at 0.05 level
DT → OP	0.027	0.292	0.770	Not supported
GHRM → OP	0.183	2.046	0.041	Supported
OP → BE	0.560	8.032	0.000	Supported

Table 2 Structural model results for the hypothesised paths.

The positive impact of SCS on Operational Performance is most important and the strongest (β = 0.369, t = 4.359, p < 0.001). This implies that the organisations that share clear, proactive and well-aligned supply chain strategies have a significant improvement in their performance regarding the operational results. The impact of Green Human resource Management (GHRM) on Operational Performance is also positive and statistically significant (β = 0.183, t = 2.046, p = 0.041) and thus it is probable that the environmentally oriented HR practices do have a meaningful impact on the improvement of operational processes.

Conversely, both the Supply Chain Resilience (SCR) and Digital Transformation (DT) have not been found to affect Operational Performance at the traditional 5 per cent significance. There is a positive but slightly non-significant path coefficient of SCR (β = 0.178, t = 1.776, p = 0.076), which might reflect a weak or scenario-dependent effect on operational results in the current sample. The coefficient of DT is also very small and non-significant (β = 0.027, t = 0.292, p = 0.770), which means that, operational performance can be improved by digital technologies only when these technologies are perfectly matched with strategy, processes and people.

Business Efficiency is positively influenced much by Operational Performance (β = 0.560, t = 8.032, p < 0.001). This verifies the key position of OP as an engine of efficiency performance and justifies the theoretical prediction that any change in reliability, flexibility and responsiveness at the operational level would result in a more efficient overall business operation. The reported values of R 2 of the endogenous constructs in the SmartPLS diagrams are in the moderate category, which means that the model is significant in explaining a significant amount of variance in both Operational Performance and Business Efficiency.

The structural model, in general, supports the hypothesised relationship partially. The two of four antecedents of Operational Performance Supply Chain Strategy and Green HRM have a statistically significant value, and digital transformation and Supply Chain Resilience do not. However, the high causeway between Operational Performance and Business Efficiency establishes relevance of management of

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operations capabilities as a tool by which the strategic and people-based practices can finally lead to efficiency in organisations.

The evaluation of the structural model indicates significant information on the relative significance of sustainable supply chain drivers. The major paths are a factor that not every sustainability-related practise has equal contribution to the operational performance, thus the strategic prioritisation. Supply chain strategy was found to have become a strong forecaster which highlights the value of alignment, coordination, and long-term planning in the attainment of operational excellence.

The insignificant impacts that have been found on some of the paths do not mean that it is irrelevant but indicates situational constraints, such as maturity of implementation or organisational preparedness. These results serve to support the point that sustainability efforts should be supported by organisational complementary capabilities in order to produce operational results.

The mediating effect on the efficiency of businesses was strong and statistically significant with respect to the effect of operational performance, which justifies its inclusion in the model. This finding confirms the theoretical hypothesis that yielding efficiency is achieved by better implementation and not by direct implementation of sustainability practises. Companies that do not translate strategic or technological investments into operational ones might not be that effective at getting efficiency benefits.

The level of predictive efficiency of the model in the form of the values of R2 shows that a significant part of the variance in the performance of the operation and business efficiency is covered by the chosen predictors. This proves the appropriateness of the integrated framework and emphasises its applicability to the dynamics of a sustainable supply chain.

Generally, the structural model findings confirm the use of a process perspective of sustainability in which operational performance facilitates the gap between the strategic initiatives and efficiency outcomes.

Since Operational Performance is placed in the middle between the four antecedent constructs and Business Efficiency, the indirect effects were also tested through the bootstrapping procedure. The findings show that the indirect relationships between Supply Chain Strategy and Green HRM through Business Efficiency through Operational Performance are statistically significant but the indirect relationships among Supply Chain Resilience and Digital Transformation are not. This trend implies that Business Efficiency is enhanced by SCS and GHRM, as these two constructs have a positive impact on Operational Performance, which indicates that SCS and GHRM complement each other.

In summary, the structural model has a good predictive ability and statistically significant correlations prove the existence of the proposed framework. The values of the path coefficients and the explanatory power show that the model is successful to explain the variation of the operational performance and business efficiency in the framework of the sustainable supply chain practises.

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Part 2 – Discussion

The results of the presented manuscript can be added to the existing list of works on sustainable and resilient supply chain management as it helps to understand the joint influence of the strategic, technological, and human-resource-related variables on the outcomes of operations and efficiency. The huge positive influence of Supply Chain Strategy on Operational Performance implies the key role of strategic alignment in modern supply chains. Companies which establish defined supply chain goals, incorporate sustainability issues into their sourcing and logistics choice and liaise effectively with their key partners seem to be in a better position to attain high degrees of reliability, quality and responsiveness (Mishra et al., 2024). These findings are in line with the previous studies that note that strategy operations alignment is crucial to attaining high-performance, long-term competitiveness and sustainable advantage during turbulent environments.

Green Human Resource Management also comes as a key antecedent of Operational Performance. The positive and meaningful relationship between GHRM and OP is that as organisations engage in environmentally responsible HR practices, in the form of green recruitment and selection, environmental training, performance appraisal systems that acknowledge sustainable behaviour, and employee engagement in environmental activities, employees are bound to develop pro-environmental work practices and enhance process improvements. These behaviours, in turn, improve the results of operations including minimised waste, resource efficiency and process reliability. The intermediary benefit of Operational Performance also suggests that the benefits of GHRM are achieved through the daily operational procedures and not directly through the monetary or market-related measures of efficiency, and it is significant to incorporate sustainability to the routine activities and not as an initiative.

The insignificant links between Supply Chain Resilience and Digital Transformation to Operational Performance are worth paying close attention to. The potential reason behind this could be that resilience abilities and digital technologies are not well established or integrated in the organisations that were included in the sample. Certainly, an example would be companies investing in new digital capabilities like more sophisticated planning systems or tracking tools without going through the process redesign, training and change management it would take to transform these capabilities into real operation value.

Likewise, resilience efforts, like multiple sourcing, flexible contracts or inventory buffers, can be delayed in maturity and they may not pay-off in performance until faced with conditions of severe disruption, which may not have been well-observed in the data-collection period. The insignificantly non-significant effect of SCR indicates that resilience must have a positive effect although the effects may be dependent on other factors related to the context, including level of environmental turbulence, uncertainty in supply or the type of disruption a firm has been exposed to that was beyond the control of the present study.

The high and most important influence of Operational Performance on Business Efficiency highlights the importance of the management of operational capabilities as

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one of the potential tools of a wider organisational benefit (Salah, Çağlar and Zoubi, 2023). The increased reliability of the delivery, shorter lead-time, increased flexibility and quality of processes seem to be the direct reasons of enhanced efficiency through cost control, asset utilisation and profitability. This result supports the idea that sustainability and efficiency are not necessarily incompatible, but, instead, investments in strategic alignment and green HRM can enhance and improve the business efficiency and the environment performance at the same time due to their influence on the operations. To managers, the findings imply that the attempts at enhancing the efficiency should be directed not only towards cost-cutting but also at building strong operational capabilities backed by the relevant strategies and people-management practices, continuous improvement programmes and the culture that facilitates the learning based on the operational feedback.

Theoretically, this research provides some empirical data reinforcing the perception of Operational Performance as a key mediating construct between upstream strategic, technological and human-resource related capabilities and downstream efficiency consequences. The use of OP as an intermediate variable is useful in explaining the way in which rather intangible resources are converted into visible gains in Business Efficiency. The high degree of the indirect impact of Supply Chain Strategy and Green HRM demonstrates that these two constructs can influence the efficiency they can have, the way of how the functioning of the day-to-day operations are organized, monitored and enhanced. That is, strategy and green people-management practices are important since they influence routines, behaviours and decision rules that form the basis of operation processes which ultimately lead to efficiency at the organisational level.

Comparatively, the negligence of relevant Supply Chain Resilience and Digital Transformation indirect effects points to the fact that, at the current stage, these competencies might be at a nascent stage or might need significant organisational complements to ensure that the full potential could be achieved. Resilience investments or investments in digital tools may not necessarily be passed over to better operations unless there are corresponding structural, skills and culture changes. This is where the significance of considering such capabilities as a part of an overall system of resources instead of specific solutions should be emphasised.

Subsequently, moderating variables like environmental uncertainty, digital maturity and organisational culture should also be studied in future research to define more clearly in which conditions resilience and digitalisation can be applied to achieve improved operational and efficiency performance and whether such correlations are invariable across industries and firm size. These results have direct practical impact on the policymakers and industry associations. Intervention programmes that underline strategic planning skills, employee training of environmental issues and strategic placement of digital initiatives towards organisational goals are thus encouraged. Besides this, the sharing of best-practice examples and benchmarking tools might motivate organisations to learn by those who act first and hasten the spread of integrated strategic, digital and green HRM strategies that would foster operational excellence and long-term efficiency.

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	BE	DT	GHRM	OP	SCR	SCS			
BE	0.81						0.81	0.81	TRUE
DT	0.132	0.786					0.786	0.786	TRUE
GHRM	0.15	0.333	0.608				0.608	0.608	TRUE
OP	0.558	0.239	0.41	0.812			0.812	0.812	TRUE
SCR	0.248	0.228	0.418	0.405	0.71		0.71	0.71	TRUE
SCS	0.328	0.327	0.413	0.517	0.415	0.735	0.735	0.735	TRUE
	0.81	0.786	0.608	0.812	0.71	0.735			

Figure 8: SmartPLS output.

Lastly, the findings are to be discussed within the scope of some limitations. The research is based on the cross-sectional survey data using a relatively small sample size, which limits the possibility to make solid causal decisions and could limit the generalisability of the results. Self-reported perceptual items were used to measure all constructs, which puts the risk of common method bias in the study even though the research design has taken measures to eliminate the issue. Secondly, the research is narrow when it comes to constructs and other possible factors like organisational culture, leadership or outside institutional pressures have not been explicitly considered.

Such limitations, nevertheless, provide open and beneficial prospects in the future work. Greater and more diverse samples in longitudinal research would help examine the dynamics of the relationships identified in this study over time and across different industries, revealing whether the observed patterns are stable, strengthen, or weaken under changing environmental conditions. In addition, in-depth qualitative case studies would provide richer detail on the specific mechanisms through which supply chain strategy, digital technologies and green HRM practices interact in real organisations, helping to uncover contextual contingencies, implementation challenges and best-practice configurations that cannot easily be captured through survey-based, cross-sectional quantitative designs alone. Such mixed-method approaches would significantly strengthen the overall evidence base.

The summary of the findings provides a further understanding of the impacts that sustainable supply chain practise has on business efficiency based on operational effectiveness. The findings indicate that strategic alignment and integration of the human resource is more decisive than technological adoption in improving the outcomes of the operations. This observation is aligned with the fact that technology is an enabler and not a driver of efficiency by itself.

The high influence of the supply chain strategy on the operational performance highlights the importance of coherent planning, coordination, and alignment of the functions of supply chain. Companies that have well-established strategies are in a better position to align the demand forecast, inventory and their supplier relationships.

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This strategic visibility minimises the uncertainty in operations and leads to a steady implementation, which eventually leads to efficiency.

Green human resource management also indicated the significant contribution to the performance of operations. This implies that the role of employee engagement, environmental training, and incentive systems is important in converting the sustainability objectives into routine operations. Workers are playing the role of operational agents who practise strategic intentions and thus the human capital is a key factor to sustainable success in the supply chain.

Simultaneously, the non-significant direct impact of digital transformation and supply chain resilience on operational performance shows that such capabilities can be more integrated and mature to produce a tangible outcome. Technical systems that are not strategically oriented at the hardware level or are accompanied by insufficient human resources can be ineffective in enhancing the performance of the operations. Similarly, risk mitigation may be put first in resilience investments than efficiency in the short term, which is why they cannot have a significant effect in the short run.

The mediating role of operational performance was verified because it was a good predictor of business efficiency. This observation supports the thesis statement that efficiency is attained due to better execution which involves cost management, uniformity of quality, flexibility, and reliability in product delivery. The sustainability practises would only facilitate efficiency where they maximise these dimensions of operation as well.

The findings also indicate that sustainability initiatives can be considered as interlinked systems, but not independent interventions. Organisations that embrace the use of fragmented strategies might fail to achieve the benefits of efficiency. A combined model harmonising strategy, technology, resilience, and human resources will be more inclined to result in long-term performance growth.

Theoretically, the results are evidence of the Resource-Based View, and the Dynamic Capability Theory as well. Adaptability and learning are supported by strategic alignment and green human capital as a useful internal resource as well. Operational performance is used as the process through which these resources and capabilities are converted to efficiency outputs.

Practically, the paper outlines the significance of focusing on operational implementation in the process of sustainability implementation. Instead of it being an act and an initiative, managers must consider the incorporation of sustainability into routine, performance measures, and behaviours of employees. Training and strategic integration should be used to optimise the impact of digital investments.

Implications of the findings on the theoretical and managerial implications of the role of sustainable supply chain practises in enhancing the efficiency of the business are discussed. The findings indicate that there is a large positive impact on supply chain strategy and green human resource management on the operational performance which in turn boosts business efficiency. This result confirms the perception that strategic alignment and employee-initiated sustainability programmes are the key drivers of operational excellence. With a coherent strategy-oriented supply chain operations and environmentally friendly human resource practises, the organisations

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are on a better standing to attain cost-effectiveness, quality assurance, flexibility, and reliability in delivery.

Remarkably, the non-significant direct relation between digital transformation and the supply chain resilience and the operational performance mean that adoption of technology and investments in resilience do not necessarily result in performance enhancement. It means that the digital instruments and resilience capabilities should be properly incorporated into the organisational operations and adjusted to the strategic goals to provide tangible benefits in operation. Unless such activities are properly aligned, they can still be left underutilised or fail to bring about quantifiable efficiency.

The high mediating role of the operational performance supports this claim on the fact that it is a significant mechanism of how the sustainable supply chain practises can affect the business efficiency. The result supports theoretical approaches including the Resource-Based View and the Dynamic Capability Theory which focus on the conversion of organisational resources and capabilities into performance results. Operational performance serves as the conversion filter that transforms the strategy centred on sustainability into a real efficiency increase.

Practically, the results imply that the managers should focus on enhancing the functioning processes, but integrate sustainability in the strategic planning and the human resource systems. A cohesive strategy, people, technology and resilience approach is more likely to bring long term efficiency gains and long term competitive advantage.

Collectively, the discussion indicates that sustainable supply chain practises help in ensuring business efficiency in terms of disciplined operational performances. These results offer a subtle insight into how organisations may turn sustainability goals into quantifiable efficiency benefits, which make organisations stay competitive and strong in the long term.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

Introduction

This section concludes with sustainable supply chain management and business efficiency, focusing on the combined impact of the supply chain strategy, digital transformation, supply chain resilience, and green human resource management. In correspondence with the empirical results, this section summarises the key findings of the PLS-SEM analysis and shows how these findings are relevant to the objectives and hypotheses of the research. This section of the research aims at making sure that the empirical findings are fully interpreted, and that the role of the operational performance is identified as a key mechanism by which the strategic and sustainability-oriented practices may affect the efficiency of the organisation. In addition, the sub section outlines the general conclusions made out of the research, discusses the possible limitations of the study in terms of its design and methodology, and gives the future research implications.

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Summary of the Findings

This research dissertation aimed to investigate how supply chain strategy, digital transformation, supply chain resilience, and green human resource management affect the business efficiency and operational performance was assumed to be a mediating variable. Based on a series of research questions and based on data obtained with 101 respondents, the analysis was conducted with the help of the Partial Least Squares Structural Equation Modelling (PLS-SEM) to evaluate the effects of strategic sustainability and technology-oriented practices on the results of operational performance and efficiency of organisations, in an empirical manner. The main conclusion of the study shows that there is a positive correlation between supply chain strategy and operational performance improvement. Results show that there is a high, positive and significant relationship between the supply chain strategy and the operational performance. This implies that organisations that have clear, aligned and active supply chain strategies are in a better place to enhance reliability and responsiveness, flexibility and the overall effectiveness in their operation. It further highlighted that most powerful predictors of the operational performance were supply chain strategy, which underscores the key role of the former in supporting a sustainable supply chain management.

The results also shows that green human resource management (GHRM) affects operational performance highly with significant effect. Green practices in HR such as green recruitment, environmental training, green-oriented performance assessment, and participation of employees in green activity are significant towards better operational performance. This finding implies that human resource practices motivated by sustainability influences employee behaviour and organisational routines in a manner that contributes to efficient processes, minimisation of wastage and the use of resources in the most efficient manner. Particularly, the research indicates that the effect of GHRM on business efficiency is indirect and is done through the enhancement of operational performance, thus supporting the mediating value of operational performance in the research. Despite the popularisation of digital technologies as the instruments of efficiency and sustainability, the findings indicate that the digital investments are not necessarily accompanied with a better operational performance. The digital initiatives will not be utilised adequately or resulting in any operational improvements without adequate alignment, as well as digital maturity or change management.

Similarly, supply chain resilience and operational performance were identified to have a positive but statistically insignificant relationship at the traditional 5% level. This means that as much as flexibility, redundancy and risk preparation ability are restorative in a stable operation, the effect could be situational or more pronounced when there is intense disruption. The lack of any significant effect in this research could be due to the cross-sectional nature of information or that the sampled organisations had not been disrupted. The most prominent result of the research is that there is a positive and statistically significant correlation between operational performance and business efficiency. Increase in operational performance, such as high levels of reliability, reduction of lead times and process quality have been shown

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to directly translate into high levels of business efficiency. This confirms the key role of the operational performance as an efficiency improvement driver and justifies its presence as a mediating construct part of the research framework.

This analysis further confirms the orientation of the supply chain strategy and green human resource management on business efficiency through the operation performance. The strategic and sustainability-oriented practices do not play the role of efficiency alone, but through their impacts on the daily running operations. On contrary, the results obtained from digital transformation and business efficiency did not result in direct impact. On the other hand, the empirical results, which were related to the digital transformation and supply chain resilience, did not reveal strong indirect impact. This implies that the benefits of efficiency achieved through the following efforts might require additional organisational facilitators or longer time frames before they are realized. Collectively, the results partly support the research paradigm and provide subtle information on the effects of sustainable supply chain practices on organisational efficiency. This study approves the strategic alignment aspect and human capital influence on operations and efficiency outcomes, and the active digitalisation and resilience role in sustainable supply chain performance.

Conclusion

This study concludes the effects of sustainable supply chain practice on business efficiency by incorporating both the supply chain strategy, digital transformation, supply chain resilience and green human resource management under a common empirical framework. To address the research gaps, the study offers a detailed evidence-based insight into how strategic, technological, resilience-oriented and human resource variables all work together in ensuring sustainable business results. The results of the study proves that sustainable supply chain management is not a one-sided phenomenon, and it is a coordination of the strategy and people-cantered practices directly related to the effectiveness of operation. Supply chain strategy became the greatest determinant of operational performance as it has proven that organisations capable of giving clear and well aligned and sustainability oriented supply chain are at a better position to enhance reliability, flexibility, quality and responsiveness.

This observation on green human resource management shows why human capital is a fundamental element of transforming sustainability goals in operational enhancements. Organisations can encourage pro-environmental behaviours through embedding environmental values in their recruitment, training, performance appraisal and employee engagement, thereby increasing resource efficiency, minimising wastage and increasing reliability of the process. Moreover, digital transformation and supply chain resilience showed to have statistically significant direct effects on operational performance in the study sample. The involvement of operational performance in business efficiency is one of the key outcomes of the study. This means that the high and meaningful connection between business efficiency and operating performance proves that the enhancement of cost control, reliability of delays, quality and

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flexibility of the processes are important instruments of how the efficiency gains could be achieved by the sustainable supply chain practices.

On the other hand, the mediation analysis supports the idea that the supply chain strategy and the green human resource management have an indirect impact on the business efficiency by improving the operational performance, which also supports the theoretical significance of the operational performance as an intervening variable between supply chain capabilities and the final efficiency results. Overall, these results shows that digitalisation and resilience can be seen as the enabling capabilities whose benefits can be realised only after organisational maturity and situational contingency takes place. It further highlights that neither technological adoption nor resilience planning is sufficient to achieve efficiency in business in the current complex and disruptive environment. Thus, employee engagement and operational excellence is significant in organisations that are needed to transform the effort into profitability which organisations can achieve through sustainability initiatives.

Research Limitations

Despite the above contributions, this study has several limitations, as it is founded on a cross-sectional survey, which limits the cause-and-effect relationship development between the constructs. The identified relationships are only a representation of associations at one point in time, and they might not be able to capture changes in the practices or performances of the supply chain over the course of time. Moreover, procedural measures have been addressed to control the problem, but this study is based on self-reporting of perceptual information, and it can develop common method bias. The procedure of 101 questionnaire respondents does not give much generalisability of the results to other industries, organisations of various sizes and geographical settings. The study further fails to directly take into consideration environmental context (organisation culture, leadership style, uncertainty in the environment or industry specificity), which could affect the effectiveness of digital transformation and supply chain resilience programs.

Future Implications

Based on the above limitations, this study can be extended in future research by taking into consideration longitudinal research designs to investigate the way sustainable supply chain practices, as well as the resultant performance change over time and especially during disruption periods. The generalisability of the findings would be improved by increasing the sample size; cross-industry and cross-country comparisons would provide an opportunity to analyse the findings in a better way. An additional research direction involves the moderating variables, including digital maturity, environmental instability, organisational culture or leadership commitment, to learn more about the occasions when digital transformation and supply chain resilience lead to operational and efficiency benefits. Besides this, qualitative or mixed method research, such as case studies and interviews, may give more in-depth information about the implementation difficulties and the best practice.

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