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The Role of Sustainability Practices in Enhancing Supply Chain Efficiency: An Investigation of Supply Chain Integration and Supplier Diversity in Pakistan

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ABSTRACT

This study examines the direct effect of Supply Chain Integration (SCI) and supplier diversity (SD) on Supply Chain Efficiency (SCE) and the mediation effect of Sustainability Practices (SP) in the context of Pakistan's industry. The study is guided by a multi-theoretical framework, which combines the Resource-Based View, Transaction Cost Economics, Stakeholder Theory, Dynamic Capabilities, Relational View, and Institutional Theory. A quantitative cross sectional survey design was used, and 325 valid responses were obtained from medium and large organizations located in Karachi, Lahore, Faisalabad and Islamabad from supply chain managers, procurement officers and logistics professionals. The analysis of data was performed using SPSS, and mediation hypotheses were tested using the PROCESS macro (Model 4, 5,000 bootstrap samples, bias-corrected confidence intervals). The results strongly support all four of the hypotheses. The direct positive impact of SCI on SCE is significant, in terms of decreased costs, lead times, and operational waste. There is also a strong positive direct impact of SD that is manifested through flexibility, innovation and resilience. More importantly, sustainability practices serve as the link between the two relationships: integration creates opportunities for collaborative platforms for integrated environmental and social efforts, and supplier diversity provides an additional source of sustainability portfolio diversity through indigenous and green practices that together can have a larger impact on efficiency gains. Theoretically, the study extends the nomological network of supply chain efficiency by providing empirical support for sustainability as a mediator between the performance effects of integration and diversity. In fact, it provides a data-informed framework for Pakistani managers to harness integration, diversity and sustainability as a means of boosting operational performance and for policymakers to provide evidence-based incentives for SME integration and green supply chains. Although there are limitations in the cross-sectional and single-informant nature of the study, the model can be replicated for future studies regarding sustainable performance of supply chains in emerging economies.

Introduction

In today's world, contemporary supply chains are no longer linear and consist of a sequence of production and distribution; instead, they are multi-tiered and cross-continental. In today's world, organizations are judged not just for the quality of their products and their competitiveness on price, but also on how efficient and resilient their supply chains are and how ethical they are (Christopher 2016). The efficiency of the supply chain includes the entire cost of providing products and/or services to the

final customer in a fast, flexible, and high quality manner (Beamon, 1999). In an environment of volatile markets and increasing customer expectations organizations are forced to rethink all value chain activities, eliminate any non-value adding activities, shorten lead times and improve coordination (Stock & Boyer, 2009). The COVID-19 pandemic has also highlighted the fragility of global supply chains, making it increasingly important for organisations to create resilient, adaptive and sustainable supply chain ecosystems (Ivanov & Dolgui, 2020). Recent studies in developing countries highlight that supply chain efficiency is no longer an operational issue, but a strategic instrument to achieve competitiveness and economic growth (Baliga et al., 2020).

Supply Chain Integration (SCI) is a basic tool to achieve the efficiency of Supply Chain. SCI refers to the extent of strategic partnership building and joint intra- and inter-organizational process management by the manufacturer for enabling smooth flows of products, services, information, finances and decisions (Flynn et al., 2010). Integration can be either internal, between functional departments or external, between customers and suppliers. Implementing SCI decreases information asymmetry, realigns incentives, and allows for synchronised planning, leading to lower levels of buffer inventory, shorter order fulfilment times and the optimisation of resources (Lee, 2000). There is a significant amount of empirical evidence that shows that an increased level of SCI is positively related to better operational and financial performance (Frohlich & Westbrook, 2001; Kim, 2009). However, seamless integration is a significant challenge, especially in emerging economies (Zhao et al., 2011), due to various factors such as lack of trust, fragmentation of information systems, and cultural differences. The current literature remains supportive of the importance of supply chain integration as a key enabler that links the management practices with the performance outcomes, for example, in South Asia, integration plays a significant role in the pharmaceutical and textile sectors (Ali et al., 2024).

In addition to the integration discussion, Supplier Diversity is a key strategic factor. Supplier diversity is a proactive approach for doing business that aims to include minorities, women, veterans and other historically underrepresented businesses in the supply base as well as small and medium enterprises (Carter & Easton, 2007). In addition to the social equity, supplier diversity is also now known as a source of competitive advantage. A diversified supplier base enables us to decrease the dependence on individual suppliers, adds a competitive element that can lead to a cost reduction, and provides a variety of perspectives that can fuel innovation and flexibility (Krause et al., 2009). In times of supply chain disruptions and scarce resources, this risk mitigation potential of a diversified supply base becomes more relevant (Adobor & McMullen, 2007). Recent empirical research has offered rigorous evidence that supplier diversity does not negatively affect the performance, and that, in fact, small and diverse suppliers can outperform larger suppliers in fulfillment of the contract (Mishra et al., 2024). In Pakistan, which has a highly concentrated supply market, with a high share of large companies and limited SME participation, the potential of supplier diversity to create resilience and innovation is still largely untapped (Hashim et al., 2021).

Sustainability Practices have become a driving force that is transforming the face of today's supply chains. However, sustainability in SCM is not only related to the environment, but also to economic viability and social responsibility, which are summarized by the triple bottom line (Elkington, 1998). Green purchasing, eco-design, reverse logistics, carbon footprint reduction and ethical labour standards are practices that have been originally regarded as niche corporate social responsibility activities but have now turned into strategic imperatives (Srivastava, 2007). The arguments are compelling: operational efficiencies in energy and material use lower costs, regulatory and reputational risks are reduced, brand value is increased, and stakeholders exhibit increased awareness of corporate actions (Bowersox et al., 2000; Pagell & Wu, 2009). In addition, there are increasing indications that sustainability is not only a direct performance lever, but serves as a facilitator for other SCM practices, such as supplier diversification and integration (Sarkis, 2003). Adopting a sustainability stance by supply chain partners enables them to work together to achieve common environmental goals and different suppliers may have different experiences with sustainable practices for their local regions (Vachon & Klassen, 2006). More recent research has also shown that these practices of sustainable supply chain management have a huge impact on firm performance, mediated by the construct of supply chain integration, especially in the context of developing economies (Baliga et al., 2020).

The present study aims to fill these gaps utilizing a quantitative survey-based design and analysing the data using PROCESS macro to test mediation hypotheses. The research gap can be outlined as the three following areas under-explored in the context of Pakistan: (i) Relationship between SCI and Supply Chain Efficiency; (ii) Sustainability Practices as a mediator in these relationships; and (iii) Robust quantitative testing of these relationships. The study fills this void by offering theoretical findings to the SCM literature and offering practical insights to the Pakistani managers and policy-makers that aim to improve the performance of their supply chain by using integrated, diversified, and sustainable practices. The results of this study are anticipated to help shape evidence-based strategies for SME inclusion and incentives for green supply chains, contributing to Pakistan's overall economic and environmental sustainability goals.

Literature Review

This study's theoretical basis is a combination of the Resource-Based View (RBV) and the Transaction Cost Economics (TCE) theories, which elucidate how supply chain integration, supplier diversity and sustainability practices can be combined to achieve improvements in supply chain efficiency. The RBV argues that organizations can sustain a competitive advantage by possessing four types of resources: "valuable, rare, imperfectly imitable, and nonsubstitutable" (Barney, 1991), and supply chain integration can be considered a socially complex and causally ambiguous resource (Rungtusanatham et al., 2003; Asamoah et al., 2021). Diverse supplier base also forms a source of unique knowledge and innovation that is difficult for other firms to replicate (Blount & Hill, 2015; Miguel & Silva, 2024) and the process of sustainability-building contributes to the generation of firm capabilities, which in turn reduces environmental impact and operational costs (Hart & Dowell, 2011; Hussein & Song, 2024). Supply chain integration helps to reduce these costs by creating trust and transparency of information (Grover & Malhotra, 2003; Patil et al., 2023), supplier diversity, when managed strategically, can help to reduce procurement costs by inducing a competitive tension (Rindfleisch & Heide, 1997; Alcalde & Dahm, 2024), and sustainability, by standardizing environmental and social expectations, can help to minimize supplier non-compliance risk and reputational penalties (Carter & Rogers, 2008; Huang et al., 2024). These theoretical models in combination indicate that integration, diversity and sustainability are not only operational approaches, but tools that when they are used together, and with efficient governance, can significantly increase the efficiency impacts of a supply chain.

Supply Chain Integration and Supply Chain Efficiency

Information asymmetry decreases and the bullwhip effect gets smaller as companies become more integrated, both internally and externally, with important suppliers and customers (Frohlich & Westbrook, 2001), and inventory buffers shrink and order fulfilment becomes faster. The resource-based logic assumes that the features that give a business a competitive advantage are the assets related to SC integration, including production schedules, demand forecasts and logistics infrastructure, which competitors cannot easily duplicate (Rungtusanatham et al., 2003). Meta-analytical evidence suggests that there exists a strong positive relationship between external integration and operational performance indicators such as cost reduction, delivery speed and quality (Ataseven & Nair, 2017). These results have been supported by recent studies which have shown that supply chain integration is playing a pivotal role in the mediation of SCM practices and performance in the pharmaceutical industry in Pakistan (Ali et al., 2024). Moreover, by integrating blockchain in the supply chain, sustainable logistics capabilities and performance of the firms in Pakistan retail industry has been improved, while integration has been found to help in reducing waste and decreasing carbon emissions in the SCs (Nazir & Fan, 2024).

In developing countries with weaker institutions and less developed market intermediaries, integration gains in significance as an efficiency lever. In the absence of institutions, deeply integrated firms can build trust-based governance structures that can mitigate opportunistic actions (Liu et al., 2018). Integrating information systems and reducing logistics costs are critical to address the disintegration of information systems and the high logistics costs in the Pakistani supply chains. Empirical evidence from Pakistan shows that companies with high level of supplier and customer integration have better lead-time reliability and inventory turnover (Asad et al., 2019). Furthermore, recent studies have also found that internal integration plays a mediating role between IoT capabilities and supplier integration in regard to the performance of the supply chain in the textile industry of Pakistan further underscores the critical role of integration in technology-led performance improvement (Khan et al., 2023). It is therefore argued that integration in supply chain should positively affect the supply chain efficiency in Pakistan. The first hypothesis is thus formulated:

H1: *Supply Chain Integration (SCI) has a positive impact on Supply Chain Efficiency in Pakistan.*

Supplier Diversity and Supply Chain Efficiency

Supplier Diversity, as the conscious effort to engage a diverse set of suppliers, such as small businesses, medium sized businesses, geographically dispersed suppliers, and underrepresented businesses, is thought to create efficiency in various ways. A diverse supplier base can enhance a firm's sensing and seizing capabilities by accessing knowledge, technologies and problem-solving solutions from the diverse suppliers (Blount & Hill, 2015). This diversity can lead to process and product innovations which directly lead to the reduction of operating costs and improve responsiveness (Richard et al., 2013). Finally, another theory of how supplier diversity is related to efficiency is based on transaction cost economics, which argues that supplier diversity is able to reduce the reliance on a few large suppliers, which means it lessens the risks of disruption and price increases (Adobor & McMullen, 2007). In recent studies on supplier diversity implementation in emerging economies, the trajectory towards effective

supplier diversity implementation is seen as having distinct stages of structuring, operation, and adaptation and the availability of legitimized intermediary organisations and consistent knowledge bases can also have a significant influence on implementation (Miguel & Silva, 2024). Additionally, supplier diversity initiatives can lead to more resilient supply chains which are agile, adaptable and better equipped to withstand disruption (Rosti, 2024).

Empirical research has shown that the more suppliers, the lower the procurement costs and that more suppliers will likely lead to better supplier performance (Krause et al., 2009). In the context of Pakistan where the supply process is dominated by large suppliers, cost-effective solutions with locally adapted SMEs and regional suppliers can increase resilience to logistical disruptions (Asad et al., 2019). A recent study underscored the significance of supplier diversity to cost savings across the supply chain, highlighting the need for holistic planning and management to enhance services (Silva et al., 2024). Limited availability of green materials can be overcome by diversifying the supplier base and implementing supplier development programs, while ensuring quality control through robust measures and periodic inspections (Khan et al., 2024). Although supplier diversity can add coordination complexity, strategic management can provide an overall positive impact on efficiency. Therefore, it is proposed that the second hypothesis is the following:

H2: *Supplier Diversity has a positive impact on Supply Chain Efficiency in Pakistan.*

Mediation by Sustainability Practices

Sustainability practices are theorized to partially mediate the relationship between integration and efficiency of the supply chain. Collaborative infrastructure and trust serve as a base from which co-development efforts such as green packaging development, coordinated green logistics and waste reduction programs can be carried out in integrated supply chains (Vachon & Klassen, 2006). These partnerships allow resource and information sharing and help partners to make more sustainable investments than they would be able to do on their own. These sustainability practices, in turn, create efficiency gains, such as green logistics, which optimises the use of fuel and routes, waste reduction which minimises material costs, and energy-efficient production which reduces energy costs (Green et al., 2012). Port supply chain integration studies, based on a resource-based perspective, have recently demonstrated that integrative approaches bring benefits not only from an economic standpoint (cost and operational efficiency), but also from an environmental perspective (energy efficiency and green management) (Hussein & Song, 2024). Moreover, positive effects have been demonstrated on SME performance by implementing GSCM practices, which subsequently act as intermediaries for the positive relationship between the sustainability practices and performance outcomes by the use of Industry 4.0 technologies (Huang et al., 2024).

The Resource Based View states that sustainability capabilities along with integrated partner relationships create cost advantages that cannot be easily replicated (Hart & Dowell, 2011). In the manufacturing sector, empirical studies have demonstrated that integration is partially mediated by environmental collaboration with suppliers, implying that integration can affect operational performance, but also can promote the development of sustainability practices which in turn further improve operational performance (Danese & Romano, 2011). The evidence gathered from the emerging economies in recent times shows that sustainable practices in the supply chain create a competitive advantage through the mediation of productivity, while in the presence of the mediator (productivity), all the dimensions of sustainability become significant (Razzak, 2023). In the textile and manufacturing sectors in Pakistan, the probability of adopting eco-standard is greater when the supply chain is also integrated, which helps to achieve production efficiency (Ali & Habib, 2021). This reasoning gives rise to the third hypothesis:

H3: *Sustainability Practices mediate the relationship between Supply Chain Integration (SCI) and Supply Chain Efficiency in Pakistan.*

Mediation by Sustainability Practices

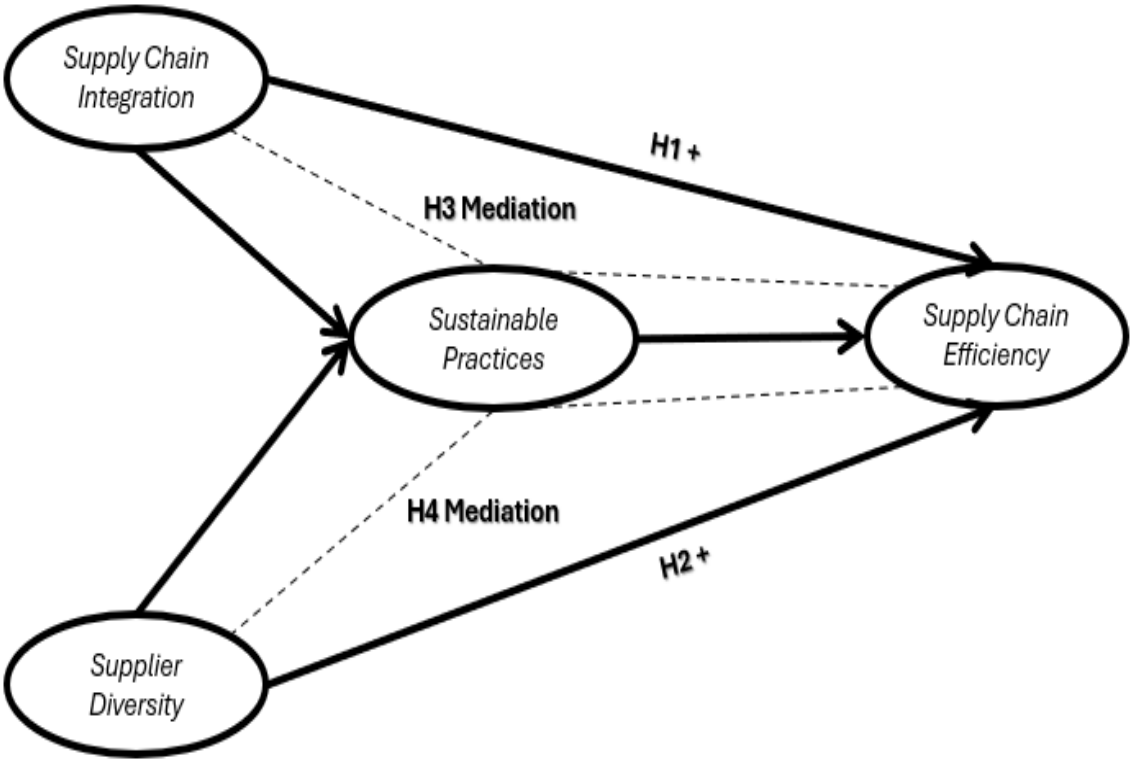
Likewise, supplier diversity is expected to affect the effectiveness of the supply chain due to better sustainability practices. Diverse suppliers may have niche skills with sustainable materials, traditional green processes and innovative low-cost green technologies which are not available in mainstream large suppliers (Walker & Brammer, 2012). Companies that actively look for such suppliers also directly reduce waste and the use of resources due to the use of recycled materials, biodegradable packaging, or energy-efficient production processes, which contribute to an expanded sustainability portfolio. The rationale of this pathway is that having a diverse supplier base indicates the company's dedication to being socially and environmentally responsible, and will gain them support from customers, regulators, and communities, while simultaneously decreasing the friction that can occur during a business operation and improving efficiency, based on the stakeholder theory (Freeman et al., 2010). Additionally, recent studies

have shown that supplier diversity and supplier development initiatives have a positive impact on the scarcity of green materials, as diverse suppliers offer access to sustainable materials that may not be readily available (Khan et al., 2024).

The implementation of sustainability criteria into the procurement process of different suppliers, these suppliers will be more willing to conduct GSCM, which then pushes supply chain sustainability up one level (Sarkis, 2012). Evidence suggests that supplier diversity programs combined with sustainability programs outperform diversity programs on their own (Blount & Hill, 2015). Recent research has shown that green supply chain management practices play a mediating role in the industry 4.0 technologies and sustainable supply chain performance, while also strengthening the mediation effect (Malhotra et al., 2023). In Pakistan, where the supplier diversity culture is in the infancy stage, companies which are implementing both supplier diversity and sustainability are likely to see synergy effects that will result in efficiency improvements. Hence, the following can be formulated as a hypothesis:

H4: *Sustainability Practices mediate the relationship between Supplier Diversity and Supply Chain Efficiency in Pakistan*

Figure 1: Conceptual Research Framework



Research Methodology

In the present study the research design chosen was cross sectional quantitative research using the survey approach which is suitable for the aim of the study that involves testing a theory-based hypothesis involving measurable constructs using statistical procedures (Creswell & Creswell, 2018). This design was chosen to look at the direct and mediated impact of Supply Chain Integration and Supplier Diversity on Supply Chain Efficiency, mediated through Sustainability Practices. The data were gathered at a specific moment, and a sample was obtained from the target population (Saunders et al., 2019; Hayes, 2022). These included Supply chain managers, procurement officers, logistics professionals and operations managers from medium and large sized organizations in Pakistan. The respondents were chosen because they had experience in supplier integration, diversity sourcing, sustainability, and overall supply chain performance (Schoenherr & Swink, 2012). The sample included various industries such as textile and apparel, food and beverages, pharmaceuticals, automobiles, retail and wholesale, third party logistics and general manufacturing (Khan & Sadiq, 2016). Based on the guideline of 10 - 20 observations per parameter for path analysis (Hair et al., 2019), a target of 325 observations was set. A post-hoc power analysis for multiple regression (with three predictors), using medium effect size ($f^2 = 0.15$), and $\alpha = 0.05$ indicated an adequate sample size of 77, and 325 was well above it (Cohen, 1992).

Measurement of Variables

The questionnaire assessed four focal constructs with a 5-point scale from Strongly Disagree (1) to Strongly Agree (5). Supply Chain Efficiency was modeled as a multi-dimensional variable, consisting of cost, lead time, inventory management, flexibility and customer satisfaction which comprised of six items adapted from Beamon (1999) and Gunasekaran et al. (2004). Supply Chain Integration was assessed through six items adapted from Flynn et al. (2010) and re-validated by Wong et al. (2011) which covers internal integration and external integration such as information sharing, collaborative planning and system integration. Supplier Diversity was evaluated by using six items adapted from Carter and Jennings (2004) and Krause et al. (2009) for the socio-economic context of Pakistan. Sustainability Practices were measured with 6 items adapted from Srivastava (2007) and larger sustainability measurement models (Bowersox et al., 2000; Pagell & Wu, 2009).

Data Analysis Techniques

The internal consistency reliability of the instruments was tested using cronbach's alpha, and the values of 0.70 or more were regarded as acceptable, and good values were those greater than 0.80 (Nunnally & Bernstein, 1994). Corrected item-total correlations were explored for items that had corrected item-total correlation values below the .30 cut-off (Field, 2018) and alpha-if-item-deleted statistics were examined to see whether the deletion of the items would improve the reliability of the scale (Fornell & Larcker, 1981). Pearson's bivariate correlation analysis was used to examine the linear relationships among the major variables and to ensure no multicollinearity issues by restricting the correlation coefficients to greater than 0.80 (Field, 2018) and the Variance Inflation Factor values to under 5 (Hair et al., 2019). A correlation between the independent variables and the mediator, and between the mediator and the dependent variable was also carried out to test for foundational conditions of mediation: for a significant relationship to exist between the independent variables and the mediator, and another between the mediator and the dependent variable (Baron & Kenny, 1986).

The PROCESS macro (Hayes, 2022) in SPSS version 4.2 was used to perform hypothesis testing. Model 4 was used which involved one mediator (Sustainability Practices (M)) and multiple independent variables (Supply Chain Integration (X1) and Supplier Diversity (X2)), and an outcome variable, Supply Chain Efficiency (Y). The model simultaneously estimated direct paths from each independent variable to the mediator (a1, a2), the path from the mediator to the outcome controlling for the independent variables (b), direct paths from independent variables to the outcome (c'1, c'2) and the total effects. 5,000 bootstrap samples were used to test the indirect effects (a1 × b and a2 × b), and the 95 percent confidence interval (CI) was bias corrected; statistical significance was established when the 95 percent CI did not include the value of zero (Hayes, 2022). The Sobel test was not used in favor of bootstrapping because it is not required to assume normal distribution of the indirect effect and because it produces more accurate Type, I error in moderate sized samples (MacKinnon et al., 2004). All mediation hypotheses were tested, and each path was estimated while controlling for the other independent variable.

Data Analysis, Interpretation and Discussion of Results

Table 1 shows the result of the reliability analysis for all four constructs and the number of items used to measure each construct. Cronbach's alpha indicated good internal consistency for every scale, with .908 for Sustainability Practices and .928 for Supplier Diversity. These coefficients exceeded the acceptable threshold of .70 and benchmark of .80 for good reliability, suggesting that items in each construct measure the same underlying latent variable. When item-total statistics were examined, no single item, should it be removed, would significantly increase alpha coefficients for the scale. The corrected item-total correlations were above the recommended minimum of .30 (Field, 2018) and varied from .716 to .814. The measurement model therefore has acceptable reliability and is considered to be appropriate for hypothesis testing.

Table 1: Construct Reliability

Construct	Number of Items	Cronbach's Alpha
Supply Chain Integration (SCI)	**6**	**.927**
Supplier Diversity (SD)	**6**	**.928**
Sustainability Practices (SP)	**6**	**.908**
Supply Chain Efficiency (SCE)	**6**	**.924**

In order to test the hypothesized direct and mediated relationships, the PROCESS macro in SPSS (Model 4) was used with 5,000 bootstrap samples and 95% bias corrected confidence intervals. Two mediation models were considered: the first was a mediation path between Supply Chain Integration (SCI) and Supply Chain Efficiency (SCE) with Sustainability Practices (SP) as

mediator, and the second was a mediation path between Supplier Diversity (SD) and SCE via SP. The independent variable was labeled 'X', the mediator variable was labeled 'M', and the outcome variable was labeled 'Y' in each of these models. The results are shown in Tables 4.2 and 4.3 and are discussed below.

In the first hypothesis H1 stated that Supply Chain Integration had a positive effect on Supply Chain Efficiency. After controlling for the mediator, the direct effect of SCI on SCE was positive and statistically significant ($\beta = 0.3113$, $t = 7.2068$, $p < .001$, 95% CI [0.2263, 0.3963]). The confidence interval does not contain 0, so there is strong evidence for H1. This finding shows that firms with a high degree of supply chain integration (SCI) with real-time information sharing, collaborative planning, and system integration, experience significant gains in cost efficiency, lead time, and operational flexibility (Flynn et al., 2010; Ataseven & Nair, 2017). Previous studies in developed economies have shown that companies with a greater level of integration across information systems, processes and partner relationships are more efficient in terms of lower costs, faster delivery, and flexibility (Frohlich & Westbrook, 2001; Flynn et al., 2010; Wong et al., 2011). Emerging meta-analytic evidence also highlights the pivotal role of supply chain integration as a partial mediator between supply chain resilience and performance, highlighting the importance of its role in converting capabilities to results (Li et al., 2023). This current discovery adds to the existing body of literature in the Pakistani context where institutional voids, infrastructural gaps and high transaction costs are prevalent and hinder the efficiency of supply chains.

A positive relationship between Supplier Diversity and Supply Chain Efficiency (H2). The direct effect of SD on SCE was positive and significant ($\beta = 0.3050$, $t = 7.5540$, $p < .001$, 95% CI [0.2256, 0.3844]), providing support for H2. The results indicate that companies intentionally diversifying their supply bases (both with SMEs and geographically dispersed suppliers and underrepresented business entities) experience useful operational gains. Supplier diversity can lead to flexibility, supplier dependency reduction and innovation, all of which are linked to enhance efficiency (Krause et al., 2009; Adobor & McMullen, 2007). Much of what has been written about supplier diversity has been focused on social equity motivations and regulatory compliance requirements, especially in the U.S. (Carter & Jennings, 2004). The business case for diversity has been made, with a diverse supply base bringing competition, innovation and flexibility which has a positive impact on operations (Krause et al., 2009; Richard et al., 2013).

Recent studies have further substantiated this claim by showing how supplier diversity programs can positively impact the resilience of a firm's supply chain by building more resilient, agile and adaptable supply networks (Rosti, 2024). Moreover, recent evidence dispels the notion that supplier diversity leads to lower performance: In some cases, small and diverse suppliers can execute a contract more effectively than larger suppliers (Mishra et al., 2024). A recent study has explored the balancing act between supplier diversity and cost-effective procurement, identifying affirmative action mechanisms that can yield both. (Alcalde & Dahm, 2024). This study is one of the first quantitative validations of the business case for supplier diversity in a South Asian context and suggests that strategic supplier development and performance management can be used as performance levers, similar to integration (Walker & Brammer, 2012; Worley et al., 2016).

The mediation hypothesis (H3) was that Sustainability Practices mediate between SCI and SCE. The indirect effect of SCI on SCE through SP was positive and statistically significant ($\beta = 0.2628$, Boot SE = 0.0321, 95% Boot CI [0.2004, 0.3259]). These integrated supply chains provide opportunities for the co-development and implementation of green initiatives by participating companies, leading to lower waste, energy costs and energy savings, as well as more efficient operations (Vachon & Klassen, 2006; Green et al., 2012). Supply chain managers provide the required trust, shared goals and joint investments to achieve good environmental and social practices (Touboulic & Walker, 2015). At the level of the supply chain, integration facilitates companies to co-create eco-design specifications, coordinate green logistics and share the expenses of clean technologies. For example, an integrated manufacturer might redesign the package to decrease the amount of material used, which would in turn decrease transport volumes, and thus both could save costs that they would otherwise not be able to save on their own (Seuring & Müller, 2008). In the past, the relationship between Industry 4.0 technologies and sustainable performance has been explored, and it has been found that supply chain integration has a moderating effect on resilience and circular economy practices' impact on sustainable supply chain performance, thereby enhancing the impact of sustainability-oriented capabilities (Alkhatib et al., 2025). Moreover, digital and green supply chain strategies have been found to have a significant impact on environmental and economic performance through various pathways, such as reducing environmental impacts, optimizing operations in the supply chain, and improving operational efficiency (Zhang et al., 2026), and mapping of the upstream supply chain plays a crucial mediating role.

Table 2: Relationship Hypothesis

Hypothesis	Effect	SE	t	p	LLCI	ULCI	Result
H1: SCI → SCE (direct)	.3113	.0432	7.2068	.0000	.2263	.3963	Supported
H2: SD → SCE (direct)	.3050	.0404	7.5540	.0000	.2256	.3844	Supported
H3: SCI → SP → SCE (indirect)	.2628	.0321 (Boot)	—	—	.2004	.3259	Supported
H4: SD → SP → SCE (indirect)	.2432	.0307 (Boot)	—	—	.1861	.3065	Supported

Note. Bootstrap sample size = 5,000. [1]Bootstrap 95% confidence interval (LLCI, ULCI).

The final hypothesis was that Sustainability Practices was posited to mediate the relationship between Supplier Diversity and Supply Chain Efficiency. The indirect effect of SD on SCE via SP was positive and significant (β = 0.2432, Boot SE = 0.0307, 95% Boot CI [0.1861, 0.3065]); this result supports H4. This discovery suggests that supplier diversity has not just a direct link to efficiency but also an indirect link due to the additional sustainability practices they provide the firm (Walker & Brammer, 2012; Sarkis, 2012). Recent empirical research on supplier diversity in emerging economies has shown that the supplier diversity journey can be divided into three phases: structuring, operating, and adapting; and that intermediate stages are necessary to achieve success, as they help develop a legitimate intermediary network and a coherent knowledge base (Miguel & Silva, 2024). Moreover, research indicates that supplier diversity initiatives contribute to supply chain resilience by establishing more flexible, dynamic, and resilient supply chains, which can help minimize reliance on a few key suppliers and minimize the risks of supply chain disruptions (Rosti, 2024). The use of a diverse supply base therefore is not just about supply chain expansion but also supply chain diversity to enhance the firm's sustainability portfolio to increase efficiency. Different suppliers have different sustainable characteristics, often smaller, local companies (Walker & Brammer, 2012; Hart & Dowell, 2011). The efficiency gains based on legitimacy may be significant (Hassan et al., 2020). Diversity on the supply base itself is a sensing mechanism, which can be used to identify new sustainable technologies and practices that can then be exploited and absorbed by the firm (Teece et al., 2007; Akbar & Aslam, 2023). This approach is consistent with supplier diversity as a dynamic sourcing capability that is continually evolving in response to market needs (Sordi et al., 2022).

The mediation models are fitness statistics significant as per the model fitness statistics presented in Table 4.3. The model with SCI as the independent variable explained 53.87% of the variance in SCE (R^2 = .5387, F (2, 322) = 187.98, p < .001), while the model with SD as the independent variable explained 54.49% of the variance (R^2 = .5449, F (2, 322) = 192.77, p < .001). These R^2 values can be regarded as high for a survey research study in the field of supply chain (Hair et al., 2019) and reveal that the combination of SCI, SD and SP provides a strong predictive power of efficiency. Furthermore, the substantial F tests indicate that both models are a good fit to the data in the ordinary least squares regression sense. The PROCESS macro does not calculate fit indices as one would with traditional SEM, however the large amount of variance explained, and the close range of the bootstrapped confidence intervals support the validity and reliability of the results.

Table 3: Model Fitness of Process Hayes Analysis

Model (X)	R	R^2	MSE	F	df1	df2	p
SCI	.7339	.5387	.3419	187.9849	2	322	.0000
SD	.7382	.5449	.3373	192.7676	2	322	.0000

Conclusion

The present study responded to a significant gap in literature on supply chain management by developing and testing the integrated model, which brings together supply chain integration, supplier diversity, sustainability practices and supply chain efficiency in the context of Pakistan's industry by drawing on the Resource-Based View, Transaction Cost Economics, Stakeholder Theory, Dynamic Capabilities, Relational View and Institutional Theory (Barney, 1991; Williamson, 1985; Freeman, 1984; Teece et al., 1997; Dyer & Singh, 1998; DiMaggio & Powell, 1983). The supply chain professionals confirmed structural and relational performance effects of integration and supplier diversity, respectively, and confirmed the mediating role of sustainability practices on both, thus strengthening the positive performance impact of both strategies. These results position sustainability as a facilitator of integration and diversity's efficiency gains as well as a translator of the direct effects of integration and diversity, in order to give a more nuanced view of the sustainable supply chain management than direct-effects perspectives alone, as exposed by Carter & Rogers (2008) and Seuring & Müller (2008). The validated model also offers evidence of the cross-cultural validity of

existing SCM scales in an emerging economy, which helps to de-parochialize supply chain knowledge geographically, and suggests a multi-theory template for future study.

Recommendations and Future Research

Supplier diversity should be raised to a pillar of procurement, with formal supplier diversity programmes, which involve the identification, pre-qualification and development of SMEs, women-led businesses and vendors from less developed areas and supplier selection criteria to include sustainability aspects such as green inputs, energy efficiency and social compliance. Joint sustainability initiatives need to be institutionalized in procurement, logistics and operations, such as through shared green logistics, co-innovation workshops and environmental joint projects with cost reduction and strengthening of relational capital. Industry associations and chambers of commerce can contribute to these endeavors by implementing digital matchmaking platforms, conducting industry-wide sustainability benchmarking and organizing collective training, and government agencies may offer tax credits, access to financing for shared green infrastructure, and streamlined customs clearance for sustainability certified exports. In addition, multi-informant and mixed-method designs would enhance construct validity and limit common method concerns, and an in-depth, qualitative study of companies with high integration, diversity, and sustainability could uncover the micro-processes and routines that result in synergistic effects. It is important to include moderating factors (environmental uncertainty, technological turbulence, top management commitment, organizational culture and competitive intensity) to examine moderated-mediation, and to determine boundary conditions (Hayes, 2018).

Limitations

Since data were self-reported by individual informants, common method variance is still a potential issue as Harman's single factor test did not suggest there was a serious problem (Podsakoff et al., 2003). The convenience sample with purposive elements restricts statistical generalizability, because the study targets larger urban areas and medium-to-large organisations, resulting in an underrepresentation of small firms, rural supply chains and informal enterprises. Unmeasured variance was also not controlled by excluding other variables such as firm age, ownership structure, R&D intensity, and industry sub-sector from the hypothesis-testing model. There was the possibility of supplier diversity being operationalised as a combined measure of SME status, geographic dispersion and gender ownership, thus masking some dimension-specific effects, and all efficiency measures were perceptual based on managerial judgement rather than objective measures like inventory turnover, logistics cost percentage or on-time delivery statistics.

Appendix A-Questionnaire

Section A: Screening and Demographics

Q1. Are you currently employed in a supply chain, procurement, logistics, or operations role? Yes; No. (A response of No ended the survey).

Q2. Name of your organization (optional). Q3. Industry of your organization.

Textile/Apparel; Food & Beverage; Pharmaceutical; Automotive; Retail/Wholesale; Manufacturing (other); Logistics/3PL; Construction; IT/Telecom; Other (please specify).

Q4. Your job title or functional role.

Supply Chain Manager; Procurement Manager/Officer; Logistics Manager; Operations Manager; CEO/Director; Other (specify).

Q5. Total work experience in the supply chain field.

Less than 1 year; 1–5 years; 6–10 years; 11–15 years; More than 15 years.

Q6. Location of your main office or operations (city).

Karachi; Lahore; Faisalabad; Islamabad/Rawalpindi; Sialkot; Gujranwala; Multan; Other (specify).

Q7. Number of employees in your organization.

1–50; 51–250; 251–500; More than 500.

Section B: Supply Chain Integration

SCI1. Our organization shares real-time production and inventory information with key supply chain partners.

SCI2. Our supply chain partners are involved in our demand forecasting and planning processes.

SCI3. We have a high level of strategic collaboration with our major suppliers and customers.

SCI4. Our information systems (e.g., ERP, EDI) are well integrated with those of our supply chain partners.

SCI5. Joint planning and decision-making with supply chain partners occur frequently.

SCI6. We regularly measure and share performance metrics (e.g., on-time delivery, quality) with supply chain partners.

Section C: Supplier Diversity

SD1. Our company actively sources from a wide range of suppliers, including small and medium enterprises (SMEs).

SD2. We have formal policies or programmes to engage women-owned or minority-owned businesses in our supply base.

SD3. Supplier diversity is considered a strategic priority in our procurement decisions.

SD4. Working with diverse suppliers has increased the variety of innovative solutions available to us.

SD5. Our supplier base includes businesses from different geographic regions within Pakistan.

SD6. Diverse supplier participation has reduced our dependency on a few large suppliers.

Section D: Sustainability Practices

SP1. Our organization has implemented environmental criteria in supplier selection and evaluation.

SP2. We actively work to reduce waste (e.g., packaging, energy, water) in our supply chain operations.

SP3. Our logistics and transportation activities are regularly audited for environmental performance (e.g., carbon footprint).

SP4. We collaborate with supply chain partners to improve social and ethical standards (labour rights, health and safety) throughout the chain.

SP5. Our sustainability initiatives have led to measurable cost savings (e.g., through energy efficiency, reduced material use).

SP6. We regularly report on sustainability performance to both internal and external stakeholders.

Section E: Supply Chain Efficiency

SCE1. Over the past two years, our supply chain has significantly reduced total operational costs.

SCE2. Our order fulfilment lead times have consistently improved.

SCE3. We maintain optimal inventory levels, neither excessive stock-outs nor overstock situations.

SCE4. Our supply chain is able to respond quickly to unexpected changes in demand or supply disruptions.

SCE5. The quality of products or services delivered to customers has improved due to better supply chain coordination.

SCE6. Overall customer satisfaction with our delivery performance has increased.

Section F: Open Feedback (Optional)

Q8. Any additional comments regarding sustainability, supplier diversity, or supply chain efficiency in your organization

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