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EXAMINING THE IMPACT OF LEAN AND AGILE MANUFACTURING PRACTICES ON SUSTAINABLE FIRM PERFORMANCE: THE MEDIATING ROLE OF GREEN PRACTICES

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Abstract
This study examines how lean manufacturing practices including Total Quality Management (TQM), Just in Time (JIT) and agile manufacturing practices affect the Sustainable Firm Performance (SFP) with green manufacturing practices acting as a mediator. Based on the Resource-Based View (RBV), this study primarily examined the business's operational and environmental skills as strategic capabilities that contribute to long-term, sustainable firm performance. Data was gathered from 241 respondents in Pakistan's leather export sector, including executives, operational managers, and quality supervisors. Information gathered through the use of cluster sampling. Every item and associated construct was measured using a validated five-point Likert scale. The measurement and structural models, including mediation effects, were evaluated using Covariance-based Structural Equation Modeling (CB-SEM) in AMOS. The results reveal that while JIT has no measurable effect on SFP or Green Practices, TQM and Agile Manufacturing Practices both directly and indirectly improve SFP through Green Practices. The linkages among TQM and Agile Manufacturing Practices with SFP were shown to be somewhat mediated by green practices, indicating the crucial role that eco-friendly efforts play in converting operational and manufacturing excellence into long-term results. In addition to providing management insights by highlighting the combination of quality, agility, and green practices to achieve better sustainability performance, the study advances theory by expanding RBV to include environmental capabilities as strategic resources.

1.0 Introduction

Rapid technological innovation and increased worldwide competition force businesses to constantly reevaluate their strategic orientations in order to maintain and gain a competitive edge. The manufacturing sector's rapid expansion has intensified competition among businesses, forcing them to improve operational efficiency and performance, responsiveness, and sustainability. Flexibility and adaptation are essential in today's complicated and changing economy. According to recent empirical research, maintaining competitive performance requires the ability to be efficient, effective, agile, and environmentally conscious (Chen, 2019; Hashem & Aboelmaged, 2023; Khalfallah & Lakhal, 2021). Even with this acknowledgment, a lot of suppliers and manufacturers still have challenges properly integrating these characteristics into their operating systems.

Operational efficiency and effectiveness sometimes damaged by the unplanned and inefficient waste reductions attempts (de Oliveira et al., 2019; Nawanir & Moshood, 2025; Negrão et al., 2020). Under the lean paradigm, manufacturing practices like; lean manufacturing practices and agile manufacturing practices considered as the main approaches for quality enhancement, reductions of waste, efficient workflows and continuous improvements. On the other hand, just in time concept just deal with appropriate amount of production and raw material and avoid excessive inventory to reduce inefficiencies. Total quality management focused on the gradual improvement in the processes and manufacturing, enhance employee's involvement and their productive contributions. But their holistic, integrated and embedded contribution to achieve the sustainability goals of the firm has been often decreased because of unplanned and uneven implementation with related to operational and environmental activities.

On the other hand, agility and responsive approach has become more important with respect to ever changing customer demands. Often in today's competitive world, businesses react quickly and proactively on customer needs, demands and expectations by adopting agile manufacturing approach (Nabass & Abdallah, 2019). Although agile manufacturing approach is acknowledged as competitive advantage and strategic advantage but lack of technical approach, firms inflexible approach and rigidities, and lack of environmental policies make the firms unable to get sustainable results. More significantly, the implementation of green manufacturing practices has become essential due to increasing environmental constraints and legal obligations by the governments and related agencies. By preventing pollution, using resources efficiently, and using sustainable production methods, green manufacturing seeks to reduce its negative effects on the environment by implementing such initiatives which protect the environment from waste and pollution (Abualfaraa et al., 2020; Yue et al., 2023; Zameer et al., 2021). The long-term competitiveness of businesses may be further weakened by a lack of environmental knowledge, related green practices and a poor integration of green efforts with operational goals.

In such a dynamic environment, failing to improve competitiveness can have serious implications, such as failing to meet customer demands and expectations which ultimately lead the firm to loss the sustainable advantage in the long run, losing market share (Ehie & Muogboh, 2016), becoming less profitable (Nawanir et al., 2016), and eventually failing as a business(Sansone et al., 2020). These hazards show how urgently manufacturing companies must have integrated strategic capabilities and related competencies that improve operational excellence and long-term firm performance.

Despite the fact that lean manufacturing practices, agile manufacturing practices, and green practices have all been studied in the past, much of the research has either addressed these paradigms separately or looked at how they directly affect performance results. Examining lean manufacturing through its fundamental components—TQM and JIT—as well as agile manufacturing techniques, while also looking into the way that green practices mediate these operational capabilities and strengths into sustainable firm performance, has received little attention. Specifically, limited information is known about how green practices mediate the relationship between lean (TQM and JIT) and agile manufacturing techniques and sustainable firm performance. In the literature on manufacturing, operations and sustainability, this constitutes a substantial theoretical, conceptual and empirical gap.

Furthermore, despite some research has looked at the synergistic and combined frameworks of lean manufacturing and green practices or lean manufacturing and agile manufacturing practices, there is currently a lack of empirical data and concrete evidence demonstrating how green practices serve as a channel for operational and manufacturing practices that improve sustainable firm performance, especially in developing manufacturing contexts. Beyond efficiency and adaptability, sustainable firm performance—which includes economic, environmental, and social aspects—requires the methodical integration of environmental or green practices into operational processes. Thus, it is crucial to comprehend whether and how green manufacturing practices mediate the connections between agile manufacturing techniques, TQM, JIT, and sustainable firm performance.

With green manufacturing practices acting as a mediating variable, the current study aims to fill this gap by investigating the effects of agile manufacturing practices and lean manufacturing techniques—operationalized through TQM and JIT—on the sustainable firm performance. In this research study, total ten hypotheses are proposed, which are: (H1–H3) investigating the direct impact of total quality management (TQM), just in time (JIT) and agile manufacturing practices (AMP) on the sustainable firms performance (SFP); (H4) investigating the direct impact of green manufacturing practices (GMP) on the sustainable firms performance (SFP); (H5–H7) measuring the effect of total quality management (TQM), just in time (JIT) and agile manufacturing practices (AMP) on green manufacturing practices (GMP); and (H8–H10) exploring the mediating role of green manufacturing practices (GMP) in the relationships between total quality management (TQM), just in time (JIT) and agile manufacturing practices (AMP), and sustainable firm performance (SFP).

This study is important since it makes multiple theoretical and practical contributions. Theoretically, it adds to the body of literature by using a mediation approach to integrate sustainability with lean and agile manufacturing views. In terms of methodology, it breaks down lean manufacturing practices into its two main components, TQM and JIT, to offer a more complex understanding of their respective and combined impacts. In practical terms, the results will give managers and supervisors evidence-based recommendations on how to improve sustainable firm performance by coordinating inventory and stocks systems, agility, quality management and quality control. The report provides practical insights for manufacturing companies looking to satisfy sustainability requirements and attain long-term competitiveness by understanding these connections. This is how the rest of the paper is organized. The next part examines relevant studies and related literature on agile manufacturing techniques, lean manufacturing (TQM and JIT), green manufacturing practices, and sustainable firm performance before formulating framework and hypotheses. The study approach and empirical results are then provided. Lastly, the comparative discussion's, theoretical and practical implications, and potential research gaps and directions are presented.

2.0 Literature Review

2.1 Sustainable Firm Performance

The ability of a company to succeed over the long run while concurrently achieving social, environmental, and economic goals is known as sustainable firm performance, or SFP. The idea is based on John Elkington's Cannibals with Forks framework, which codified the triple bottom line (TBL) viewpoint. According to the TBL method, businesses must maximize profits while reducing their negative effects on the environment and improving society. Sustainability is now a important operational and strategic requirement in contemporary industrial settings, driven by stakeholder expectations and requirements, regulatory demands, and ever changing global competition (Dahri et al., 2025; Hassan & Pasha, 2023).

According to the Resource-Based View (RBV), businesses that create highly valuable, uncommon, unique, and non-substitutable assets that provide them a sustained competitive edge achieve long-term and sustainable success (Barney, 1991; Wernerfelt, 1984). It is possible to think of operational strengths as strategic resources incorporated into organizational operations, such as quality management and control systems, synchronized processes for manufacture, production agility, and environmental management practices. Businesses have a better chance of achieving long-term, sustainable results when these competencies are successfully implemented in an integrated way (Mfarrej et al., 2025; Mohaghegh et al., 2024). Finding the operational drivers of SFP is still a top research objective in the body of literature on manufacturing, operations and strategic management, especially in light of the rising significance of sustainability in global supply chains (Le et al., 2025).

2.2 Lean Manufacturing Practices

With an emphasis on reducing waste and increasing customer value, lean manufacturing practices has become a prominent operational and manufacturing approach. Its philosophical roots are found in the manufacturing method created by Toyota Motor Corporation and subsequently made popular by James P. Womack and associates in The Machine That Changed the World. The goal of lean is to get rid of non-value-added processes including delay, overcapacity, excessive stock, overproduction, flaws, and ineffective processing (Negrão et al., 2020; Rahardjo et al., 2023). Integrated processes deeply rooted in routines and company culture are recognized as lean practices. The two main pillars of this study's conceptualization of lean manufacturing practices are Total Quality Management (TQM) and Just in Time (JIT). Established organizational skills that improve minimize waste and operational effectiveness are represented by these aspects (Hariyani & Mishra, 2024; Khalfallah & Lakhal, 2021).

2.2.1 Total Quality Management (TQM)

The core principles of total quality management include rigorous monitoring and process control, employee engagement and participation, customer priority, and persistent and incremental improvements in the operations. TQM increases efficiency in operation, improves production quality, reliability and quality of the product enhanced and lowers variation in the operational process (Fok et al., 2022; Hassan & Pasha, 2022; Nawanir & Moshood, 2025). Because TQM is deeply integrated in company-specific procedures and processes, learning methodologies, and culture, making it hard for opponents to replicate, it is considered an advantageous organizational skill within the RBV paradigm. TQM is regularly linked in empirical research to greater resource use, increased financial results, and improved operational and manufacturing performance (Abualfaraa et al., 2020; Nawanir & Moshood, 2025). Efforts for continual growth lower energy use, waste of materials, repair and rework, and faults, therefore indirectly advancing environmental sustainability goals.

Additionally, TQM promotes uniformity and process discipline having standardization, which may help with the deployment of organized green initiatives and environmental management systems. Businesses may lessen environmental shortcomings and encourage sustainable practices by using systematic monitoring and process improvement (Medyński et al., 2023; Powell et al., 2024).

2.2.2 Just in Time (JIT)

A lean manufacturing technique called Just in Time aims to create and deliver goods in the appropriate amount at the appropriate time. JIT lowers overproduction, surplus output, and inventories holding costs by aligning manufacturing with demands of the customers. By removing superfluous inventory, lowering storage needs, and enhancing supply chain collaboration, JIT improves operating efficiency. From the standpoint of sustainability, smaller inventory levels result in less energy use, materials waste, and emissions related to logistics, transport and warehousing (Hariyani & Mishra, 2024). JIT is a tactical supply chain ability that integrates supplier relationships and enhance their connections, process alignment and synchronization, and coordination systems according to the RBV lens. Its fundamental focus on waste reduction is in line with environmental management concepts, indicating possible overlaps between lean production and green projects (Ding et al., 2023; Hariyani & Mishra, 2022).

2.3 Agile Manufacturing Practices

Agile manufacturing practices are the ability of the firm to respond quickly to customer needs, want and demands and satisfy the customer well before their competitor (Agarwal et al., 2023; Nabass & Abdallah, 2019). Due to intense competition and ever changing customer needs, agile manufacturing approach is the key for firm to respond proactively and efficiently to changes in the marketplace, advancements and adoption of the updated technology, and also well address the client's demands. This approach strongly emphasizes on production agility, customization, flexibility, speed and versatility (Ding et al., 2023). Firms can effectively and efficiently modify and change the manufacturing levels, launch new products with respect to customer requirements, reshape and reorganize the processes and procedure when they adopt agility. Such flexible approach in extremely uncertain business environment gain the long-term sustainability in terms of profits and growths. Agile businesses comparatively more responsive to adopt to shifting environmental laws and more responsive to customer's desires while achieving sustainability (Nawanir & Moshood, 2025). According to the RBV viewpoint, agility is a changing skill and capabilities that enables businesses to reorganize and reshape their current resources in response to developments in the environment with respect to customer needs, wants and demands. Agile manufacturing increases the ability to innovate, thinks creatively and makes it easier to incorporate eco-friendly technology into functional and operational systems (Hariyani & Mishra, 2022; Khalfallah & Lakhal, 2021). According to empirical data and research findings, agile approaches enhance organizational flexibility and agility, competitive edge, strategic capability and operational performance—all of which are directly related to sustainable business performance in the long run (Nabass & Abdallah, 2019; Nguyen Thi Huyen et al., 2025).

2.4 Green Practices

Environmentally focused methods of manufacture that minimize environmental effect while preserving efficiency are referred to as "green manufacturing." Energy-efficient procedures, reuse and recycling, pollution control, ecologic design, and green supply chain management are some examples of these approaches (Kouser et al., 2025; Shehzad et al., 2023).

By minimizing environmental damage, cutting operating expenses via effective resource use, and enhancing business image, green manufacturing practices directly support the triple bottom line. Businesses that implement environmental efforts frequently see improvements in stakeholder engagement, compliance with environmental laws, and financial sustainability (Dahri et al., 2025).

Green practices are strategic intangible resources that are rooted in organizational knowledge and expertise, environmental skills, and processes of innovation, according to the RBV concept. Businesses may gain long-term competitive and sustainability benefits by cultivating strong environmental competence (Öztürk et al., 2024; Umar et al., 2022).

2.5 Conceptual Framework and Hypotheses Development

According to the aforementioned literature, lean (TQM and JIT) and agile manufacturing techniques are significant operational competencies that improve productivity, adaptability, and waste minimization. However, integrating green initiatives may be necessary for them to fully contribute to Sustainable Firm Performance.

TQM facilitates handling environmental issues by encouraging process discipline, standardization and continuous progress. JIT minimizes emissions and waste from materials by cutting down on overproduction, excessive output and surplus inventories (Rahardjo et al., 2023). Agile manufacturing improves flexibility, allowing businesses to embrace environmentally friendly technology and successfully comply with environmental laws. As a result, green practices might operate as a mediator between operational capabilities and more general sustainability results (Nawanir & Moshood, 2025). The conceptual framework suggests both direct and mediated links between lean manufacturing practices, agile manufacturing, green practices, and sustainable firm performance based on this philosophical and conceptual justification.

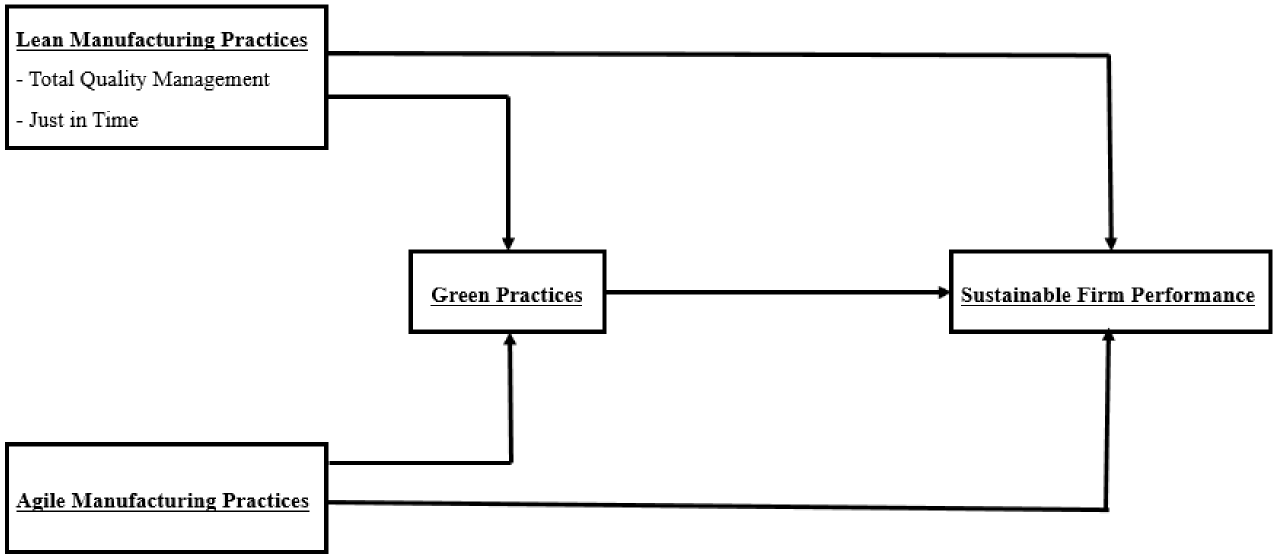

Figure 01: Conceptual Framework

Therefore, the following hypotheses are put proposed:

H1: Total Quality Management has a positive impact on Sustainable Firm Performance.
H2: Total Quality Management has a positive impact on Green Practices.
H3: Just in Time has a positive impact on Sustainable Firm Performance.
H4: Just in Time has a positive impact on Green Practices.
H5: Agile Manufacturing Practices have a positive impact on Sustainable Firm Performance.
H6: Agile Manufacturing Practices have a positive impact on Green Practices.
H7: Green Practices have a positive impact on Sustainable Firm Performance.
H8: Green Practices mediate the relationship between Total Quality Management and Sustainable Firm Performance.
H9: Green Practices mediate the relationship between Just in Time and Sustainable Firm Performance.
H10: Green Practices mediate the relationship between Agile Manufacturing Practices and Sustainable Firm Performance.

3.0 Methodology

With Green Manufacturing practices acting as a mediator, this study uses a method of quantitative study to investigate the effects of lean manufacturing methods—especially, Total Quality Management (TQM) and Just in Time (JIT)—and Agile Manufacturing Practices on Sustainable Firm Performance in leather export industry of Pakistan. Because it allows for rigorous testing of hypotheses and empirical validation and confirmation of proposed theoretical linkages using statistical methods, a quantitative method is suitable. This research, which is based on the Resource-Based View (RBV), views lean manufacturing practices, agile manufacturing, and green practices as strategically organizational capabilities and strengths that serve as distinct and valuable assets that support sustainable performance for the firms (Barney, 1991; Wernerfelt, 1984). In order to provide a comprehensive evaluation of mediation effects within a philosophically and theoretically organized research framework, the proposed study model examines both direct and indirect relationships between constructs.

The intended target population for the data collection includes corporate executives, senior managers, and quality supervisors working in Pakistan's leather export industry. The leather industry makes a significant contribution to the nation's exports and is coming under growing international pressure to adhere to quality standards, integrate the newest technologies, and respect environmental sustainability. As a result, it provides an appropriate scientific and empirical context for investigating the potential integration of lean manufacturing, agile manufacturing, and green practices to enhance the sustainable performance of businesses. To collect data, a cluster sampling technique was employed. Cluster sampling picks respondents from naturally formed groupings, such as leather export enterprises, by treating them as clusters. This approach increases reliability, precision, and feasibility (Etikan, 2017). Cluster sampling is particularly helpful when the population is geographically dispersed and separated into discrete groups since it reduces money and time without compromising accurate representation from the population. After being screened for incomplete questionnaires and survey forms and missing data, 241 valid responses were retained for the final analysis and evaluation. This sample size meets recommended standards for covariance-based structural equation modeling (SEM), which frequently requires adequate sample sizes for model stability and precise parameter estimates.

Data was collected using a standardized questionnaire that was modified from previously validated, approved and recognized measuring scales in total quality management research, agile manufacturing, green practices, sustainability studies and Just in Time research studies. To guarantee contextual relevance and content validity, the instrument was subjected to expert assessment by academics and business executives. According to Hair et al. (2019), including expert comments increases construct validity and measurement accuracy. Because of its dependability and responder friendliness, the five-point Likert scale, which ranges from 1 (strongly disagree) to 5 (strongly agree), was employed to measure all constructs. The measurement model consists of total 9 items from Total Quality Management (TQM), Just in Time (JIT) also having 9 items, Agile Manufacturing Practices (AMP) have 10 items, Green Practices have total 6 items and 6 items are also for Sustainable Firm Performance (SFP). In line with earlier studies carried out in sustainability and operational management, all constructs were defined as reflective latent variables, in which the theoretical construct is reflected in the observable indicators (Hair et al., 2019).

Covariance-based Structural Equation Modeling (CB-SEM) with AMOS software was used to evaluate the gathered data. When the goal is to assess the overall model fit and validate theoretically based links, CB-SEM is especially well-suited for testing the theory, validation and its confirmation. Factor loadings, discriminant validity, convergent validity using Average Variance Extracted (AVE), and internal consistency reliability (Cronbach's Alpha and Composite Reliability) were all investigated using Confirmatory Factor Analysis (CFA). Following predetermined SEM thresholds, the model's fit was assessed using a variety of goodness-of-fit indices, such as Chi-square (χ^2), the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR) (Hair et al., 2019; Hu & Bentler, 1999). After determining the applicability of the measurement model, the structural model was assessed to test propositions H1–H10. Standardized path coefficients and associated significance levels were used to evaluate the claimed relationships' extent, degree and level of importance. Squared multiple correlations were used to evaluate the explanatory power of endogenous constructs (R^2). As advised for mediation analysis, bootstrapping techniques were used inside AMOS to estimate indirect effects and provide bias-corrected confidence intervals in order to assess the mediation hypotheses (H8–H10) (Preacher & Hayes, 2008). Mediation was confirmed when the indirect impacts were statistically significant and the confidence intervals opposed zero. This comprehensive SEM procedure ensures robust validation of both direct and mediated effects within the proposed study scope. Ethical considerations were strictly followed during the whole research process. Participation was completely optional, and participants were assured of their privacy and confidentiality. No personally identifying information was exchanged, and the data was used exclusively for academic purposes in accordance with recognized ethical research standards.

4.0 Analysis

4.1 Convergent Validity, Reliability and Factor Loadings

Table 1 displays the results of the measurement model evaluation using AMOS and Confirmatory Factor Analysis (CFA) respectively. We evaluated the measurement model for indicator reliability, convergent validity, and internal consistency reliability for each of the study's latent constructs: Lean Manufacturing Practices (operationalized as Just in Time and Total Quality Management), Agile Manufacturing Practices, Green Practices, and Sustainable Firm Performance. In compliance with recognized SEM criteria, convergent validity was assessed using standardized factor loadings and Average Variance Extracted (AVE), and internal consistency reliability was assessed using Cronbach's alpha and Composite Reliability (CR) (Fornell & Larcker, 1981; Hair et al., 2019). First, we examined the standardized factor loadings obtained from AMOS in order to evaluate indication reliability.

The results showed that each item above the recommended cutoff value of 0.70 and had a substantial load on its respective construct (Hair et al., 2019). Specifically, loadings for the nine criteria measuring overall quality management fell between 0.738 and 0.844, demonstrating adequate dependability. Significant loadings in the range of 0.823 to 0.892 were also seen for the nine Just in Time items. The results showed very high standardized loadings between 0.882 and 0.930, suggesting strong measurement characteristics, when Agile Manufacturing Practices were quantified using ten indicators. Green practices were assessed using six items, with loadings ranging from 0.695 to 0.834. Even though one loading (0.695) was just marginally below the recommended 0.70 level, it was nevertheless acceptable because of its proximity to the cutoff and the fact that the construct's total AVE was greater than the minimal criterion (Hair et al., 2019). The Sustainable Firm Performance items' range of 0.822 to 0.892 further demonstrated strong indicator reliability. Collectively, these findings confirm that the observable variables faithfully capture the underlying latent properties.

Convergent validity was examined further using the Average Variance Extracted (AVE), which has a recommended baseline value of 0.50 (Fornell & Larcker, 1981). The AVE values for Just-in-Time, Agile Manufacturing Practices, Green Practices, Total Quality Management, and Sustainable Firm Performance were 0.582, 0.712, 0.841, and 0.621, respectively. All AVE values were over the suggested threshold, indicating that each concept accounts for more than half of the variance in its linked indicators. These results provide strong empirical support for convergent validity in the CFA measurement model calculated in AMOS.

Internal consistency dependability was assessed using Cronbach's alpha and Composite dependability (CR); for recognized and well established scales, a minimum value of 0.70 is recommended (Hair et al., 2019). The results demonstrate high reliability across all parameters and constructs. While Just in Time had values of 0.959 and 0.957, Cronbach's alpha and CR for Total Quality Management were 0.937 and 0.936, accordingly. Agile Manufacturing Practices showed exceptionally high reliability with Cronbach's alpha and CR of 0.982 and 0.981, respectively. Green Practices revealed a Cronbach's alpha and CR of 0.892 and 0.949, respectively, whereas Sustainable Firm Performance gave values of 0.950 and 0.949. These findings demonstrate strong internal consistency and justify the stability and consistency of the measurement scales.

Overall, the CFA results obtained with AMOS demonstrate that the measurement model satisfies the recommended criteria for indicator reliability, convergent validity, and internal consistency dependability. Therefore, the constructs measuring Lean Manufacturing Practices, Agile Manufacturing Practices, Green Practices, and Sustainable Firm Performance in Pakistan's leather export industry are suitable for additional structural model evaluation and hypothesis testing within the framework of the SEM and are psychometrically sound.

Table 1. Convergent validity, reliability and factor loadings

Variables	Items	Convergent Validity		Internal Consistency Reliability	
		Loadings >0.70	AVE >0.50	Cronbach's alpha >0.60	CR >0.60
TQM			0.621	0.937	0.936
	TQM1	0.824			
	TQM2	0.827			
	TQM3	0.738			
	TQM4	0.777			
	TQM5	0.741			
	TQM6	0.800			
	TQM7	0.844			
	TQM8	0.837			
	TQM9	0.817			
JIT			0.712	0.959	0.957
	JIT1	0.892			
	JIT2	0.879			
	JIT3	0.858			
	JIT4	0.864			
	JIT5	0.827			
	JIT6	0.823			
	JIT7	0.829			
	JIT8	0.860			
	JIT9	0.840			
AMP			0.841	0.982	0.981
	AMP1	0.914			
	AMP2	0.918			
	AMP3	0.905			
	AMP4	0.920			
	AMP5	0.930			
	AMP6	0.895			
	AMP7	0.913			
	AMP8	0.903			
	AMP9	0.910			
	AMP10	0.882			
GMP			0.582	0.892	0.892
	GMP1	0.695			
	GMP2	0.714			
	GMP3	0.701			
	GMP4	0.756			
	GMP5	0.812			
	GMP6	0.834			
SFP			0.759	0.949	0.95
	SFP1	0.822			
	SFP2	0.874			
	SFP3	0.892			
	SFP4	0.871			

SFP5	0.885
SFP6	0.849

Note(s): TQM – Total Quality Management; JIT – Just In Time; AMP – Agile Manufacturing Practices; GMP – Green Manufacturing Practices; SFP – Sustainable Firm Performance

4.2 Discriminant Validity and Measurement Model Fitness Values

Table 2 displays the discriminant validity assessment for the AMOS-derived latent components in the setting of structural equation modeling (SEM). The constructs included Green Practices (GNP), Just-in-Time (JIT), Agile Manufacturing Practices (AMP), Sustainable Firm Performance (SFP), and Total Quality Management (TQM). Discriminant validity was evaluated using the Maximum Shared Variance (MSV) approach and the Fornell–Larcker criteria, which are often recommended procedures in covariance-based SEM (Hair et al., 2019).

The diagonal components in Table 2 indicate the square roots of AVE. The square root of AVE is 0.917, 0.844, 0.788, and 0.871 for AMP, JIT, TQM, SFP, and GNP, in that order. These values exceed the corresponding inter-construct associations in each instance's off-diagonal elements. Since each idea shares more variance with its own indicators than with other latent variables, this meets the Fornell–Larcker criterion and confirms sufficient discriminant validity.

Furthermore, for any notion to have enough discriminant validity, MSV must be smaller than AVE (Fornell & Larcker, 1981). According to the findings, AMP's MSV is 0.094, JIT is 0.074, TQM is 0.071, SFP is 0.233, and GNP is 0.233. The MSV values are always less than the previously published matching AVE values, suggesting that no construct shares more variation with another construct than with its own indications. This gives the measurement model's discriminant validity more empirical backing.

Additionally, statistically significant positive correlations between a number of constructs are revealed by the correlation matrix. Green practices show strong positive correlations with AMP ($r = 0.306$, $p < 0.001$), JIT ($r = 0.272$, $p < 0.001$), TQM ($r = 0.266$, $p < 0.001$), and SFP ($r = 0.483$, $p < 0.001$), indicating that greater adoption of lean and agile manufacturing practices is linked to improved sustainable firm performance. Additionally, at the 0.05 significance level, AMP and JIT have strong positive correlations with SFP. The correlations' magnitudes, however, are still below the square roots of AVE for each concept in spite of these statistically significant relationships, which supports discriminant validity and shows that multi collinearity issues are not present (Hair et al., 2019).

All things considered, the AMOS results validate that the study's latent constructs are theoretically and empirically separate. Both the MSV comparison and the Fornell-Larcker criterion provide evidence of excellent discriminant validity. As a result, the measurement model shows sufficient construct uniqueness, confirming the accuracy of the SEM framework's following structural model estimate and hypothesis testing.

Table 2. Discriminant validity

	AMP	JIT	TQM	SFP	GNP
AMP	0.917				
JIT	0.074	0.844			
TQM	0.144*	0.109	0.788		
SFP	0.157*	0.160*	0.077	0.871	
GNP	0.306***	0.272***	0.266***	0.483***	0.763

Note: Significance of Correlations: † p < 0.100; * p < 0.050; ** p < 0.010; *** p < 0.001

Measurement model fitness values are shown in Table 3. The fit statistics of the original measurement model and the re-specified model following theoretically supported changes are contrasted in the table. According to accepted SEM principles, model fit was evaluated using a variety of fit indices, such as absolute, incremental, and parsimonious fit measures (Hair et al., 2019; Hu & Bentler, 1999). A favorable fit was shown by CMIN/DF, which was 2.302 and fell inside the acceptable criterion of less than 3.0. Nonetheless, a number of other indicators indicated potential for enhancement. Suboptimal model fit was indicated by the Goodness-of-Fit Index (GFI = 0.758) and Adjusted Goodness-of-Fit Index (AGFI = 0.728), both of which were below the suggested cutoff value of 0.90. The Normed Fit Index (NFI = 0.847) was below the suggested level, even though the Comparative Fit Index (CFI = 0.907), Tucker–Lewis Index (TLI = 0.900), and Incremental Fit Index (IFI = 0.907) all reached the minimum acceptable threshold of 0.90. Acceptable residual fit was indicated by the Standardized Root Mean Square Residual (SRMR = 0.053) being below the suggested threshold of 0.08 and the Root Mean Square Error of Approximation (RMSEA = 0.074) falling within the acceptable range (≤ 0.08). The PCLOSE value of 0.000, however, indicated that the close fit hypothesis (RMSEA < 0.05) could not be validated.

Significant gains were seen in all fit indices when the model was re-specificated using modification indices and theoretical reasoning. A better and more well-fitting model was shown by the CMIN/DF dropping to 1.905. Nearing the suggested threshold and indicating improved absolute fit, the GFI and AGFI rose to 0.885 and 0.875, respectively. With CFI increasing to 0.936, TLI to 0.931, IFI to 0.936, and NFI to 0.974—all over the 0.90 benchmark and demonstrating high comparative fit with respect to the null model—the incremental fit indices demonstrated a discernible improvement. The SRMR increased to 0.041, suggesting excellent residual fit, but the RMSEA dropped to 0.061, falling into the good fit range (≤ 0.06–0.08). Significantly, the PCLOSE value rose to 0.166, indicating that the tight fit null hypothesis could not be disproved and strengthening the suitability of the revised model. Overall, the re-specified measurement model meets well recognized SEM fit requirements and shows a significantly better match than the original model. The measurement model effectively captures the observed data, as seen by the gains across absolute, incremental, and residual-based indices. As a result, the revised model is regarded as statistically sound and suitable for moving on to the estimation of structural models and hypothesis testing in the SEM framework.

Table 3. Measurement model fitness values

CFA Indicator	Initial model	Re-specified model
CMIN/DF	2.302	1.905
GFI	0.758	0.885
AGFI	0.728	0.875
CFI	0.907	0.936
RMSEA	0.074	0.061
NFI	0.847	0.974
TLI	0.9	0.931
IFI	0.907	0.936
PCLOSE	0.000	0.166
SRMR	0.053	0.041

4.3 Direct Path Effect Coefficients, Direct and Indirect Effects

Using Structural Equation Modeling (SEM) in AMOS, the structural model analysis findings are shown in Table 4. This table presents the t-statistics (critical ratios), standardized path coefficients (β), standard errors, and corresponding p-values for the proposed direct relationships between TQM, JIT, AMP, GNP, SFP, and Agile Manufacturing Practices. According to (Hair et al., 2019), the significance of structural routes was assessed using critical ratio (t-value) criteria larger than ±1.96 at the 0.05 significance level.

H1 is supported by the findings, which show that Total Quality Management positively and statistically significantly affects Sustainable Firm Performance (β = 0.269, t = 3.362, p < 0.001). According to this research, Pakistan's leather export sector performs better over the long term when TQM methods are used. On the contrary, H2 is rejected due to the positive but statistically negligible direct effect of Just in Time on Sustainable Firm Performance (β = 0.057, t = 0.708, p = 0.479). This implies that JIT practices alone don't significantly affect the sustainable firm's performance.

The significant positive impact Agile Manufacturing Practices have on Sustainable Firm Performance (β = 0.302, t = 2.960, p < 0.001) supports H3. This result highlights the importance of agility-oriented abilities in enhancing performance with regard to sustainability. Similarly, Green Practices have a favorable and statistically significant effect on Sustainable Firm Performance (β = 0.144, t = 2.880, p < 0.001), which supports H4. This study highlights the relationship between long-term performance outcomes and ecologically conscious behavior.

Regarding the antecedents of Green Practices, Total Quality Management has a significant beneficial effect on GNP (β = 0.223, t = 3.048, p < 0.001), which supports H5. This suggests that quality-conscious management systems promote the adoption of environmentally friendly practices. Due to the poor statistical significance of the relationship between Just in Time and Green Practices (β = 0.061, t = 0.532, p = 0.595), H6 is rejected. This implies that JIT approaches have little effect on the adoption of green initiatives in the businesses under study. Conversely, Agile Manufacturing Practices significantly and favorably influence Green Practices (β = 0.280, t = 4.448, p < 0.001), which strongly supports H7 and suggests that organizational agility promotes environmental responsiveness.

On the whole, the structural model's findings demonstrate that TQM and AMP are significant contributors of both Green Practices and Sustainable Firm Performance, while JIT has no statistically noteworthy direct impact on any of these factors. Furthermore, green practices significantly improve the performance of sustainable businesses, indicating that they operate as a mediator between manufacturing techniques and performance results. These findings provide empirical evidence that flexible and quality-focused manufacturing capabilities are significant determinants of sustainable performance in Pakistan's leather export industry.

Table 4. Direct path effect coefficients

Hypothesis	Structural Relationships	Coefficient (β)	Standard error	t Statistics	p-value
H1	TQM --> SFP	0.269	0.08	3.362	***
H2	JIT--> SFP	0.057	0.081	0.708	0.479
H3	AMP --> SFP	0.302	0.102	2.96	***
H4	GNP --> SFP	0.144	0.05	2.88	***

H5	TQM -> GNP	0.223	0.073	3.048	***
H6	JIT--> GNP	0.061	0.116	0.532	0.595
H7	AMP -> GNP	0.28	0.063	4.448	***

Note: Significance of Correlations: † $p < 0.100$; * $p < 0.050$; ** $p < 0.010$; *** $p < 0.001$

Table 5 displays the results of the mediating research that examined the indirect effects of Just-in-Time (JIT), Total Quality Management (TQM), and Agile Manufacturing Practices (AMP) on Sustainable Firm Performance (SFP) by Green Practices (GNP). As recommended for mediation assessment, AMOS was used to investigate the mediation interactions within the Structural Equation Modeling (SEM) structure, and bootstrapping techniques were used to assess the significance of indirect effects (Hair et al., 2019; Preacher & Hayes, 2008). The findings show that the connection between sustainable firm performance and total quality management is considerably mediated by green practices. While the indirect effect through GNP is similarly favorable and statistically significant ($\beta = 0.164$, $p < 0.001$), the direct effect of TQM on SFP is still positive and substantial ($\beta = 0.269$, $p < 0.01$). This implies partial mediation since both the direct and indirect pathways are meaningful. Thus, there is evidence for the theory that Green Practices moderate the link between TQM and SFP. This result suggests that via encouraging the adoption of ecologically friendly practices, TQM improves sustainable performance both directly and indirectly.

On the other hand, there is no evidence to support the idea that Green Practices mediate the link between Just in Time and Sustainable Firm Performance. Both the direct effect of JIT on SFP ($\beta = 0.057$) and the indirect effect ($\beta = 0.148$) are statistically insignificant while being positive. These findings point to the lack of both direct and indirect effect, indicating that, in the context of Pakistan's leather export sector, JIT does not significantly contribute to sustainable performance either on its own or through Green Practices.

Additionally, the results show that the association between Agile Manufacturing Practices and Sustainable Firm Performance is highly mediated by Green Practices. Both the direct and indirect effects of AMP on SFP are positive and substantial ($\beta = 0.302$, $p < 0.001$), as is the indirect impact through GNP ($\beta = 0.206$, $p < 0.001$). Partial mediation is indicated by the presence of considerable direct and indirect effects. This implies that Agile Manufacturing Practices promote responsiveness and flexibility, which directly improves sustainable company performance, and indirectly encourages the adoption of Green Practices.

All things considered, the mediation study demonstrates that Green Practices are a significant mechanism that connects manufacturing practices to long-term business success. In particular, the impacts of TQM and AMP on SFP are somewhat mediated by Green Practices, but JIT does not exhibit any mediating effects. These results support the theoretical claim that operational capabilities with an emphasis on the environment are a crucial bridge that connects manufacturing excellence to sustainable performance results.

Table 5. Direct and indirect effects

Hypothesis	Direct Effect	Indirect Effect	Results
TQM→GNP→SFP	0.269**	0.164***	Supported
JIT→GNP→SFP	0.057	0.148	Not Supported
AMP→GNP→SFP	0.302***	0.206***	Supported

5.0 Discussion

With Green Practices acting as a mediating mechanism, this study examined the effects of Lean Manufacturing Practices (Total Quality Management and Just in Time) and Agile Manufacturing Practices on Sustainable Firm Performance (SFP). The empirical findings offer a number of theoretical, philosophical and applied insights into how operational and environmental skills influence sustainability outcomes in Pakistan's leather export sector.

The results show that Green Practices and Sustainable Firm Performance are significantly improved by Total Quality Management (TQM). This is in line with the Resource-Based View (RBV), which holds that sources of competitive advantage are firm-specific competencies and capabilities that are valued, exclusive, and challenging to replicate (Barney, 1991; Wernerfelt, 1984). As an embedded organizational practice that prioritizes waste reduction, process uniformity and standardization, and quality improvement, TQM seems to promote the adoption of ecologically friendly methods while also immediately enhancing operational and financial results. Although TQM directly affects sustainability performance, its impact is increased when businesses include environmental activities, according to the partial mediation effect of Green Practices in the TQM–SFP connection. These findings are in line with other research showing that quality management procedures improve environmental performance and operational efficiency.

Conversely, neither Sustainable Firm Performance nor Green Practices showed a significant direct impact from Just in Time (JIT), and the mediation effect through Green Practices was not substantiated either. According to this research, JIT procedures might not be enough on their own to promote sustainability in the leather export sector. Although JIT emphasizes inventory reduction and process synchronization, contextual issues such supply chain complexity, poor technology integration, or uneven environmental management implementation in the studied enterprises may be to blame for the lack of noticeable impact. According to contingency theory viewpoints, which contend that operational procedures may only improve performance in favorable organizational and environmental circumstances, this finding emphasizes the situational character of JIT's efficacy.

Green practices and sustainable firm performance were found to be strongly positively impacted by agile manufacturing practices, or AMP. Agile capabilities improve responsiveness, flexibility, and adaptation, enabling businesses to use eco-friendly technology and reorganize manufacturing processes under dynamic market conditions. By allowing businesses to incorporate environmental efforts into their production processes, agility not only enhances operational performance but also supports sustainability results, according to the partial mediation of green practices. These results validate earlier research that suggested agile capabilities are dynamic assets that enhance environmental responsiveness and operational excellence.

Green practices have a positive and considerable impact on sustainable company performance, which demonstrates how important they are for achieving sustainability goals. In addition to directly contributing to SFP, green practices operate as a mediator, converting operational capabilities into more extensive triple-bottom-line advantages. The idea that lean and agile approaches by themselves are insufficient for reaching complete sustainability targets without supplementary green efforts is further supported by the mediation analysis, which emphasizes the significance of incorporating environmental issues into operational strategy.

Overall, the findings indicate that while JIT alone might not be enough to affect sustainability outcomes in the leather export industry, TQM and Agile Manufacturing Practices are important facilitators of sustainable performance, both directly and indirectly through environmental practices. The results expand RBV by showing that environmental capabilities must be added to operational capabilities in order to attain sustainable business performance, which has significant theoretical significance. The significance of contingency concerns is further highlighted by the partial support for JIT, which raises the possibility that contextual elements like industry characteristics, technology maturity, and regulatory demands may influence how operational techniques affect sustainability.

Practically speaking, managers in the leather export sector should concentrate on incorporating agility and quality management into daily operations while aggressively incorporating green practices. Adopting green practices as a mediating mechanism increases productivity, lowers waste, and boosts a company's reputation in addition to improving compliance with environmental standards. When paired with environmental measures, investments in quality-oriented and flexible skills are likely to produce a sustainable competitive advantage over the long run.

The study's conclusion highlights that the best way to achieve sustainable company performance is to integrate quality, agility, and green practices in a synergistic way. In order to completely achieve sustainability goals, operational capabilities—while crucial—must be combined with environmental activities. To further understand the circumstances in which lean, agile, and green practices transfer into improved sustainable performance, future study may examine other contextual elements as corporate culture, supply chain maturity, and technology integration.

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