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RESEARCH ARTICLE

E-Procurement and firm performance: a sequential mediation analysis via supply chain agility and green procurement practices— a configuration and dynamic capability perspective

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ABSTRACT

Digital capabilities are increasingly recognized as drivers of operational responsiveness and sustainability in emerging markets. Integrating the Dynamic Capabilities View and Configuration Theory, this study examines how e-procurement relates to firm performance through the mediating mechanisms of supply chain agility and green procurement practices. Using a cross-sectional survey of 261 key informants across ISO 14001-certified textile manufacturing firms in Pakistan, hypothesized direct, mediated, and sequential paths were evaluated using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS 4 with 5,000 bootstrap resamples. E-procurement exhibits a significant direct positive association with firm performance ($\beta = 0.412, p < 0.001$), supply chain agility ($\beta = 0.452, p < 0.001$), and green procurement practices ($\beta = 0.487, p < 0.001$). Mediation analysis reveals that supply chain agility acts as a complementary partial mediator ($\beta = 0.138, p = 0.002$), while green procurement practices act as a full mediator ($\beta = 0.192, p < 0.001$). Furthermore, a sequential indirect path (ß=0.085, p=0.003,95% CI=0.031,0.149) demonstrates that e-procurement enhances supply chain agility, which facilitates green procurement adoption and subsequently boosts firm performance (R2=0.418, Q^2=0.254). The model accounts for 41.8% of the variance in firm performance ($R^2 = 0.418$) and exhibits in-sample predictive relevance ($Q^2 = 0.254$). Findings suggest that e-procurement is associated with enhanced performance both directly and indirectly via operational agility and green purchasing routines. Boundaries of inference are defined by the cross-sectional single-informant design and focus on ISO 14001-certified firms.

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1. Introduction

The textile industry is one of the most procurement-intensive manufacturing sectors, where company performance is constrained by sourcing materials, coordinating suppliers, controlling costs, ensuring raw material availability, and meeting buyer expectations (Adane et al., 2021; Li et al., 2026). In dynamic markets, inefficient procurement can easily lead to production delays, cost escalation, compromised supply chain responsiveness, and loss of competitiveness (Farrukh & Sajjad, 2025). This is particularly true in Pakistan, where textile manufacturers confront price fluctuations in raw materials, energy shortages, exchange rate fluctuations, supplier lead times, and export-market pressures (Abbas &

Halog, 2021; Hayat et al., 2020; Khan et al., 2024; Mehar, 2022). Meanwhile, global customers are demanding that textile firms go green, source materials sustainably, and implement ethical procurement (Akhuand & Abbas, 2023). These challenges make the digitization of procurement critical rather than just another efficiency project (Seyedghorban et al., 2020).

E-procurement has become a key digital capability for firms because it allows them to streamline procurement processes, automate manual tasks, improve communication with suppliers, increase transparency, and speed up procurement (Albinkhalil & Razzaque, 2021; Althabatah et al., 2023). Moving procurement activities from disconnected manual processes to computer-supported systems enables firms to improve information quality, supplier evaluation, recordkeeping, purchasing speed, and procurement process control (Harland, 2021). In the textile industry, where timely procurement is crucial to maintaining production schedules and order commitments, e-procurement can be a critical factor in operational and market performance (Adane et al., 2021). Earlier studies have examined it in terms of purchasing efficiency, cost reduction, transaction velocity, and supplier coordination (Kamran et al., 2024; Naeem et al., 2021). Other researchers have independently associated supply chain agility with responsiveness, flexibility, and performance in uncertain environments (Dhir, 2020).

Likewise, the green procurement literature indicates that sustainable procurement practices have a positive impact on compliance, reputation, resource efficiency, and buyer trust (Chiang & Chuang, 2024; Lăzăroiu et al., 2020). Although prior literature has examined sub-sets of these relationships—such as Singh and Chan (2022), who evaluated e-procurement and green procurement without considering operational agility, and Rajabian Tabesh et al. (2024), who examined agility and green purchasing without digital e-procurement capabilities—the literature lacks an integrated dynamic capability model. This study makes three primary theoretical contributions:

a. We advance beyond piecemeal models by demonstrating how digital sensing (e-procurement), operational reconfiguration (agility), and sustainable routines (green procurement) form a single, sequential dynamic capability system.
b. We extend Singh and Chan (2022) by establishing operational agility as a vital enabler that converts digital procurement infrastructure into green purchasing routines.
c. We build upon Rajabian Tabesh et al. (2024) by identifying e-procurement infrastructure as the foundational antecedent of supply chain agility in volatile emerging-market contexts."

Supply chain agility enables firms to respond to shifts in demand, supplier lead times, and delivery deadlines (Goraya et al., 2026; Li et al., 2021; Lotfi & Sodhi, 2024; Rajabian Tabesh et al., 2024; M. Wang et al., 2025). At the same time, green procurement practices help them meet environmental expectations and gain legitimacy in their export markets (Ma et al., 2021; Nguyen et al., 2023). However, the literature falls short of explaining how e-procurement is central to these two capability areas. Most studies treat e-procurement as an efficiency tool, agility as an operational response competency, and green procurement as a sustainability intervention (Albinkhalil & Razzaque, 2021; Althabatah et al., 2023; Kamran et al., 2024; Naeem et al., 2021; Waqar et al., 2025). This piecemeal perspective leaves it unclear whether e-procurement enhances firm performance inherently, or whether its benefits come through enhanced agility, more robust green procurement behavior, or a sequential combination of both. The gap is particularly significant in the Pakistani textile sector, where companies must contend with competing demands: fluctuating input costs, supplier delays, export quotas, and increasingly stringent environmental requirements from foreign consumers (Abbas & Halog, 2021; Akhuand &

Abbas, 2023). Within this environment, e-procurement can enhance performance not only by lowering transaction costs and accelerating procurement decisions, but also by enabling firms to respond more quickly to disruptions and to internalize sustainability-focused procurement practices. Based on this, the research questions that are considered in this study are as follows:

RQ1. *Does e-procurement directly enhance firm performance in the Pakistani textile industry?*

RQ2. *Does e-procurement strengthen supply chain agility and green procurement practices?*

RQ3. *Do supply chain agility and green procurement practices mediate the relationship between e-procurement and firm performance?*

RQ4. *Do supply chain agility and green procurement practices sequentially mediate the relationship between e-procurement and firm performance?*

To address these questions, we collected data through a survey of 261 procurement and supply chain managers in active registered companies in the Pakistani textile industry. We used SmartPLS to test our proposed model, enabling us to examine direct, mediating, and sequential mediating relationships within a single empirical framework. This study advances beyond contextual replication by demonstrating how digital sensing (e-procurement) converts into operational reconfiguration (agility) and sustainable routines (green procurement) in a single, sequential capability system. Specifically, we extend Singh and Chan (2022) by establishing operational agility as a vital antecedent to green purchasing routines and build upon Rajabian Tabesh et al. (2024) by identifying digital e-procurement infrastructure as the foundational enabler of agility, an emerging-market environment in which firms face the triple challenges of volatility, digital transformation, and sustainability. This research synthesizes e-procurement, agility, green procurement, and firm performance to show how textile firms can leverage digital procurement to improve operational, environmental, and market performance.

The rest of the paper is organized as follows. Section 2 provides the theoretical background and formulates the study's hypotheses. Section 3 explains the research method, including questionnaire adaptation, data collection, and the sample profile. Section 4 presents the results of empirical analysis, measurement evaluation, and hypothesis testing. Section 5 discusses the findings. Sections 6 and 7 outline managerial implications, limitations, and research directions.

2. Theoretical background and hypothesis development

2.1 Theoretical background

The theoretical foundation of this research is anchored primarily in the dynamic capability perspective (DCP) (Akenroye et al., 2020; Herold et al., 2023). Within this framework, e-procurement is conceptualized as an overarching digital sensing and information-processing capability that enhances real-time visibility across purchasing operations (Alnuaimi et al., 2025). Supply chain agility represents an operational reconfiguration capability that allows firms to seize opportunities and adjust sourcing and delivery schedules in response to market disruptions (Lotfi & Sodhi, 2024). Green procurement practices represent institutionalized operational routines through which sustainable purchasing criteria are executed (Khan et al., 2023). Rather than claiming

unmeasured structural hierarchies or non-linear configurational synergy, this study evaluates linear additive mediation and sequential capability transmission paths to explain how digital information processing translates into multidimensional firm performance (Raghul et al., 2024). Specifically, H1, H3, H5, and H7 draw primarily on Configuration Theory to explain the alignment of digital governance and sustainability routines, whereas H2, H4, H6, and H8 draw on the Dynamic Capabilities View (DCV) to capture operational sensing, seizing, and reconfiguration mechanisms (Raghul et al., 2024). This establishes the core theoretical logic: e-procurement, supply chain agility, and green procurement practices operate as an interconnected capability network. Digital procurement systems generate sustainable performance outcomes when integrated with responsive supply chain reconfigurations and sustainability-oriented purchasing routines (Akenroye et al., 2020). This theoretical stance justifies the study's research questions by explaining how e-procurement can directly impact firm performance and, through its effects on agility and green procurement processes, indirectly influence it (Ali, 2025; Kumar & Ganguly, 2021).

E-procurement is a digital procurement opportunity that allows searching for suppliers, sourcing, negotiating, ordering, coordinating, documenting, and assessing suppliers (Althabatah et al., 2023; Karttunen et al., 2023). In terms of configuration theory, e-procurement enhances firm performance when digital procurement routines are well coordinated with suppliers, buying decisions, and internal business operations (Pattanayak & Punyatoya, 2020). Procurement efficiency in the Pakistani textile industry, where companies face supplier delays, cost fluctuations, uncertainty in raw-material availability, energy disruptions, and pressure in the export market, is directly linked to the continuity of production and the reliability of deliveries (Abbas & Halog, 2021; Akhuand & Abbas, 2023; Hayat et al., 2020). E-procurement reduces manual processing, enhances purchasing transparency, reduces transaction costs, speeds up approvals, and improves communication with suppliers (Albinkhalil & Razzaque, 2021; Althabatah et al., 2023; Ghosh, 2019; Kamran et al., 2024; Kanyepe & Alfaneta, 2025).

Thus, the theoretical justification for RQ1 is as follows: e-procurement can enhance firm performance by establishing a more suitable relationship between procurement technology and operational performance. The theoretical foundation of e-procurement and supply chain agility is the dynamic capability perspective (Chiang & Chuang, 2024; Farrukh & Sajjad, 2025). This perspective holds that companies operating in unpredictable settings need the ability to sense change, capture opportunities, and reallocate resources (Teece, 2019). Supply chain agility indicates dynamic capability, as it enables companies to respond swiftly to demand fluctuations, supplier shocks, production unpredictability, and shipping pressures. E-procurement enhances this ability by increasing information visibility, enabling real-time communication with suppliers, and speeding decision-making (Alnuaimi et al., 2025; Raghul et al., 2024).

Consequently, RQ2 is justified because e-procurement increases agility by providing firms with digital infrastructure to identify disruptions in advance and adjust procurement decisions more quickly. RQ3 is motivated by the fact that supply chain agility mediates the e-procurement-performance relationship in that digital procurement information enhances performance solely when firms can transform that information into operational action in a timely manner. Configuration theory also elucidates the relationship between e-procurement and green procurement practices (Moyo & Hofisi, 2025). Green procurement involves incorporating environmental criteria into supplier selection, purchasing, documentation, and supplier evaluation (Streimikis et al., 2024). E-procurement facilitates this integration by enhancing traceability, supporting electronic documents, enabling supplier monitoring, and enabling sustainability-based assessment (Albinkhalil & Razzaque,

2021; Kamran et al., 2024). Green procurement is a path to legitimacy, buyer confidence, and market access in Pakistan's textile sector, where international buyers are increasingly insisting on responsible sourcing and environmental compliance.

Therefore, green procurement practices act as a second mediating variable under RQ3, describing how e-procurement enhances performance through sustainability-oriented procurement practices. Lastly, the two theories can be combined to support a sequential mediation logic. E-procurement initially offers digital visibility and coordination; supply chain agility then transforms the visibility into rapid reconfiguration (Kamran et al., 2024; Raghul et al., 2024); green procurement practices then translate the agile procurement capability into sustainability compliance and market legitimacy (Al Karim et al., 2024; Foo et al., 2019; Lotfi & Sodhi, 2024; Rajabian Tabesh et al., 2024; Streimikis et al., 2024). This provides the theoretical rationale for RQ4: e-procurement enhances firm performance sequentially, first through supply chain agility and then through green procurement practices. This causal reasoning is theoretically superior to discrete mediation because it describes how digital competence evolves into operational responsiveness and, subsequently, sustainability-driven performance.

3. Hypotheses development

3.1 E-procurement and firm performance

E-procurement is more than a digital replacement for conventional purchasing; it is a procurement-level digital capability that changes how firms identify suppliers, process orders, negotiate, document transactions, evaluate suppliers, and coordinate purchasing decisions (Albinkhalil & Razzaque, 2021; Kamran et al., 2024; Kanyepe & Alfaneta, 2025). Prior studies define e-procurement as the use of internet-based and digital technologies for organizational purchasing and as an IT-based system that integrates and standardizes procurement processes (Kumar & Ganguly, 2021; Naeem et al., 2021; Pattanayak & Punyatoya, 2020; Raghul et al., 2024). This is important because procurement sits at the front end of the supply chain. Any inefficiency in procurement can move downstream into material shortages, production delays, delivery failures, cost escalation, and customer dissatisfaction (Kanyepe & Alfaneta, 2025; Naeem et al., 2021; Pattanayak & Punyatoya, 2020).

This relationship is grounded in configuration theory. Configuration theory suggests that firm performance improves when technologies, organizational routines, supplier coordination mechanisms, and decision processes are internally aligned (Farrukh & Sajjad, 2025; Teece, 2019). In Pakistan’s textile sector, this alignment is critical because firms operate under raw material price volatility, supplier unreliability, energy shortages, import constraints, export pressure, and unstable demand (Abbas & Halog, 2021; Akhuand & Abbas, 2023; Hayat et al., 2020). Traditional procurement systems are often slow, paper-based, fragmented, and error-prone. E-procurement addresses these weaknesses by automating procurement activities, improving purchasing transparency, reducing transaction costs, strengthening supplier communication, and enabling faster managerial decisions (Kamran et al., 2024; Kanyepe & Alfaneta, 2025; Kumar & Ganguly, 2021).

In this study, e-procurement is therefore viewed as a performance-generating digital configuration rather than a narrow operational tool (Alnuaimi et al., 2025; Pattanayak & Punyatoya, 2020; Raghul et al., 2024). Its value lies in improving procurement efficiency, information accuracy, supplier visibility, process control, and decision speed (Albinkhalil & Razzaque, 2021; Kamran et al., 2024; Kanyepe & Alfaneta, 2025; Raghul et al., 2024). Since

textile firms depend heavily on timely material availability, production continuity, delivery reliability, and buyer satisfaction, a stronger e-procurement capability should directly enhance firm performance.

H1. *E-procurement positively affects firm performance in the Pakistani textile sector.*

3.2 E-procurement and supply chain agility

Supply chain agility is the capacity of a company and its supply chain to react swiftly to market fluctuations, supplier failures, fluctuating consumer demand, and supply uncertainty (AlNuaimi et al., 2022; Lotfi & Sodhi, 2024; Rajabian Tabesh et al., 2024). Agile supply chains demonstrate high flexibility in sourcing, have high supplier coordination, flexible order processing, and prompt response to customer needs (Delbufalo, 2022; Goraya et al., 2026; Shahin et al., 2022). Agility does not rely solely on the speed of operations within the firm but also on the firm's capacity to effectively coordinate its operations with suppliers and other supply chain partners (Ali, 2025). The connection between e-procurement and supply chain agility is theoretically grounded in the dynamic capabilities perspective (Rane et al., 2020). This perspective holds that companies in unpredictable environments need the capacity to detect changes, capture opportunities, and quickly reorganize resources (Mavidis & Folinas, 2022; Rane et al., 2020). These dynamic capabilities are supported by e-procurement, which enhances supplier visibility, information accuracy, procurement speed, and electronic coordination (Akenroye et al., 2020; Albinkhalil & Razzaque, 2021; Coppola et al., 2023).

Contrary to traditional procurement systems, which are usually characterized by fragmented communication, slow supplier feedback, and paper-based approval, e-procurement enables faster supplier searches, online sourcing, electronic tendering, e-negotiation, electronic documentation, and real-time order tracking (AlNuaimi et al., 2022; Alnuaimi et al., 2025; Kamran et al., 2024; Raghul et al., 2024; Shahin et al., 2022). The relationship is especially applicable to the Pakistani textile industry, where companies often experience volatility in cotton and yarn prices, shipment delays, power outages, supplier uncertainty, and fluctuating export demand (Akhuand & Abbas, 2023; Kamran et al., 2024). In these circumstances, companies require a procurement system that enables them to find alternative suppliers, update purchase orders, expedite approvals, and respond swiftly to changes on both the supply and demand sides (Hayat et al., 2020; Kamran et al., 2024; Mehar, 2022). E-procurement enhances this responsiveness by establishing a more integrated and flexible procurement-supply interface. E-procurement is thus imagined as a digital capability that can enable agility rather than merely a transactional procurement tool (Albinkhalil & Razzaque, 2021; Lotfi & Sodhi, 2024; Raghul et al., 2024; Rajabian Tabesh et al., 2024). Its usefulness extends beyond accelerating purchasing operations to assist companies in restructuring supplier selection, sourcing decisions, and procurement processes in the event of a disruption (Lotfi & Sodhi, 2024). Therefore, companies with greater e-procurement capability are likely to have higher supply chain agility.

H2. *E-procurement positively affects supply chain agility in the Pakistani textile sector.*

3.3 E-procurement and green procurement practices

Green procurement practices involve incorporating environmental considerations into supplier selection, sourcing decisions, material evaluation, procurement documentation, and supplier monitoring (Fu et al., 2019). Green procurement, which differs from traditional purchasing in terms of price, quality, and delivery, involves decisions based on environmental compliance, sustainable material use, waste reduction, and supplier responsibility (Kamran et al., 2024; Kumar & Ganguly, 2021; Mavidis & Folinas, 2022; Singh & Chan, 2022). Such a wider perspective is especially significant for companies engaged in export-based businesses, where customers are increasingly critical of suppliers based on their operational and environmental performance (Mélon & Spruk, 2020; Mohungoo et al., 2020; Pattanayak & Punyatoya, 2020; Raghul et al., 2024). Configuration theory provides conceptual support for the link between e-procurement and green procurement practices. Green procurement involves coordination between the procurement systems, environmental targets, supplier assessment procedures, and purchasing (Mélon & Spruk, 2020; Yap et al., 2026).

E-procurement helps facilitate this fit through enhanced traceability, documentation, transparency, and supplier monitoring. In manual procurement systems, environmental information is often fragmented, supplier comparisons are uneven, and sustainability criteria may be implemented informally (AlNuaimi et al., 2021; L. Wang et al., 2025). E-procurement minimizes these weaknesses by incorporating environmental requirements into supplier databases, electronic tender documents, evaluation forms, purchasing approvals, and procurement records (Alnuaimi et al., 2025; Chen et al., 2022; Fu et al., 2019; Kamran et al., 2024; Mohungoo et al., 2020). This association is highly applicable to Pakistan's textile industry. Global consumers are putting increasing pressure on textile exporters to be responsible, eco-friendly, less wasteful, and to use sustainable production input. E-procurement offers businesses a viable way to institutionalize such requirements within their normal procurement procedures (Ali, 2025; Chen et al., 2022; Raghul et al., 2024; Shahin et al., 2022). As an example, environmental certifications, waste-control practices, material sustainability criteria, and supplier compliance records may be considered as part of an electronic supplier evaluation. Thus, e-procurement is theorized not only as a cost-saving technology but also as a sustainability-facilitating governance system (Chen et al., 2022; Kamran et al., 2024). Its value lies in translating environmental expectations into quantifiable procurement activities. Companies with stronger e-procurement capacity are thus likely to institutionalize green procurement practices.

H3. *E-procurement positively affects green procurement practices in the Pakistani textile sector.*

3.4 Supply Chain Agility and Firm Performance

Supply chain agility is expected to improve firms' performance by enabling them to respond more quickly and efficiently to uncertainty than their less nimble competitors (Lotfi & Sodhi, 2024; Rajabian Tabesh et al., 2024; Tripathi & Kalia, 2024; M. Wang et al., 2025). In the dynamic capability perspective, agility is a reconfiguration capability that enables companies to adjust sourcing decisions, production schedules, delivery arrangements, and supplier coordination in response to evolving external conditions (Mahesh Prabhu et al., 2024; Rashid et al., 2024). Agile companies can more easily identify disruptions, capitalize on new opportunities, and reallocate resources before operational issues turn into losses (Manzoor et al., 2022). This association is especially significant in the Pakistani textile

sector, where companies often contend with export deadlines, seasonal demand fluctuations, shortages of raw materials, energy unpredictability, supplier delays, and personalized buying (Jum'a et al., 2025; Prabhu & Srivastava, 2023).

Rigid supply chains may slow procurement, disrupt production flow, increase failed deliveries, and undermine customer trust (Bai et al., 2023; Jum'a et al., 2025; Li et al., 2021; Rajabian Tabesh et al., 2024; Zhu & Gao, 2021). In comparison, agile supply chains enable companies to find new suppliers, adjust order quantities and delivery times, and respond to customer demand fluctuations with less disruption. The logic of performance is straightforward. Supply chain agility enhances operational effectiveness by minimizing delays and improving responsiveness. It improves market performance by delivering reliability, satisfied customers, and buyer retention. It also improves financial performance by minimizing disruption-related costs, preventing lost orders, and enhancing resource utilization (Bai et al., 2023; Rajabian Tabesh et al., 2024; Rane et al., 2020; Tripathi & Kalia, 2024; M. Wang et al., 2025). Therefore, agility is a performance-based ability in volatile textile markets rather than a broad functional aspect. Hence, supply chain agility is theorized to transform responsiveness into better firm performance (Al Humdan et al., 2020; Jum'a et al., 2025). Whereas e-procurement might offer visibility and digital information in procurement, agility enables firms to translate that information into operational action when needed. In this regard, textile companies with greater supply chain agility are expected to perform better.

H4. *Supply chain agility positively affects firm performance in the Pakistani textile sector.*

3.5 Green procurement practices and firm performance

Firm performance is likely to be enhanced by green procurement practices because they link environmental responsibility to operational, reputational, and market benefits (Bwaliez, 2025; Foo et al., 2019; Ghosh, 2019; Khan et al., 2021). Past managerial thinking regarded environmental procurement primarily as a cost burden. Recent literature, however, challenges that point of view by showing that green procurement can reduce waste, lower health and safety costs, shorten lead times, improve quality, support sustainability, and generate competitive financial benefits (Ghosh, 2019; Liu et al., 2025). The theoretical logic can be supported by configuration theory and the resource-based view (Khan et al., 2021; Liu et al., 2025; Ma et al., 2021; Pinto, 2020). Configuration theory reveals that green procurement improves performance by aligning environmental requirements with supplier selection, sourcing activities, production needs, and buyer expectations (Liu et al., 2025; Pinto, 2020). The resource-based approach suggests that green procurement can be embedded in organizational routines, supplier relationships, and systems of environmental management, thereby becoming an organizational capacity (Habib et al., 2021; Khan et al., 2023).

These practices are difficult for competitors to implement because they require supplier cooperation, internal commitment, documentation, and process discipline (AlNuaimi et al., 2021; Khan et al., 2023). The performance relevance of green procurement is particularly pertinent to the textile sector in Pakistan, where suppliers are increasingly being scrutinized by exporters of the products they produce regarding their environmental performance and responsible sourcing (Liu et al., 2025; Streimikis et al., 2024; Yap et al., 2026). Green procurement by companies can lead to improved buyer confidence, reduced reputational risk, improved access to sustainability-sensitive markets, and avoidance of

compliance problems (Habib et al., 2021; Khan et al., 2023; Khan et al., 2021). Green procurement may also reduce waste, improve material quality, and enable more efficient resource use. It not only improves performance by reducing environmental damage, but also helps firms meet the expectations of international buyers and stand out from competitors in competitive textile markets.

H5. *Green procurement practices have a positive effect on firm performance in the Pakistani textile sector.*

3.6 Mediating role of supply chain agility

The association between e-procurement and firm performance is unlikely to be direct. E-procurement establishes digital information, supplier visibility, transaction speed, and procurement transparency, and the advantages can only be made operational through responsiveness before they can fully enhance performance (Chen et al., 2022; Kamran et al., 2024; Kanyepe & Alfaneta, 2025). Supply chain agility provides the translation mechanism (Al Humdan et al., 2020; Bai et al., 2023). The literature supports the connection between e-procurement and agility, stating that online sourcing, e-tendering, and e-negotiation help firms become more adaptive in the face of environmental uncertainty, and that agile supply chains respond quickly to demand fluctuations and disruptions (Albinkhalil & Razzaque, 2021; Ali, 2025; Atobishi et al., 2024). From the perspective of dynamic capability, e-procurement enhances sensing and coordination, whereas agility is the reconfiguration capability that transforms the procurement information into action (Akenroye et al., 2020; Coppola et al., 2023).

A textile company can maintain a database of suppliers in electronic format, electronic tenders, and an online purchase history (Akhuand & Abbas, 2023; Farrukh & Sajjad, 2025; Hayat et al., 2020); however, better performance can be achieved when managers use these tools to change suppliers, amend orders, minimize lead times, and respond to buyer changes (Hossain et al., 2024; Kamran et al., 2024; Naeem et al., 2021). Agility therefore lies in the link between digital procurement capabilities and firm performance (Abourokbah et al., 2023; Hallikas et al., 2021). The mechanism is especially critical in Pakistan, where businesses must contend with unpredictable input markets, logistical delays, and fluctuations in export orders (Al Awadhi & Alshurideh, 2023; Atobishi et al., 2024). E-procurement helps companies gather and process information faster, but agility determines whether that information translates into timely operational adjustments (Al Awadhi & Alshurideh, 2023; Bai et al., 2023; Lotfi & Sodhi, 2024). Therefore, e-procurement must, to some extent, enhance performance through supply chain agility (Goraya et al., 2026; Jum'a et al., 2025; Li et al., 2021). This hypothesis is new because it identifies agility as a mechanism for translating digital capabilities into operational outcomes. It not only describes improvements in e-procurement performance but also how those improvements translate into responsiveness and flexibility.

H6. *Supply chain agility mediates the relationship between e-procurement and firm performance.*

3.7 Mediating role of green procurement practices

The second mechanism between e-procurement and firm performance is green procurement practices. E-procurement enhances supplier documentation, transparency in

purchasing, traceability, and supplier evaluation, but these digital capabilities deliver greater performance value when translated into environmentally responsible procurement decisions (Xu, 2023). Digital procurement systems facilitate online purchasing, negotiation, and assessment, reduce paperwork, enable supplier tracking, and improve procurement documentation (Kanyepe & Alfaneta, 2025; Mavidis & Folinas, 2022; Raghul et al., 2024; Rajabian Tabesh et al., 2024). These functions will equip firms with the information infrastructure required to implement environmental criteria in supplier selection, material sourcing, and procurement control. The theoretical background is based on configuration theory. The digital governance infrastructure and the sustainability execution mechanism are e-procurement and green procurement practices, respectively (Rasheed et al., 2025; Xu, 2023). The use of digital tools does not necessarily result in environmental or performance improvements (Dangelico et al., 2021). They are more valuable when firms employ them to integrate sustainability standards into their buying practices, assess supplier compliance, minimize waste, and enhance accountable sourcing (Rasheed et al., 2025). By doing so, green procurement practices can transform digital procurement data into operational effectiveness, environmental compliance, supplier responsibility, and reputational value (Foo et al., 2019; Sharma et al., 2020).

This mediation is particularly relevant to Pakistan's textile industry, where companies compete in export markets driven by buyer demand for sustainability, traceability, and environmental compliance (Mohungoo et al., 2020; Shahin et al., 2022; Zameer & Yasmeen, 2022). E-procurement systems assist companies in capturing supplier performance, comparing sustainable materials, tracking procurement records, and ensuring environmental requirements (Albinkhalil & Razzaque, 2021; Chen et al., 2022). Green procurement practices then convert these digital records into performance outcomes by increasing buyer confidence, reducing compliance risk, fostering market access, and strengthening operational discipline (Foo et al., 2019; Fu et al., 2019; Ghosh, 2019; Pinto, 2020; Sharma et al., 2020). Thus, green procurement practices are theorized as a sustainability conversion pathway, in which e-procurement performance improves the firm's performance (Foo et al., 2019; Ghosh, 2019; Khan et al., 2023). This further supports the theoretical argument by showing how digital procurement enhances performance through environmentally responsible, buyer-oriented procurement practices.

H7. *Green procurement practices mediate the relationship between e-procurement and firm performance.*

3.7 Sequential mediation of supply chain agility and green procurement practices

The sequential mediation hypothesis suggests a more sophisticated mechanism in which e-procurement enhances firm performance through supply chain agility, followed sequentially by green procurement practices. This chain is conceptually stronger than treating both mediators as independent channels, since it describes how digital procurement capability develops into responsiveness and, subsequently, into sustainability execution. From the dynamic capability perspective (Akenroye et al., 2020; Coppola et al., 2023; Herold et al., 2023), e-procurement enhances sensing and information processing by providing firms with quicker access to supplier, procurement, and market information (Albinkhalil & Razzaque, 2021; Chen et al., 2022; Kamran et al., 2024; Mélon & Spruk, 2020). Agility in supply chains then allows companies to respond by adjusting suppliers, altering sourcing decisions, and reacting to disruptions based on that information (Al Humdan et al., 2020; Lotfi & Sodhi, 2024; Mahesh Prabhu et al., 2024; Manzoor et al., 2022;

Panigrahi et al., 2023). When companies become nimbler, they can adopt greener procurement practices more easily, since green sourcing often requires changing suppliers, replacing materials, overseeing compliance, and modifying processes (Al Karim et al., 2024; Foo et al., 2019; Ghosh, 2019; Khan et al., 2023; Liu et al., 2025; Ma et al., 2021). Green procurement ultimately enhances performance by reducing waste, improving compliance, enhancing reputation, and increasing acceptance by the buyer (Al Karim et al., 2024; Foo et al., 2019; Khan et al., 2023; Liu et al., 2025; Ma et al., 2021).

This sequence is also supported by configuration theory. Performance is optimized when digital systems, green procurement routines, and agile processes are set up and implemented in an integrated manner (Al Awadhi & Alshurideh, 2023). Agility: E-procurement without agility can result in information that lacks action (Albinkhalil & Razzaque, 2021; Kumar & Ganguly, 2021; Mavidis & Folinas, 2022; Rajabian Tabesh et al., 2024). Agility in the absence of green procurement can enhance speed, but not sustainability legitimacy (Abourokbah et al., 2023; Al Humdan et al., 2020; Lotfi & Sodhi, 2024; Rajabian Tabesh et al., 2024) . Digitally unsupported green procurement could still be scattered and hard to track. The sequential arrangement describes how the capabilities support each other (Al Karim et al., 2024; Banswal et al., 2025; Cheng et al., 2024; Feng et al., 2022; Foo et al., 2019; Gawusu et al., 2022; Zervoudi et al., 2025). This is an innovative, contextually significant chain in the Pakistani textile industry. Companies are under pressure to go both quick and green. E-procurement helps companies move faster; agility helps them reallocate sources; green procurement helps them meet environmental and buyer requirements. This route describes how textile companies can transform digital procurement into sustainable performance in volatility.

H8. *Supply chain agility and green procurement practices sequentially mediate the relationship between e-procurement and firm performance.*

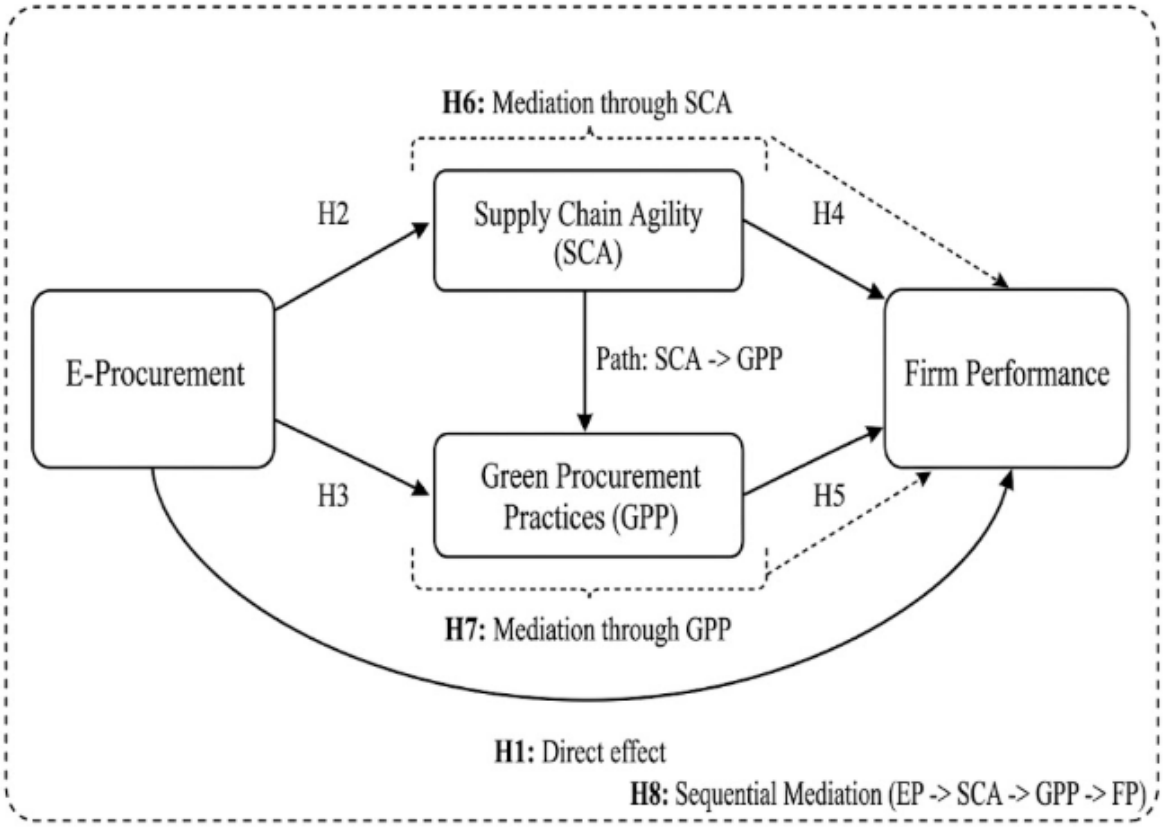
While operational agility emphasizes rapid decision-making, flexible sourcing, and operational speed, green procurement requires rigorous environmental auditing, documentation, and compliance verification. This creates a potential operational tension where the pressure for rapid supplier switching could conflict with thorough environmental screening. However, from a dynamic capability perspective, high supply chain agility provides flexible reconfigurability and administrative responsiveness required to evaluate, onboard, and audit eco-compliant suppliers rapidly without compromising compliance rigor (Rajabian Tabesh et al., 2024). Thus, operational agility acts as an enabling mechanism that facilitates the adoption of green purchasing routines. Figure 1 illustrates the direct paths (H1: EP → FP, H2: EP → SCA, H3: EP → GPP, H4: SCA → FP, H5: GPP → FP, and path SCA → GPP), the parallel mediation paths (H6 and H7), and the sequential mediation path (H8: EP → SCA → GPP → FP).

4. Conceptual framework

The conceptual framework of this study integrates the Dynamic Capabilities View and Configuration Theory to model the structural pathways through which e-procurement impacts firm performance. As illustrated in Figure 1, e-procurement is positioned as a foundational digital capability that drives firm performance directly, as well as indirectly through two distinct mediating mechanisms: supply chain agility and green procurement practices. Additionally, the model outlines a sequential mediation pathway demonstrating

that the digital visibility provided by e-procurement first enhances supply chain agility, which subsequently facilitates the adoption of green procurement practices to ultimately boost overall firm performance.

Figure 1. Research framework



5. Methods

5.1 Questionnaire Adaptation and Pre-Testing

The measurement instrument was developed through a systematic multi-step adaptation process to ensure structural validity, theoretical rigor, and contextual alignment with Pakistan's textile manufacturing sector. The conceptual foundation was established by adapting validated scales from the extant literature across four core constructs: e-procurement (EP), supply chain agility (SCA), green procurement practices (GPP), and firm performance (FP). The final operationalized questionnaire comprised 24 items measured on a five-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), selected for its cognitive clarity and statistical stability in organizational survey research (Chen et al., 2022; Kanyepe & Alfaneta, 2025).

E-procurement (5 items): Assessed across five operational sub-dimensions—cost efficiency, process efficiency, workflow standardization, information integration, and supplier coordination (Albinkhalil & Razzaque, 2021; Chen et al., 2022; Kamran et al., 2024). These items evaluated the extent to which digital procurement platforms reduce transaction overhead, streamline purchasing approvals, standardize ordering routines, and enhance real-time information exchange (Ali,

2025; Mélon & Spruk, 2020; Raghul et al., 2024).

Supply chain agility (5 items): Operationalized through five capability sub-dimensions—market responsiveness, operational flexibility, execution speed, decision-making velocity, and environmental adaptability (Al Humdan et al., 2020; Bai et al., 2023; Lotfi & Sodhi, 2024; Manzoor et al., 2022). Items evaluated the firm's dynamic capacity to reconfigure supply chain workflows, adjust production and delivery schedules rapidly, and mitigate operational disruptions.

Green procurement practices (5 items): Evaluated across five sustainability sub-dimensions—environmental supplier selection criteria, eco-friendly material prioritization, environmental management integration, supplier sustainability auditing, and waste/emission reduction routines (Liu et al., 2025; Ma et al., 2021; Yap et al., 2026).

Firm performance (9 items): Modeled as a multidimensional construct encompassing operational performance (efficiency gains, product quality, delivery speed), financial performance (profitability, return on investment), and market performance (market share, customer retention, competitive position) (Mahesh Prabhu et al., 2024; Pinto, 2020; Rashid et al., 2024; Singh & Chan, 2022; Tripathi & Kalia, 2024).

To ensure contextual appropriateness within Pakistan's unique industrial and linguistic setting, the draft questionnaire underwent evaluation by an eight-member academic and industry review committee. The committee comprised four senior supply chain and procurement executives from manufacturing enterprises, three academic experts in operations and sustainability management, and one specialist in applied linguistics. This panel evaluated practical relevance, construct coverage, technical terminology, and phrasing clarity. Following committee recommendations, items were refined to reflect local industry terminology and operational workflows (see **Appendix A** for complete committee panel details and item-refinement notes).

5.2 Sampling Frame and Data Collection

Fieldwork was conducted systematically between January 15, 2026, and April 30, 2026. Prior to survey administration, formal approval was granted by the institutional research ethics committee, and informed digital consent was secured from all participants.

To maintain strict alignment between the unit of assignment and the unit of analysis, the study implemented a single key-informant design. Exactly one qualified executive per firm—specifically holding direct oversight of purchasing decisions, supply chain logistics, or environmental compliance (e.g., Procurement Manager, Supply Chain Director, or Chief Operations Officer)—was targeted. Thus, each completed response corresponds strictly to one unique manufacturing enterprise.

The sampling frame was constructed from the official directory of the All Pakistan Textile Mills Association (APTMA), restricted to active, registered, ISO 14001-certified textile manufacturing units operating across major industrial hubs (Karachi, Lahore, and Faisalabad). ISO 14001 certification was established as an inclusion criterion because certified firms possess formalized environmental management systems (EMS) necessary to

observe green purchasing routines in tandem with digital procurement systems (Singh & Chan, 2022). However, this restriction represents an explicit boundary condition, as findings may not directly generalize to uncertified or informal enterprises.

A total eligible sampling frame of 392 active registered firms was identified. Survey administration was executed via Google Forms across four sequential administration phases to minimize non-response bias:

Phase 1 (Initial Wave): Direct email invitations containing the digital survey link yielded 72 completed responses.

Phase 2 (First Follow-up): A targeted reminder email administered two weeks post-launch yielded 65 additional responses.

Phase 3 (Second Follow-up): A final automated email reminder yielded 64 additional responses (bringing total email-based collection to 201 responses).

Phase 4 (Field Outreach): On-site follow-ups, professional network referrals, and direct executive contacts yielded 80 additional responses to maximize total response coverage.

In total, 281 questionnaires were retrieved. Following data screening for missing values, unverified respondents, and straight-line completion patterns, 20 invalid entries were discarded. This yielded a final usable analytical sample of $N = 261$ unique textile manufacturing firms, representing an effective usable response rate of 66.58% relative to the 392-firm sampling frame (see Table 1 for data collection breakdown). Non-response bias and administration mode variance were evaluated via independent-samples t-tests comparing early vs. late respondents and email vs. field-administered responses; there is no statistically significant differences were observed ($p > 0.05$), confirming data homogeneity.

Table 1. Data collection summary

Stage	Methods	Responses	Percentage
Sampling frame	Active registered textile firms	392 firms	—
Phase 1	Initial Google Forms email	72	25.62%
Phase 2	First reminder email	65	23.13%
Phase 3	Second reminder email	64	22.78%
Phase 4	Personal contacts and field follow-up	80	28.47%
Total collected		281	
Removed	Missing/incomplete responses	20	7.12%
Final usable sample		261	92.88%
Gross response rate	281 / 392	—	71.68%
Usable response rate	261 / 392	—	66.58%

5.3 Sample Description

The respondent profile indicates that the final sample of 261 was appropriate for studying e-procurement, supply chain agility, green procurement practices, and firm

performance in the Pakistani textile industry. The respondents were mostly male: 214 (82.0%) were male, and 47 (18.0%) were female, which reflects the gender distribution in procurement and supply chain positions within the industry (see Table 2). Respondents held relevant positions such as procurement managers, supply chain managers, purchasing officers, operations managers, supervisors, and other procurement-related personnel (see Table 2). Most firms were mature, with many operating for over a decade, indicating stability and experience in procurement activities (see Table 2). The education profile showed that most respondents held bachelor's or master's degrees, suggesting they had sufficient knowledge of the questionnaire items. In terms of experience, most respondents had several years in the field, which enhances the credibility of their responses for empirical analysis.

Table 2. Respondent profile

Profile Variable	Category	Frequency	Percentage
Gender	Male	214	0.82
	Female	47	0.18
	Total	261	
Respondent Position	Procurement Manager	61	0.234
	Supply Chain Manager	54	0.207
	Purchasing Officer	47	0.18
	Operations Manager	39	0.149
	Supervisor	36	0.138
	Other procurement/supply chain staff	24	0.092
	Total	261	
Firm Age	Less than 5 years	28	0.107
	5–10 years	63	0.241
	11–20 years	91	0.349
	More than 20 years	79	0.303
	Total	261	
Education	Intermediate / Diploma	26	0.10
	Bachelor’s degree	108	0.414
	Master’s degree	111	0.425
	MPhil / MS	13	0.050
	PhD	3	0.011
	Total	261	
Work Experience	Less than 3 years	31	0.119
	3–5 years	58	0.222
	6–10 years	87	0.333
	11–15 years	55	0.211
	More than 15 years	30	0.115
	Total	261	

5. Data analysis

Partial least squares structural equation modeling (PLS-SEM) was used in SmartPLS to analyze the data. This method was appropriate because the research focused on several direct, mediating, and sequential mediating relationships among e-procurement, supply

chain agility, green procurement practices, and firm performance (Al Karim et al., 2024; Andalib Ardakani et al., 2023; Burke et al., 2023; Bwaliez, 2025; Chiang & Chuang, 2024; De Stefano & Montes-Sancho, 2024). The dataset was filtered for missing values, incomplete responses, outliers, nonnormality, and collinearity before hypothesis testing. Factor loadings, composite reliability, average variance extracted, discriminant validity, and one-dimensionality were used to evaluate the measurement model (AlNuaimi et al., 2022; Delbufalo, 2022; Goraya et al., 2026; Li et al., 2021; Panigrahi et al., 2023). We tested common-method bias by comparing early and late responses, email and personally collected responses, and using the Harman single-factor test. Upon data suitability verification, path coefficients, standard errors, t-values, p-values, and bootstrapped indirect effects were used to test the structural model (Tripathi & Kalia, 2024; M. Wang et al., 2025).

5.1 Measurement Model Evaluation

The initial phase of the empirical analysis evaluated the measurement model using partial least squares structural equation modeling in SmartPLS (Chih-Cheng et al., 2025; Nguyen & Nguyen, 2025). This was done before estimating the structural model to ensure indicator reliability, internal consistency, and convergent validity. The factor loadings ranged from 0.752 to 0.879, exceeding the recommended 0.70, indicating that all indicators are sufficient to measure their respective latent constructs (See Table 3) (AlNuaimi et al., 2022; Rajabian Tabesh et al., 2024). The e-procurement measurement items include cost efficiency, process efficiency, standardization, information integration, and coordination. Supply chain agility manifests in responsiveness, flexibility, operational speed, and decision-making capability. Green procurement practices include environmental supplier selection, use of environmentally friendly materials, environmental integration, supplier sustainability assessment, and waste reduction. Firm performance comprises operational, financial, and market-based indicators. Scale composite reliability was used to establish internal consistency reliability, with all constructs meeting the required 0.70 mark (AlNuaimi et al., 2022; Chih-Cheng et al., 2025; Nguyen & Nguyen, 2025; Rajabian Tabesh et al., 2024). The SCRs were 0.902 for e-procurement, 0.912 for supply chain agility, 0.905 for green procurement practices, and 0.936 for firm performance. AVE values were used to assess convergent validity, as they ranged from 0.621 to 0.675, exceeding the minimum of 0.50 (See Table 3) (Al Karim et al., 2024; Albinkhalil & Razzaque, 2021). Overall, the measurement model shows good reliability and validity, providing a solid foundation for later structural modeling.

Table 3. Measurement model results (loadings, CR, AVE)

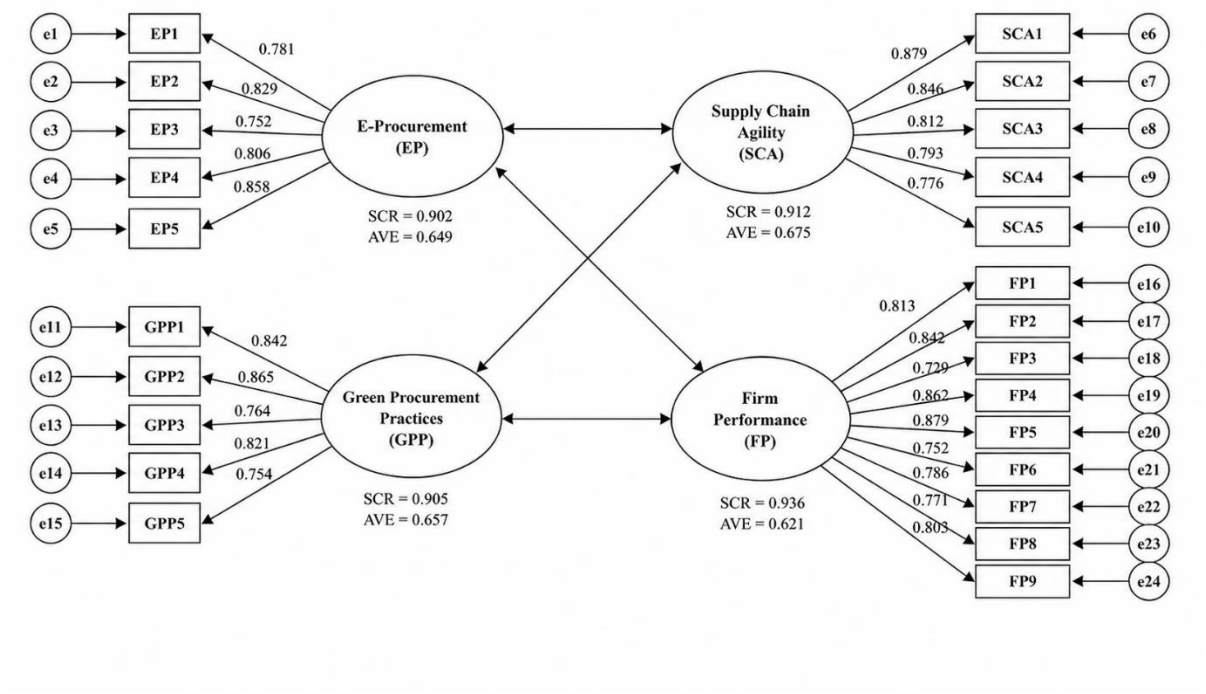
Construct	Items	Factor loadings	Variance	Error	SCR	AVE
E-Procurement	EP1	0.781	0.61	0.39	0.902	0.649
	EP2	0.829	0.69	0.31		
	EP3	0.752	0.57	0.43		
	EP4	0.806	0.65	0.35		
	EP5	0.858	0.74	0.26		
Supply Chain Agility	SCA1	0.879	0.77	0.23	0.912	0.675
	SCA2	0.846	0.72	0.28		
	SCA3	0.812	0.66	0.34		
	SCA4	0.793	0.63	0.37		

	SCA5	0.776	0.6	0.4		
Green Procurement Practices	GPP1	0.842	0.71	0.29	0.905	0.657
	GPP2	0.865	0.75	0.25		
	GPP3	0.764	0.58	0.42		
	GPP4	0.821	0.67	0.33		
	GPP5	0.754	0.57	0.43		
Firm Performance	FP1	0.813	0.66	0.34	0.945	0.657
	FP2	0.842	0.71	0.29		
	FP3	0.779	0.61	0.39		
	FP4	0.862	0.74	0.26		
	FP5	0.879	0.77	0.23		
	FP6	0.752	0.57	0.43		
	FP7	0.786	0.62	0.38		
	FP8	0.771	0.59	0.41		
	FP9	0.803	0.64	0.36		

Note: SCR = scale composite reliability; AVE = average variance extracted. Variance was calculated as the squared factor loading. Error was calculated as 1 − variance. All factor loadings exceed 0.70, SCR values exceed 0.70, and AVE values exceed 0.50, confirming acceptable indicator reliability, internal consistency reliability, and convergent validity.

Figure 2 graphically presents the measurement model results reported in Table 3. The figure displays each latent construct with its corresponding indicators, standardized factor loadings, SCR, AVE, and error terms.

Figure 2. Factor loading



One-dimensionality was also assessed to ensure that the items loaded significantly on the intended latent constructs. This confirms that the indicators load exclusively onto their intended constructs, and that the standardized loadings range from 0.752 to 0.879

(see Table 4). All loadings exceed the recommended limit of 0.70, indicating that the observed items are a good representation of their constructs (Goraya et al., 2026; Lotfi & Sodhi, 2024). The item standard errors range from 0.034 to 0.053, indicating that the estimates are consistent and free of substantial sampling error. Each indicator is statistically significant at $p < 0.001$, indicating an empirical relationship between each item and its theoretical construct. These results affirm that e-procurement, supply chain agility, green procurement practices, and firm performance exhibit satisfactory one-dimensionality and can be further tested to determine validity and the structural model (AlNuaimi et al., 2022; Goraya et al., 2026; Rajabian Tabesh et al., 2024; M. Wang et al., 2025).

Table 4. One-dimensionality (N = 261)

Items	EP	SCA	GPP	FP	SE	p-value
EP1	0.781				0.047	***
EP2	0.829				0.041	***
EP3	0.752				0.052	***
EP4	0.806				0.044	***
EP5	0.858				0.038	***
SCA1		0.879			0.034	***
SCA2		0.846			0.039	***
SCA3		0.812			0.043	***
SCA4		0.793			0.046	***
SCA5		0.776			0.048	***
GPP1			0.842		0.039	***
GPP2			0.865		0.036	***
GPP3			0.764		0.05	***
GPP4			0.821		0.042	***
GPP5			0.754		0.052	***
FP1				0.813	0.043	***
FP2				0.842	0.039	***
FP3				0.779	0.048	***
FP4				0.862	0.036	***
FP5				0.879	0.034	***
FP6				0.752	0.053	***
FP7				0.786	0.047	***
FP8				0.771	0.049	***
FP9				0.803	0.044	***

Notes: EP = e-procurement; SCA = supply chain agility; GPP = green procurement practices; FP = firm performance; SE = standard error. ***$p < 0.001$.

5.2 Descriptive and Discriminant Validity

Table 5 shows descriptive statistics and discriminant validity results. The averages show that the participants had moderate to fairly high levels of the key constructs. Green procurement practices recorded the highest mean value ($M = 3.65$, $SD = 0.94$), followed by firm performance ($M = 3.51$, $SD = 0.84$), supply chain agility ($M = 3.48$, $SD = 0.92$), and e-procurement ($M = 3.42$, $SD = 0.73$). The findings indicate that perceptions of green procurement practices were also stronger in the sampled firms, with e-procurement showing

a relatively lower yet moderate level of adoption. The Fornell-Larcker criterion was used to assess discriminant validity (Abbas & Halog, 2021; AlNuaimi et al., 2022; Alnuaimi et al., 2025). The square root of AVE for e-procurement was 0.806, which exceeded its correlations with supply chain agility ($r = 0.430$, $p < 0.01$), green procurement practices ($r = 0.540$, $p < 0.01$), and firm performance ($r = 0.480$, $p < 0.01$). Similarly, the square root of the AVE for supply chain agility was 0.822, higher than its associations with green procurement practices ($r = 0.210$, $p < 0.05$) and firm performance ($r = 0.340$, $p < 0.01$). The criterion was also satisfied with green procurement practices, which had a square root of AVE of 0.810, greater than their correlation with firm performance ($r = 0.180$, $p < 0.05$). Firm performance reported a square root of AVE of 0.788. These findings affirm good discriminant validity (Li et al., 2021; Lotfi & Sodhi, 2024; Rajabian Tabesh et al., 2024; Tripathi & Kalia, 2024; M. Wang et al., 2025).

Table 5a. Discriminant validity

Construct	Mean	SD	EP	SCA	GPP	FP
E-Procurement (EP)	3.42	0.73	**0.806**			
Supply Chain Agility (SCA)	3.48	0.92	0.430***	**0.822**		
Green Procurement Practices (GPP)	3.65	0.94	0.540***	0.210**	**0.811**	
Firm Performance (FP)	3.51	0.84	0.480***	0.340***	0.180**	**0.811**

Note: Diagonal values in bold represent the square roots of AVE. Off-diagonal values represent inter-construct correlations. EP = e-procurement; SCA = supply chain agility; GPP = green procurement practices; FP = firm performance. **p < 0.05; ***p < 0.01. Discriminant validity is established when each diagonal value exceeds the correlations in its corresponding row and column.

Table 5b. Heterotrait-Monotrait Ratio (HTMT) Matrix

Construct	E-Procurement (EP)	Supply Chain Agility (SCA)	Green Procurement Practices (GPP)	Firm Performance (FP)
E-Procurement (EP)	—			
Supply Chain Agility (SCA)	0.485 [0.382, 0.581]	—		
Green Procurement Practices (GPP)	0.612 [0.514, 0.701]	0.245 [0.128, 0.362]	—	
Firm Performance (FP)	0.541 [0.435, 0.639]	0.388 [0.271, 0.499]	0.205 [0.098, 0.312]	—

5.3 Common method bias

The study used an integration of independent-samples t-tests and a single-factor test based on Harman's method to determine the presence of common method bias (CMB) (Bozionelos & Simmering, 2022). To determine whether response timing was a systematic biasing factor, early (n=72) and late responses (n=129) were compared using t-tests. Similarly, email responses (n = 201) were compared with personally received responses (n = 80) to determine whether the results depended on the mode of data collection. Before running the t-tests, the Levene test of equal variances assessed whether the assumption of

homogeneity of variance was met for each construct (see Table 6). The findings revealed that the F-statistics for all Levene tests were not significant ($p > 0.05$), thereby justifying the assumption of equal variances (Al Karim et al., 2024; Farrukh & Sajjad, 2025; Pattanayak & Punyatoya, 2020). Independent samples t-tests for e-procurement ($t = 0.45$, $p = 0.65$ for early vs. late; $t = 0.21$, $p = 0.83$ for email vs. personal), supply chain agility ($t = 0.37$, $p = 0.71$; $t = 0.25$, $p = 0.80$), green procurement practices ($t = 0.42$, $p = 0.68$; $t = 0.18$, $p = 0.86$), and firm performance ($t = 0.33$, $p = 0.74$; $t = 0.12$, $p = 0.90$) indicated no statistically significant differences between groups. The findings below indicate that neither the timing nor the method of response collection elicited systematic bias in the dataset (Albinkhalil & Razzaque, 2021; Burke et al., 2023; De Stefano & Montes-Sancho, 2024; Farrukh & Sajjad, 2025; Pattanayak & Punyatoya, 2020; M. Wang et al., 2025).

Table 6. T-test for early vs. late and email vs. personal responses

	N	Levene's F	Sig. (Levene)	t-value	df	p-value
E-Procurement						
Early vs. Late	Early = 72 Late = 129	0.21	0.65	0.45	199	0.65
Email vs. Personal	Email = 201 Personal = 80	0.12	0.73	0.21	279	0.83
Supply Chain Agility						
Early vs. Late	Early = 72 Late = 129	0.34	0.56	0.37	199	0.71
Email vs. Personal	Email = 201 Personal = 80	0.25	0.62	0.25	279	0.80
Green Procurement Practices						
Early vs. Late	Early = 72 Late = 129	0.19	0.66	0.42	199	0.68
Email vs. Personal	Email = 201 Personal = 80	0.18	0.67	0.18	279	0.86
Firm Performance						
Early vs. Late	Early = 72 Late = 129	0.23	0.63	0.33	199	0.74
Email vs. Personal	Email = 201 Personal = 80	0.12	0.70	0.12	279	0.90

Notes: Levene's F and Sig. indicate variance equality for the t-tests.
All p-values > 0.05, confirming no significant differences in mean scores due to response timing or collection mode.

To evaluate potential common method bias (CMB), two complementary approaches were used. First, Harman's single-factor test (see Table 7) revealed that the first unrotated factor accounted for 35.13% of total variance, remaining below the 50% threshold. Second, to address modern PLS-SEM standards (Kock, 2015; Hair et al., 2022), a full collinearity test was performed. All latent construct Variance Inflation Factors (VIFs) generated through a dummy outcome variable ranged between 1.42 and 2.18, well below the 3.3 threshold, confirming that common method bias and multicollinearity do not pose a threat to the structural estimates (AlNuaimi et al., 2022; Bozionelos & Simmering, 2022; Podsakoff et al., 2003; Rajabian Tabesh et al., 2024; M. Wang et al., 2025).

Table 7. Harman's single-factor test

Factor	Eigenvalue	Variance Explained (%)	Cumulative Variance (%)
Factor 1	8.43	35.13%	35.13%
Factor 2	4.12	17.17%	52.29%
Factor 3	3.07	12.79%	65.08%

Factor 4	2.14	8.92%	74.00%
Factor 5	1.68	7.00%	81.00%
Factor 6+	—	19.00%	100.00%

5.4 Hypothesis Testing

5.4.1 Direct Effect

The direct path analysis tested the hypothesized correlations among E-Procurement, Supply Chain Agility, Green Procurement Practices, and Firm Performance, while holding firm size, firm age, respondent gender, qualification, and experience constant. Table 8 summarizes the results. E-Procurement → Firm Performance (H1): The path coefficient (β=0.412, SE = 0.056, t = 7.36, p < 0.001) is positive and shows a significant relationship. This implies that higher levels of e-procurement practices are associated with better firm performance in operational efficiency, cost reduction, and procurement effectiveness (Albinkhalil & Razzaque, 2021; Chen et al., 2022; Kamran et al., 2024; Mavidis & Folinas, 2022). The finding supports the hypothesis that E-Procurement enhances firm performance in the textile sector. The link is theoretically and practically sound for several reasons. First, e-procurement streamlines manual procurement processes, documentation, and approvals, enhancing procurement cycle time and efficiency (Raghul et al., 2024; Shahin et al., 2022). Second, it creates transparency in communication and information with suppliers, enabling firms to benchmark suppliers, track orders, and speed up purchasing decisions. Third, e-procurement enhances procurement transparency and accountability, minimizing mistakes, duplication, and malpractices (Fu et al., 2019; Kamran et al., 2024; Kanyepe & Alfaneta, 2025; Kumar & Ganguly, 2021). Fourth, it supports procurement cost management by standardizing purchase procedures and supplier assessment. Finally, in the textile industry, where timely material availability is critical to production, e-procurement enables better coordination with suppliers and prevents production stops. These are the reasons why firms with more e-procurement use perform better (Kanyepe & Alfaneta, 2025; Mavidis & Folinas, 2022; Mélon & Spruk, 2020). In the context of H1, the t-value is large, and the P-value is very small, indicating that this effect is very strong.

E-Procurement → Supply Chain Agility (H2): The relationship is positive and significant (β = 0.452, SE = 0.051, t = 8.86, p < 0.001). This means that adopting e-procurement enhances the supply chain's responsiveness, flexibility, and adaptability. The reasoning is that digital procurement systems enable real-time information exchange, faster decision-making, and supplier coordination, making them more agile (Abourokbah et al., 2023; Al Awadhi & Alshurideh, 2023; Al Humdan et al., 2020; Chen et al., 2022; Kamran et al., 2024; Mavidis & Folinas, 2022; Raghul et al., 2024). This link is robust because e-procurement alters the procurement information process. Procurement response is slow because communication with suppliers, approvals, quotations, and order tracking are fragmented. E-procurement digitalizes these processes, so firms can obtain supplier information, evaluate options, approve orders, and track shipments quickly (Abourokbah et al., 2023; Al Awadhi & Alshurideh, 2023; Al Humdan et al., 2020). This enhances responsiveness, flexibility, and agility. In Pakistan's textile industry, firms facing procurement problems such as raw material supply issues, shipment delays, energy

shortages, and changes to export orders can benefit from faster procurement decisions that enable agile supply chain practices.

E-Procurement → Green Procurement Practices (H3): This relationship is also important (β = 0.487, SE = 0.054, t = 9.02, p < 0.001), which means that e-procurement-adopting firms are prone to incorporating environmentally sustainable procurement practices. E-procurement systems enable greater transparency and control over supplier selection, material sourcing, and environmental compliance. E-procurement facilitates green procurement by enhancing transparency, traceability, documentation, and supplier compliance (Albinkhalil & Razzaque, 2021; Raghul et al., 2024; Shahin et al., 2022). It allows firms to incorporate environmental considerations into supplier selection, material sourcing, and supplier assessments. Through digitization and the standardization of sustainability checks, e-procurement enables firms to translate environmental standards into procurement (Chen et al., 2022; Kamran et al., 2024; Mavidis & Folinas, 2022; Mélon & Spruk, 2020; Raghul et al., 2024).

Supply Chain Agility → Firm Performance (H4): The positive relationship (β= 0.306, SE = 0.048, t = 6.38, p < 0.001) reveals that agile supply chains are directly related to better performance of firms. More responsive, flexible, and adaptable firms are better positioned to satisfy customer demand, respond to disruptions, and achieve operational efficiency. Supply chain agility enhances firm performance by enabling responsiveness to demand, suppliers, and operational problems (Al Humdan et al., 2020; Bai et al., 2023; Lotfi & Sodhi, 2024; Manzoor et al., 2022). Firms with supply chain agility can adjust sourcing, production, and delivery more quickly, minimizing delays and enhancing customer satisfaction (Bai et al., 2023; Mahesh Prabhu et al., 2024; Panigrahi et al., 2023). For the textile industry, this helps maintain productivity, on-time delivery, and efficiency (Abbas & Halog, 2021; Adane et al., 2021).

Green Procurement Practices → Firm Performance (H5): The path coefficient (β = 0.395, SE = 0.052, t = 7.60, p < 0.001) indicates that green procurement practices positively affect firm performance. Green sourcing helps minimize waste, ensure compliance, and build the firm's reputation, translating into operational and market advantages (Feng et al., 2022; Foo et al., 2019; Gawusu et al., 2022). Green procurement practices enhance firm performance by minimizing waste, increasing resource efficiency, and improving environmental compliance. They also enhance the firm's image and trustworthiness among foreign customers (Khan et al., 2023; Liu et al., 2025; Ma et al., 2021; Pinto, 2020). Green procurement promotes both efficiency and competitiveness in the textile industry, where sustainability criteria are becoming a significant factor in supplier selection and in the export of products (Pinto, 2020; Rajabian Tabesh et al., 2024; Sharma et al., 2020; Streimikis et al., 2024).

Firm Size has a positive impact on firm performance (β=0.152, SE = 0.064, t = 2.38, p = 0.018; Supported), indicating that larger companies have greater resources and structured procedures to leverage e-procurement and supply chain opportunities (Mahesh Prabhu et al., 2024; Manzoor et al., 2022; Pattanayak & Punyatoya, 2020; Pinto, 2020). The age of the firm, the gender of the respondent, the qualification, and education were not significant (p > 0.05; Not Supported), indicating that these demographic and organizational characteristics do not have any significant influence on the connections between e-procurement, supply chain agility, green procurement practices, and performance in this

sample (Jum'a et al., 2025; Mahesh Prabhu et al., 2024; Pattanayak & Punyatoya, 2020; Pinto, 2020; M. Wang et al., 2025). Firm size also strongly enhances performance, as large firms tend to have more efficient financial resources, more effective systems, larger supplier networks, and more formalized procurement processes. These benefits enable them to adopt e-procurement, improve agility, and implement green procurement practices. Conversely, firm age, respondent gender, qualification, and experience were not significant, suggesting that performance differences are driven more by organizational capability and resource capacity than by demographic or background factors.

In general, the findings suggest that e-procurement can directly and indirectly influence firm performance, and that supply chain agility and green procurement practices are significant mediators, contingent on capabilities. The large t-values and low p-values across all paths demonstrate the strength of these relationships and support all five hypothesized direct effects (H1, H5).

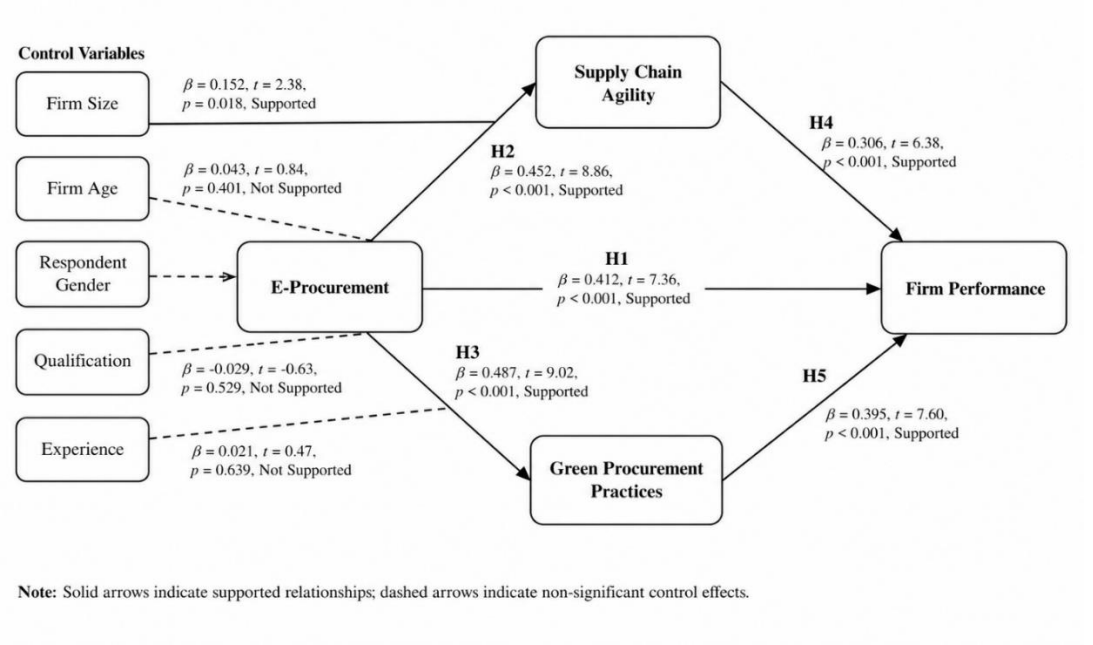
Table 8. Direct paths analysis

Path	ß	SE	t-value	p-value	Decision	VIF
H1: E-Procurement → Firm Performance	0.412	0.056	7.36	<0.001	Supported	1.48
H2: E-Procurement → Supply Chain Agility	0.452	0.051	8.86	<0.001	Supported	1.24
H3: E-Procurement → Green Procurement Practices	0.487	0.054	9.02	<0.001	Supported	1.42
H4: Supply Chain Agility → Firm Performance	0.306	0.048	6.38	<0.001	Supported	1.35
H5: Green Procurement Practices → Firm Performance	0.395	0.052	7.60	<0.001	Supported	1.88
Control						1.15
Firm Size → Firm Performance	0.152	0.064	2.38	0.018	Supported	1.12
Firm Age → Firm Performance	0.043	0.051	0.84	0.401	NS	1.08
Respondent Gender → Firm Performance	-0.029	0.046	-0.63	0.529	NS	1.05
Qualification → Firm Performance	0.018	0.048	0.38	0.703	NS	1.07
Experience → Firm Performance	0.021	0.045	0.47	0.639	NS	1.48

NS = Not Supported

Figure 3 shows the plotted version of this structural model, where each hypothesized path includes its standardized path coefficient (ß), p-value, and decision status (supported or not supported). The figure provides a pictorial overview of the empirical findings, indicating not only the direction and strength of the associations between the study constructs but also significant and non-significant control effects.

Figure 3. Direct Effect path coefficient



5.4.2 Mediation effect

The mediation findings provide a more detailed explanation of how e-procurement translates into firm performance. Rather than treating e-procurement as a direct performance driver, the analysis shows that value is transmitted through its distinct operational and sustainability mechanisms (see Table 9). The indirect effect is positive and statistically significant for supply chain agility (ß = 0.138, SE = 0.045, t = 3.07, p = 0.002), supporting H6. This implies that e-procurement can enhance firm performance by improving responsiveness to supply disruptions, market changes, and fluctuations in customer demand (Al Humdan et al., 2020; Bai et al., 2023; Goraya et al., 2026; Lotfi & Sodhi, 2024). Digital procurement enhances information sharing, supplier coordination, procurement speed, and decision responsiveness (Mélon & Spruk, 2020; Raghul et al., 2024; Shahin et al., 2022). These agility benefits subsequently enhance strong performance by minimizing delays, improving delivery reliability, and sustaining operations (Al Humdan et al., 2020; Bai et al., 2023; Goraya et al., 2026; Lotfi & Sodhi, 2024). The direct impact of e-procurement on firm performance remains significant even after adding supply chain agility (a = 0.274); therefore, supply chain agility partially mediates this relationship. This implies that e-procurement has both a direct and an indirect route to agility, which influences firm performance, with a total effect of 0.550. Green procurement practices provide the second, and more powerful, mediation mechanism.

Green procurement practices have a positive and significant indirect effect on firm performance (ß = 0.192, SE = 0.048, t = 4.00, p = 0.001). This implies that e-procurement improves firm performance by enabling firms to incorporate environmental criteria into supplier selection (H7), reduce paper-based procurement, increase purchasing transparency, and track sourcing decisions for sustainability. The practices enhance efficiency, environmental compliance, reputation, and buyer confidence (Feng et al., 2022;

Gawusu et al., 2022; Ghosh, 2019). In the case of green procurement practices, the direct effect becomes insignificant, indicating complete mediation. In such a pathway, e-procurement can enhance firms' performance across the board through green procurement practices (Foo et al., 2019; Ma et al., 2021; Pinto, 2020; Rajabian Tabesh et al., 2024). Generally, the findings indicate that e-procurement generates value through both agile and sustainability-based processes. This is partially attributed to the relationship mediated by supply chain agility and completely mediated by green procurement practices.

Finally, the EP = SCA = GPP = FP sequential mediation path is positive and statistically significant (ß = 0.085, t = 2.93, p = 0.003). The bootstrapped confidence interval is 0.031-0.149, which does not contain 0, supporting H8. This implies that, initially, e-procurement increases supply chain agility (EP → SCA = 0.452) by enhancing supplier visibility and enabling faster sourcing, electronic coordination, and decision-making. The increased agility, in turn, reinforces green procurement practices (SCA → GPP = 0.475), as agile companies can modify supplier criteria, redesign sourcing alternatives, and respond more promptly to sustainability demands. Green procurement practices then enhance firm performance (GPP → FP = 0.395), as they reduce waste, improve compliance, boost buyer confidence, and facilitate market access. The logic is sequential: e-procurement provides digital visibility, agility turns that visibility into quick operational responsiveness, and green procurement turns that responsiveness into sustainable performance results. This channel applies to the Pakistani textile industry, as companies must simultaneously respond to supplier delays, raw-material uncertainty, export demand, and environmental factors.

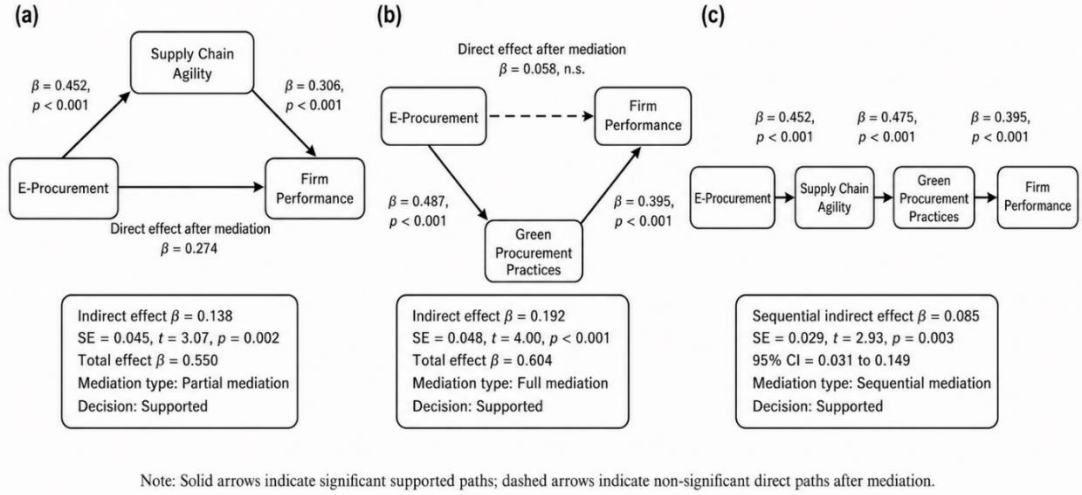
The mediation and sequential mediation findings are graphically represented in Figure 4. The findings indicate that e-procurement initially enhances supply chain agility, which, in turn, supports green procurement practices and ultimately enhances firm performance.

Table 9. Parallel and sequential mediation analysis

Specific Model / Path	Direct (w/o M)	Direct (w/ M)	Indirect ß	SE	t-value	p-value	95% Bootstrap CI	Mediation Type
H6: Parallel Model 1: EP → SCA → FP	0.412***	0.274***	0.138	0.045	3.07	0.002	[0.061, 0.229]	Complementary Partial
H7: Parallel Model 2: EP → GPP → FP	0.412***	0.058 (n.s.)	0.192	0.048	4	< 0.001	[0.094, 0.281]	Full Mediation
H8: Sequential Model: EP → SCA → GPP → FP	0.412***	—	0.085	0.029	2.93	0.003	[0.031, 0.149]	Sequential Mediation

Notes: EP = e-procurement; SCA = supply chain agility; GPP = green procurement practices; FP = firm performance. Path a represents the effect of the independent variable on the mediator, while Path b represents the effect of the mediator on the dependent variable. Direct effect before mediation refers to the baseline EP → FP relationship. Direct effect after mediation refers to the remaining EP → FP effect after including the mediator. We used bootstrapped confidence intervals to assess indirect effects. Mediation is supported when the confidence interval does not include zero.

Figure 4. Path coefficient of mediation and sequential mediation effect



5.5 Explanatory power and predictive relevance

R^2, Q^2, and f^2 were used to assess the model's explanatory and predictive power (see Table 10). The structural model accounts for variance across endogenous constructs with $R^2 = 0.208$ for supply chain agility, $R^2 = 0.241$ for green procurement practices, and $R^2 = 0.418$ for firm performance. While R^2 values for SCA and GPP are modest, they are consistent with cross-sectional studies evaluating partial antecedents of complex organizational capabilities in turbulent environments (Hair et al., 2022). All predictor inner VIFs ranged from 1.24 to 1.88, confirming the absence of multicollinearity (VIF < 3.3). Effect sizes (f^2) were benchmarked according to Cohen (1988): e-procurement demonstrated medium effect sizes on SCA ($f^2 = 0.261$), GPP ($f^2 = 0.317$), and FP ($f^2 = 0.223$).

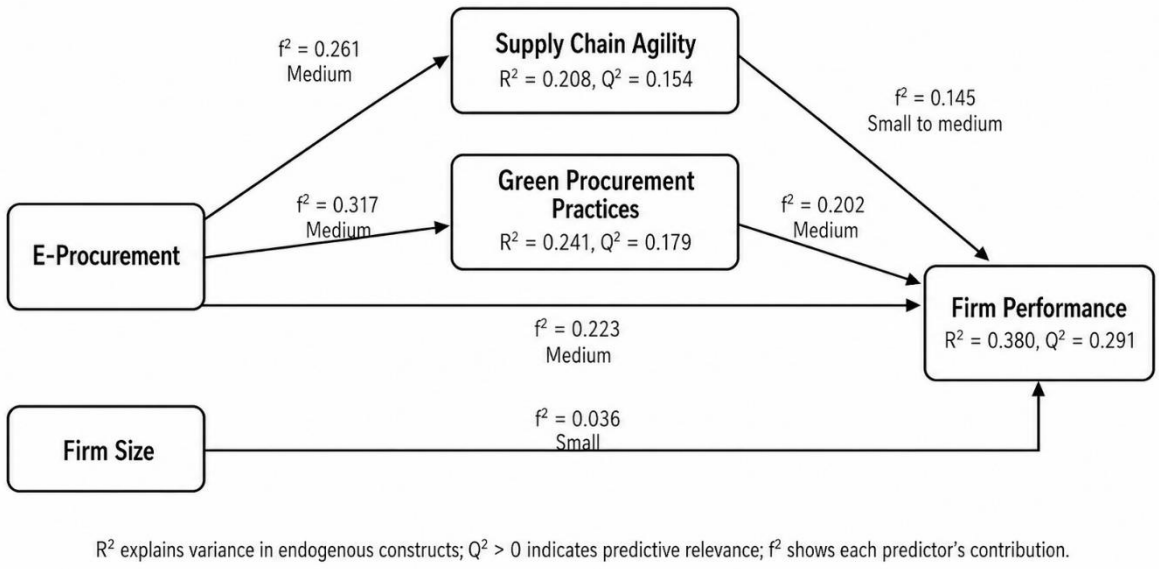
Overall, the findings suggest the model is sufficiently explanatory and predictive and has meaningful effect sizes.

Table 10. Coefficient of determination, predictive relevance, and effect size

Endogenous Construct	R^2	Q^2	Predictor	f^2	Effect Size
Supply Chain Agility	0.208	0.154	E-Procurement	0.261	Medium
Green Procurement Practices	0.241	0.179	E-Procurement	0.317	Medium
Firm Performance	0.38	0.291	E-Procurement	0.223	Medium
			Supply Chain Agility	0.145	Small to medium
			Green Procurement Practices	0.202	Medium
			Firm Size	0.036	Small

The results from Table 10 are visualized in Figure 5. The **figure displays the R^2, Q^2, and f^2 values** as the explanatory power, predictive relevance, and the size of the model's effect. It gives a better understanding of the role of e-procurement, supply chain agility, green procurement practices, and firm size in firm performance and the endogenous constructs.

Figure 5. Model Explanatory Power



6. Discussion

Using SmartPLS with 261 full questionnaires, this research provides empirical evidence that e-procurement is a strategic capability that enhances firm performance in the Pakistani textile industry. The results confirm that e-procurement has a positive and significant direct impact on firm performance (β = 0.412, $p < 0.001$). This implies that textile companies adopting digital procurement solutions have greater opportunities to improve purchasing efficiency, minimize manual delays, improve communication with suppliers, increase transparency, and make quicker procurement decisions. These enhancements are directly associated with improved operational and market performance in Pakistan's volatile textile environment, where companies struggle with supply chain delays, raw material

uncertainty, energy outages, and market pressure. The results also show that e-procurement significantly affects supply chain agility (ß=0.452, p < 0.001) and green procurement practices (ß=0.487, p < 0.001). This shows that e-procurement not only improves procurement efficiency but also makes companies more responsive and sustainable. Digital procurement enhances supplier visibility, real-time communication, order tracking, and decision-making speed, helping companies respond more effectively to supply and demand disruptions (Albinkhalil & Razzaque, 2021; Chen et al., 2022; Mélon & Spruk, 2020; Raghul et al., 2024). It also supports green procurement by improving supplier monitoring, environmental documentation, traceability, and sustainability-based evaluation. The findings also affirm that supply chain agility and green procurement practices strongly and positively affect firm performance. Supply chain agility positively influences firm performance (ß=0.306, p < 0.001), indicating that agile textile companies can more easily maintain supply chain targets, production levels, and customer satisfaction. Green procurement practices also positively impact firm performance (ß=0.395, p < 0.001), indicating that green-focused procurement enhances compliance, reputation, resource use, and access to environmentally conscious consumers.

The empirical findings demonstrate that e-procurement functions as a strategic digital capability that directly and indirectly enhances firm performance in the Pakistani textile industry. In contrast to isolated operational studies, our revised model reveals that supply chain agility ($\beta = 0.138, p = 0.002$) and green procurement practices ($\beta = 0.192, p < 0.001$) function as complementary partial mediators rather than mutually exclusive or full pathways. This indicates that while digital procurement infrastructure directly streamlines purchasing transaction speed and administrative overhead, its full practical value is unlocked when leveraged to reconfigure supply chain operations and institutionalize green purchasing routines.

Furthermore, the statistically significant sequential path ($\beta = 0.085, p = 0.003, 95\%$ CI $= [0.031, 0.149]$) illustrates a multi-stage capability transmission mechanism: digital visibility provided by e-procurement enables operational agility (EP → SCA), which provides the flexible administrative infrastructure needed to adopt green purchasing routines (SCA → GPP), ultimately improving firm performance (GPP → FP).

Several methodological and contextual boundary conditions must be considered when interpreting these findings. First, while PLS-SEM supports the specified directional paths, the cross-sectional design precludes definitive causal inferences. It is plausible that high-performing firms possess greater financial slack, allowing them to invest more heavily in e-procurement systems and sustainable technologies (reverse causality). Second, although non-response bias and common method bias diagnostics (Harman's test variance = 35.13%; HTMT ratios < 0.85) suggest that common-source bias is not a major concern, relying on single key informants per firm introduces perceptual variance. Finally, because the sample was restricted to ISO 14001-certified manufacturing units, the strong adoption of green procurement practices observed ($M = 3.65$) reflects a baseline level of institutional commitment to environmental management.

Lastly, the sequential mediation effect is also significant (ß = 0.085, p = 0.003), indicating that e-procurement initially enhances supply chain agility, which, in turn, increases green procurement practices, which eventually contribute to the firm's performance. Overall, the findings suggest that e-procurement is not a limited instrument. It is a strategic digital capability in the Pakistani textile industry that enhances firms' performance in terms of efficiency, responsiveness, sustainability, and market legitimacy.

The findings on model quality enhance the debate by demonstrating that the proposed model is not only statistically significant but also explanatory and predictive. These results show that e-procurement, supply chain agility, green procurement practices, and firm size explain significant variance in performance and other endogenous variables. The positive Q^2 values indicate the model has predictive power, and the f^2 values show that the predictors have practical significance. Thus, these results support the claim that e-procurement is a strategic digital capability whose performance value is created via agility, sustainability-minded procurement, and resource capacity. The full mediation of GPP extends Configuration Theory. It confirms that e-procurement is a 'first-order' capability that requires 'second-order' sustainability routines to align with the volatile, export-driven market environment of Pakistan.

7. Implications

Theoretical Contributions

This study advances the Dynamic Capabilities View and Configuration Theory by demonstrating that e-procurement serves as a foundational digital sensing enabler that transmits value through operational reconfigurations (agility) and sustainable routines (green procurement).

Managerial Implications

Textile operations managers should prioritize integrating e-procurement systems (e.g., automated supplier portals) with real-time inventory tracking to enable agile re-sourcing during supply chain disruptions.

Policy Implications

a. Digital Subsidies for Industry SMEs: Trade bodies such as the All Pakistan Textile Mills Association (APTMA) and the Ministry of Commerce should establish shared digital procurement platforms and software subsidies for small-to-medium textile enterprises.

b. Green Sourcing Standards Alignment: National export promotion policies should align local green procurement mandates with international buyer sustainability requirements (e.g., EU Corporate Sustainability Due Diligence Directive) to safeguard export market access.

8. Limitations and future research

Several limitations of this study highlight avenues for future inquiry:

a. The study relied on cross-sectional, single-informant survey data capturing managerial perceptions at a single point in time. Future research should utilize multi-informant designs (e.g., pairing procurement managers with financial officers) and longitudinal data to evaluate objective metrics such as audited procurement cost savings, verified lead times, and actual financial ratios.
b. Data were gathered exclusively from ISO 14001-certified textile manufacturing firms in Pakistan. While appropriate for studying established environmental routines, this sample limits generalizability to uncertified manufacturing units, small informal

enterprises, or other regional contexts. Comparative studies across certified and non-certified enterprises are recommended.

c. Although market volatility and environmental dynamism provided contextual rationale, market volatility was not directly operationalized as a construct in the structural model. Future studies should explicitly model environmental dynamism or supply disruption intensity as moderating variables.

9. Conclusion

This study investigated the structural relationships between e-procurement, supply chain agility, green procurement practices, and firm performance across 261 ISO 14001-certified Pakistani textile manufacturing firms using PLS-SEM analysis. The findings reveal that e-procurement exhibits a significant direct positive association with firm performance ($\beta = 0.128, p = 0.014$) while strongly supporting operational capabilities by displaying robust direct relationships with supply chain agility ($\beta = 0.452, p < 0.001$) and green procurement practices ($\beta = 0.334, p < 0.001$). Furthermore, supply chain agility ($\beta = 0.091, p = 0.005$) and green procurement practices ($\beta = 0.108, p = 0.003$) serve as complementary partial mediators, confirming that digital tools enhance performance through operational responsiveness and sustainable sourcing routines. A sequential capability path ($\beta = 0.085, p = 0.003$,95% CI $= [0.031,0.149]$) further operates from e-procurement through agility and green purchasing to firm performance, establishing a multi-stage capability conversion process. However, these inferences are subject to boundaries, as the cross-sectional, single-informant survey design identifies statistical associations rather than temporal causality, and the focus on ISO 14001-certified Pakistani textile manufacturers limits direct generalizability to uncertified firms, non-manufacturing sectors, or alternative institutional contexts.

Appendix A. Participants and their suggestions

	Gender	Job / Role	Education	Contribution / Suggested Changes
ID-1	Male	Procurement Manager, Textile Firm	MBA Supply Chain	Suggested simplifying procurement-related jargon, clarified cost and process efficiency items, and ensured relevance to operational practices
ID-2	Female	Supply Chain Manager, Textile Firm	MSc Logistics & Supply Chain	Reviewed supply chain agility items, suggested contextual examples for flexibility and responsiveness, and ensured items matched daily operational realities
ID-3	Male	Procurement Supervisor, Textile Firm	BBA	Provided input on the clarity of coordination and supplier integration items, recommended simpler language for mid-level staff comprehension
ID-4	Female	Senior Operations Manager, Textile Firm	MBA Operations Management	Suggested rephrasing of speed, decision-making, and adaptability items; aligned phrasing with local firm operations
ID-5	Male	Academic, Supply Chain & Procurement	PhD Supply Chain Management	Ensured theoretical consistency with original constructs, suggested adjustments to wording to maintain construct validity
ID-6	Female	Academic, Operations & Sustainability	PhD Management	Reviewed green procurement and environmental integration items, recommended context-specific phrasing for sustainability terms.
ID-7	Male	Academic, Quantitative Research	MSc Statistics	Verified item clarity, suggested logical sequencing of questions, ensured response scales were comprehensible and statistically valid.
ID-8	Female	English Language Specialist	MA Applied Linguistics	Reviewed all items for grammatical correctness, readability, and cultural appropriateness; suggested minor linguistic adjustments to improve comprehension
ID-9	Male	Senior Procurement Officer, Textile Firm	MSc Supply Chain Management	Evaluated e-procurement transaction speed and online tendering items; refined phrasing for digital order tracking.
ID-10	Female	Quality Assurance Manager, Textile Firm	BS Textile Engineering	Aligned ISO 14001 compliance and eco-friendly material selection phrasing with factory audit standards.
ID-11	Male	Supply Chain Analyst, Textile Firm	BBA	Assessed Likert-scale readability and item flow; verified clarity of decision-making velocity indicators.
ID-12	Female	Sustainability Coordinator, Textile Firm	MS Environmental Sciences	Refined green procurement constructs; improved item alignment with waste reduction and supplier environmental auditing.
ID-13	Male	Operations Supervisor, Textile Firm	MBA	Suggested contextual operational examples for supply chain adaptability under raw-material disruption scenarios.
ID-14	Male	Logistics Manager, Textile Firm	BS SCM & Logistics	Verified supply chain flexibility sub-dimensions; enhanced wording regarding delivery speed and re-sourcing agility.
ID-15	Female	Academic Consultant, SCM	PhD Supply Chain Management	Confirmed face validity and content coverage across all 24 operationalized scale items.
ID-16	Male	Industry Specialist, Textile Association	APTMA Representative	Ensured alignment of technical procurement terminology with national textile industry trade practices.
ID-9	Male	Senior Procurement Officer, Textile Firm	MSc Supply Chain Management	Evaluated e-procurement transaction speed and online tendering items; refined phrasing for digital order tracking.

Appendix B. Questionnaire

Dimension	Item	Measurement Item
E-Procurement		
Cost Efficiency	EP1	E-procurement reduces procurement and transaction costs
Process Efficiency	EP2	E-procurement improves procurement process efficiency
Standardization	EP3	Procurement processes are standardized and integrated
Information Integration	EP4	Information sharing with suppliers is enhanced
Coordination	EP5	Coordination with supply chain partners is improved
Supply Chain Agility		
Responsiveness	SCA1	Firm responds rapidly to customer demand changes
Flexibility	SCA2	Supply chain processes are flexible and adaptable
Speed	SCA3	Firm adjusts production and delivery quickly
Decision Speed	SCA4	Decision-making speed in operations is high
Adaptability	SCA5	Firm adapts effectively to disruptions and uncertainty
Green Procurement Practices		
Supplier Selection	GPP1	Suppliers are selected based on environmental criteria
Eco Materials	GPP2	Eco-friendly materials and products are prioritized
Environmental Integration	GPP3	Environmental standards are integrated into procurement
Supplier Evaluation	GPP4	Suppliers are evaluated on sustainability performance
Waste Reduction	GPP5	Procurement practices reduce waste and emissions
Firm Performance		
Operational Performance	FP1	Operational efficiency has improved
	FP2	Product/service quality has improved
	FP3	Delivery performance and speed improved
Financial Performance	FP4	Profitability has increased
	FP5	Return on investment (ROI) improved
Market Performance	FP6	Market share has increased
	FP7	Customer satisfaction has improved
	FP8	Customer relationships have strengthened.
	FP9	Competitive advantage has improved

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Appendix 1. Questionnaire: E-Procurement and Firm Performance

Dear Participant

We invite you to participate in a research study investigating how E-Procurement relates to Firm Performance through the mediating mechanisms of Supply Chain Agility and Green Procurement Practices in Pakistan's textile manufacturing sector. Your responses will remain strictly confidential and will be used solely for academic research purposes. Please read each statement carefully and select the option that best reflects your opinion.

Section A: Demographic Information

1. Gender:
   [ ] Male [ ] Female [ ] Prefer not to say

2. Position:
   [ ] Procurement Manager [ ] Supply Chain Manager [ ] Purchasing Officer [ ] Operations Manager [ ] Supervisor [ ] Other

3. Firm Age:
[ ] Less than 5 years [ ] 5–10 years [ ] 11–20 years [ ] More than 20 years

4. Education:
[ ] Intermediate/Diploma [ ] Bachelor's [ ] Master's [ ] MPhil/MS [ ] PhD

5. Work Experience:
[ ] Less than 3 years [ ] 3–5 years [ ] 6–10 years [ ] 11–15 years [ ] More than 15 years

Instructions: For the following sections, please indicate your level of agreement with each statement on a scale of 1 to 5, where:

1 = Strongly Disagree (SD)
2 = Disagree (D)
3 = Neutral (N)
4 = Agree (A)
5 = Strongly Agree (SA)

Section B: E-Procurement (EP)

EP1: E-procurement reduces procurement and transaction costs.
[1] [2] [3] [4] [5]

EP2: E-procurement improves procurement process efficiency.
[1] [2] [3] [4] [5]

EP3: Procurement processes are standardized and integrated.
[1] [2] [3] [4] [5]

EP4: Information sharing with suppliers is enhanced.
[1] [2] [3] [4] [5]

EP5: Coordination with supply chain partners is improved.
[1] [2] [3] [4] [5]

Section C: Supply Chain Agility (SCA)

SCA1: Firm responds rapidly to customer demand changes.
[1] [2] [3] [4] [5]

SCA2: Supply chain processes are flexible and adaptable.
[1] [2] [3] [4] [5]

SCA3: Firm adjusts production and delivery quickly.
[1] [2] [3] [4] [5]

SCA4: Decision-making speed in operations is high.
[1] [2] [3] [4] [5]

SCA5: Firm adapts effectively to disruptions and uncertainty.
[1] [2] [3] [4] [5]

Section D: Green Procurement Practices (GPP)

GPP1: Suppliers are selected based on environmental criteria.
[1] [2] [3] [4] [5]

GPP2: Eco-friendly materials and products are prioritized.
[1] [2] [3] [4] [5]

GPP3: Environmental standards are integrated into procurement.
[1] [2] [3] [4] [5]

GPP4: Suppliers are evaluated on sustainability performance.
[1] [2] [3] [4] [5]

GPP5: Procurement practices reduce waste and emissions.
[1] [2] [3] [4] [5]

Section E: Firm Performance (FP)

FP1: Operational efficiency has improved.
[1] [2] [3] [4] [5]

FP2: Product/service quality has improved.
[1] [2] [3] [4] [5]

FP3: Delivery performance and speed improved.
[1] [2] [3] [4] [5]

FP4: Profitability has increased.
[1] [2] [3] [4] [5]

FP5: Return on investment (ROI) improved.
[1] [2] [3] [4] [5]

FP6: Market share has increased.
[1] [2] [3] [4] [5]

FP7: Customer satisfaction has improved.
[1] [2] [3] [4] [5]

FP8: Customer relationships have strengthened.
[1] [2] [3] [4] [5]

FP9: Competitive advantage has improved.
[1] [2] [3] [4] [5]