Ali, R., Ahmed, A., Nasir, F., & Haider, S. (2025). Mediation of Supply Chain Operations on the Relationship between Lean Manufacturing and Firm Profitability. *Transformations and Sustainability, 1*(2), 100-117. https://doi.org/10.63775/v87kt449

Mediation of supply chain operations on the relationship between lean manufacturing and sustainability

Rashid Ali [a], Fouzia Nasir [b], Sheema Haider [a,*]

[a] *Faculty of Management Sciences, Indus University, Karachi, Pakistan*

[b] *Faculty of Management Sciences, Sir Syed University of Engineering and Technology, Karachi, Pakistan*

Abstract. The objective of the current research study was to examine the mediating effects of supply chain operations on the associations of lean manufacturing and firm performance in manufacturing companies in Pakistan. The research study was based on quantitative research methods to investigate the associations of the exogenous and endogenous variables with the mediating factors of the supply chain operations. The current research study was applied to analyze the developed hypotheses through Structural Equation Modeling (SEM). The lean manufacturing approach is positively associated with the operations of supply chain management, and the current research study provides significance greater understanding, and better relationships between the lean manufacturing approach and the operations of supply chain management in the manufacturing industry in Pakistan. The results indicate that the independent variables of quick setups, uniform production level, quality control level, and supplier networks are positively associated with lead time reduction, inventory minimization, and productivity. However, the supplier networks are not positively associated with lead time reduction or inventory minimization. The supplier networks are positively associated with productivity, cost reduction, lead time, positive impact on firm performance, and inventory minimization positively related to firm performance. Productivity has a positive effect on firm performance. The results indicate that productivity mediates the relationships of quick setups, uniform production levels, supplier networks, and firm performance. The results suggest that cost reduction mediates the associations of the factors of quick setups, uniform production level, quality control, and supplier networks with the firm performance. However, the Inventory minimization mediates the relationship between the supplier networks and the firm performance not supported. The Lead time reduction mediates the relationship between the supplier networks and the firm performance, but it does not mediate.

Keywords: Lean manufacturing; Supply chain operations; Firm profitability; Lead time reduction; Inventory minimization; Supplier networks.

1. Introduction

In the late 1950s to early 1960s, the concept of lean manufacturing regarding the shop floors of the Japanese auto industry associated with the company of Toyota Motor Corporation and the worldwide idea of lean manufacturing more significant importance in history explained that the word "lean" means that the use of resources

* Corresponding author, kate21540@yahoo.co.uk

Received April 2025; Revised April 2025; Accepted May 2025.

minimizes as compared to large production or substantial level of production system (Wang, 2021). The prior research study explained that this is associated with the American version of the approach of lean manufacturing used in the company of Toyota Production System and also is related to the methods of Just-in-Time (JIT), the manufacturing methods, thus the manufacturing is associated with the production system, introduced by the company of the Toyota, which is related to Toyota Production System (TPS) (Park & Lee, 2023). The lean supply chain management (Wainaina & Odari, 2023) approach is a new way of managing the network of suppliers, and the lean supply chain characteristics and the principles to develop the strategic relationships and integrate with the statistical aspects associated with the supply chain management system (Sartal et al., 2022). The prior research study explained that in 1973, the company of the Toyota Motor corporation gained more profits, compared to other companies, due to the implementation of the lean manufacturing methods in the manufacturing process, and other companies faced many losses. Thus, based on lean manufacturing methods or characteristics, other companies also used them in operations to enhance productivity and performance (Smirnov & Sorokin, 2022). The characteristics or principles of lean manufacturing came from the United States in the early 1980s and became significant and superior in Japan. European companies or manufacturers utilized lean manufacturing principles in operational activities for productivity (Psomas & Deliou, 2023). The prior research study explained that, nowadays, the high level of performance, quality, and productivity due to the implementation of the principles of lean manufacturing in the countries of the United States, Japan, and Europe is now recognized in the world as the symbol of quality (Sundar et al., 2019). Most of the past research studies suggested that in the production level performance, by implementing lean manufacturing principles, all these principles or practices are based on historical practices, which are applied in the process. Thus, past research studies identified the lack of significant studies that examine the factors of lean manufacturing practices and the impact of lean manufacturing on the organization's productivity (Chavez et al., 2013). Thus, the current research study focuses on the research gap and investigates the mediating effects of supply chain operations on lean manufacturing practices and organizational productivity performance in manufacturing companies in Pakistan.

Most of the studies analyze the manufacturing companies implementations of lean manufacturing in the context of developed countries, such as the United States, Canada, Italy, Japan, Germany, Australia, Spain, and the UK, and the significant research studies examine the mediating effects of the supply chain management practices with the lean manufacturing and the firm performance, such as the developing countries, like Pakistan (Ochieng, 2021). Thus, to conduct more focused and comprehensive research studies integrated with the approach of lean manufacturing, with the mediating role of the operational activities of the supply chain management to increase productivity through the practices of lean manufacturing in the companies of Pakistan. Therefore, the current research study is of significant importance regarding the examines the manufacturing supply chain

operational process problems in the manufacturing companies in Pakistan and finds that the lack of knowledge, lack of technical efficiency (Dijk & Szirmai, 2006), and efficiency are the main objective of the manufacturing process and the system of manufacturing in the context of Pakistan.

To achieve productivity in the manufacturing operational process, technical efficiency has a more significant impact on the firm's performance, and inefficiency means there is a failure in planning at the operational level and not achieving maximum output with the minimum resources (Jin et al., 2019). Thus, there needs to be a high level of efficiency in the resultant-oriented outputs, and more critical factors change in the process of the operational activities regarding the techniques, operations process, and methods. So, lean manufacturing significantly impacts productivity and efficiency, eliminating non-value-added activities and increasing the added activities to increase productivity (Tarigan et al., 2018). It is found that the topic of the mediating effects of the supply chain operational activities with the lean manufacturing and the firm performance is still minimal and does no empirical evidence regarding the approach of the supply chain management practices with the relationships of the lean manufacturing and the organizational performance (Qrunfleh & Tarafdar, 2013). Thus, more investigation into the significance and the substantial need for lean manufacturing with supply chain management practices (Ochieng, 2021). Therefore, the current research study was filling the empirical evidence research gap regarding the mediating effects of supply chain practices on lean manufacturing and firm performance. The prior research study suggested that supply chain practices examine the mediating effects of organizational productivity, lean manufacturing, and firm performance. Thus, a need for a better understanding of the mediating effects of the supply chain practices with lean manufacturing and the productivity of the company performance, including the factors of lean manufacturing, the aspects of supply chain practices, and the characteristics of organizational productivity (Hadrawi, 2019)

The research examines and explores the effects of mediating supply chain operations with lean manufacturing and organizational productivity, increasing profitability, reducing wastages, and minimizing operational costs, thus increasing productivity and creating competitive advantages in the manufacturing industries (Heizer & Render, 2011). The current research study was based on the quantitative method and explored the concept of lean manufacturing and the mediating effects of supply chain management practices, with the research hypotheses developed and associated with the approach of the deductive methods (Thanki & Thakkar, 2014).

The approach of lean manufacturing has significant importance in the implantations to enhance the firm’s performance in terms of profitability, in term of sales, and also satisfaction, with the mediating factors of the supply chain operations, how to increase productivity in the manufacturing process, with incorporate the important factors regarding the meditating effects of the supply chain management functionality, with the methods of the lean manufacturing, to minimize the wastage, increase productivity, also different factors should examine the manufacturing flexibility, the product quality, to reduce the lead time, the inventory management

with relate to minimizing level, reducing the cost of the manufacturing process, inventory management, distribution cost, all these factors are essential in the manufacturing all over the world. All industries followed these factors to increase productivity (Kumar, 2023). Thus, the current research study examined the supply chain operations as the mediating effects of the lean manufacturing approach and the firm profitability in the manufacturing industry (Papadopoulou & Özbayrak, 2005).

The research study was based on the functionality of supply chain management as the mediating effect, with the approach of lean manufacturing to explain the problem statement discussed in the above sections. The main objective of the current research study is to determine how the better mediating effects of supply chain management practices with lean manufacturing are associated with organizational productivity. Thus, some research questions are as follows: What are the mediating effects of supply chain practices on organizational productivity? What is the impact of lean manufacturing on the supply chain practices? What is the association the lean manufacturing and supply chain functions? What are the associations between supply chain practices and organizational performance?

The research study examined the relationships between the exogenous variables and the endogenous variable, firm performance, with the mediating effects of supply chain practices to increase firm productivity. The current research study was based on the significance of knowledge and the theories of how supply chain practices mediate the effects between independent variables of lean manufacturing methods and the dependent variable, firm performance. Thus, the current research study gave significant evidence of the importance of lean manufacturing and the mediating effects of supply chain practices on firm productivity. The prior research studies suggested that most of the research studies examined the relationship between the independent variable of lean manufacturing and the dependent variable of firm productivity. However, the current research study investigated the mediating effects of the supply chain practices between lean manufacturing and firm productivity, and the relationship between lean manufacturing and firm productivity.

2. Literature review

2.1 The concept of lean manufacturing

The prior research study suggested that lean manufacturing is globally accepted as more expansion becomes more consistent, and lean manufacturing aims to minimize wastage and maximize productivity, enhancing organizational productivity (Ochieng, 2021). The different lean manufacturing concepts and definitions are as follows. The idea of lean manufacturing is a philosophy is consists of methods, approaches, techniques, and the associated with better organizational operations, productivity, improvements, and performance, and is integrated with the management system and related to the process of production and the system of the output (Wahab, 2022).

The method of lean manufacturing is the philosophy of the manufacturing system, which focuses on the functionality of the production system, such as the functionality factors such as the correct quantity, right items, the right quality, the right place, the right time in term of the production process, and better and maximize productivity, good quality products, reduced costs, and maximalize profits, increase productivity (Smirnov & Sorokin, 2022). The lean manufacturing approach, or the philosophy, is based on removing or eliminating non-value-added production and operational activities (Hadrawi, 2019).

The concept of lean manufacturing provides significant benefits in terms of increased productivity, firm performance, removing non-value-added activities, minimizing wastage and maximizing the organizational performance, lead time improvement, better quality of production, producing correct quantity, right place, right time, through the concept of the lean manufacturing in the production system (Tarigan et al., 2018). As explained, the scope of lean manufacturing is widely used in lean manufacturing to improve firm performance and the business's performance. Thus, the prior research study based on empirical evidence shows that companies in the manufacturing sector have firmly eliminated waste, reduced lead time, and improved inventories, increasing productivity efficiency and better quality through lean manufacturing methods (Hassan & Pasha, 2023).

2.2 The importance of lean manufacturing

The prior research study suggested that, in operations management and production management, words such as the just-in-time approach, TPS, the abbreviation of Toyota production system, and the lean manufacturing approach (Cheng & Podolsky, 1993). Thus, there are few differences in the meaning and approach of the lean manufacturing, just-in-time Toyota production system (Takeuchi & Kimura, 2022). Lean manufacturing is related to the system of manufacturing, which is developed by Toyota, which is referred to as the Toyota Production System, TPS; thus, lean manufacturing is based on the TPS, which is referred to or based on just-in-time, JIT (Kibisu & Machoka, 2021).

2.3 Lean manufacturing and organizational productivity

The research study explained that lean manufacturing significantly and positively impacts organizational productivity and eliminates waste in the production system (Daonil & Zagloel, 2021). In the production system, lean manufacturing practices collectively impact the performance of organizational productivity. Thus, the complete includes or adaptations of lean manufacturing to increase productivity, better quality of the products produced, right quality, right quality, reduction of costs, minimize waste, and improve firm performance (Saini & Singh, 2022).

2.4 Lean manufacturing practices

The prior research study suggested that lean manufacturing practice has more significant benefits to implementations in the process, practices, and performance, and combining these activities increases firms' productivity (Ahmed et al., 2024a). Therefore, the practices, approach, and methods of manufacturing regarding the implementation to improve firm productivity firm performance because the concept of lean manufacturing reduces or eliminates the activities that do not produce value, products, or services (Singh & Saini, 2020)

2.5 Lean manufacturing and firm performance

The process of the significance of lean manufacturing practices is associated with a set of objectives and goals, such as the firm's performance. The firm's performance is integrated to achieve the set of objectives, and the firm's performance is based on the process, which is predetermined by the firm's goals. The firm's financial performance is incorporated with the factors of profit, and the critical factors of return on investment, price variance, return on sales, and per-employee sales are associated with the firm's performance. The indicators of the firm's performance, such as non-financial indicators, such as quality, flexibility, lead time, and customer satisfaction, impact the firm's performance (Hassan & Pasha, 2023). Most of the research studies are conducted by academicians and practitioners to examine the impact of the lean manufacturing approach on firm performance and lean manufacturing implementations of the practices of the lean manufacturing process in the manufacturing process to increase firm performance (Wainaina & Odari, 2023). The firm measures performance through indicators such as quality measures, flexibility of manufacturing, lead time reduction, minimization of inventory cost, increased productivity, reduced cost of operations, and the firm's performance related to the firm's sales, firm profitability, and customer satisfaction (Ali, 2023). Thus, the approach of lean manufacturing provides significant benefits in terms of increased productivity and firm performance, removal the non-value-added activities, minimizing wastage and maximizing organizational performance, lead time, better quality production, producing correct quantity, right place, right time, through the concept of the lean manufacturing in the production system (Tarigan et al., 2018)

The current research study was based on the significance of knowledge and the theories on how supply chain practices mediate the effects between the independent variables of lean manufacturing and the dependent firm performance. Thus, the current research study gave significant evidence of the importance of lean manufacturing and the mediating effects of the firm's productivity on supply chain practices. The prior research studies suggested that most studies examine the relationship between the independent variable of lean manufacturing and the dependent variable of firm productivity (Belekoukias et al., 2014). However, the current research study investigated the mediating effects of the supply chain practices between lean manufacturing and firm productivity and the relationship between lean manufacturing and firm productivity.

2.6 Resource-based View Theory

The prior studies suggested that the research is more significant if it incorporates a research model with the theory. Through the theory, the researcher may provide better explanations regarding the research model and the research study concept, develop logical reasoning with the research model concept and the conceptual research model, and create a relationship between the constructs (Zikmund et al., 2010).

2.7 Development of Research Hypotheses

Direct relationship is tested for the following hypotheses:

- H1(a): Quick setups have a positive impact on lead time reduction
- H1(b): Quick setups have a positive impact on inventory minimization
- H1(c): Quick setups have a positive impact on productivity
- H1(d): Quick setups have a positive impact on cost reduction
- H2(a): A Uniform production level has a positive impact on lead time reduction
- H2(b): A Uniform production level has a positive impact on inventory minimization
- H2(c): Uniform production level has a positive impact on productivity
- H2(d): Uniform production level has a positive impact on cost reduction
- H3(a): Quality control level has a positive impact on lead time reduction
- H3(b): Quality control level has a positive impact on inventory minimization
- H3(c): Quality control level has a positive impact on productivity
- H3(d): Quality control level has a positive impact on cost reduction
- H4(a): Supplier networks have a positive impact on lead time reduction
- H4(b): Supplier networks have a positive impact on inventory minimization
- H4(c): Supplier networks have a positive impact on productivity
- H4(d): Supplier networks have a positive impact on cost reduction
- H5(a): Lead time has a positive impact on firm performance
- H5(b): Inventory maximization has a positive effect on firm performance
- H5(c): Productivity has a positive impact on firm performance
- H5(d): Cost reduction has a positive effect on firm performance

Mediation relationship are tested for the following hypotheses:

- H6(a): Lead time reduction mediates the relationship between the quick setups and the firm's performance
- H6(b): Lead time reduction mediates the relationship between the uniform production level and the firm's performance
- H6(c): Lead time reduction mediates the relationship between quality control and the firm's performance

- H6(d): Lead time reduction mediates the relationship between the supplier networks and the firm's performance
- H7(a): Inventory minimization mediates the relationship between the quick setups and the firm's performance
- H7(b): Inventory minimization mediates the relationship between the uniform production level and the firm's performance
- H7(c): Inventory minimization mediates the relationship between quality control and firm performance
- H7(d): Inventory minimization mediates the relationship between the supplier networks and the firm performance
- H8(a): Productivity mediates the relationship between the quick setups and the firm's performance
- H8(b): Productivity mediates the relationship between the uniform production level and the firm's performance
- H8(c): Productivity mediates the relationship between quality control and firm performance
- H8(d): Productivity mediates the relationship between the supplier networks and the firm performance
- H9(a): Cost reduction mediates the relationship between the quick setups and the firm's performance
- H9(b): Cost reduction mediates the relationship between the uniform production level and the firm's performance
- H9(c): Cost reduction mediates the relationship between quality control and firm performance
- H9(d): Cost reduction mediates the relationship between the supplier networks and the firm performance

3. Methods

3.1 Research Design

The research philosophy framework and the basic research approach are significantly associated with the research methodology (Creswell & Plano Clark, 2011). The research study procedure is related to the justification of the research philosophy. The current chapter integrates the rationale for the philosophical and research conclusion and the recommendation based on the research process. Thus, in globalization, the shared belief system associated with the knowledge based on collecting and interpreting data analyzes the research data as empirical evidence.

The data was collected through the approach of the cross-sectional design because the technique of the cross-sectional research design is based on the data collection at the same time from different objects; thus, the current research study collects the data from other firms, organizations, and also several different factors at the same time, which are varies from organizations to organizations, and individuals to individuals (Colding-Jørgensen et al., 2023). The design of the cross-sectional

study will be conducted when data is collected at once, and all data is represented by the respondent in the form of a snapshot at one time of once. Through the quantitative research technique approach, the current research study is based on developing the measurement scales and, thus, the research pre-test instrument to validate the research instruments.

3.2 Measurement instrument

The research study explored the concept of lean manufacturing, and the data collected was enhanced with the help of the adapted questionnaire based on the research objectives. The research study measurement scales were based on five-point Likert scales, which enhanced the measurement of the concept of supply chain operations and the lean manufacturing approach. The questionnaire items should be validated after the research measurement scales are developed based on the past study. The validation method is paramount for refining the developed questionnaire. The questionnaire's construct content is inappropriate, and the research study shows no significant results.

3.3 The Sampling strategy and data collection

The sample is a subset of the population; thus, the sample is a small part of the population, representing the population. Therefore, based on the research questions, the organization as the unit of analysis is considered in the study. Thus, the organization's responsibility and the respondent’s knowledge of lean manufacturing, the supply chain management operations, the firm performance, and the factor analysis of the study's unit were investigated. Data were collected through the questionnaire survey methodology to examine the views of the postpositivist, the reality objectively, and the research objectives.

3.4 Data analysis techniques

In the current research study, the quantitative approach, the Structural Equation Modeling technique, was used to analyze, and the second-generation technique, the Structural Equation Modeling, was also used to examine more than two variables and the associations of the different variables. Thus, the first-generation technique is known as regression modeling. The technique has two crucial factors of the SEM: the measurement model and the structural model.

4. Results

4.1 Reliability and Validity

In the study, the data analysis was conducted through factor loading to assess the results of the convergent validity of the items and the average variance extracted. It included the composite reliability to evaluate the results and verify the data validity.

The convergent validity is based on the measurement model and examines the variances, including the AVE and the composite reliability. Table 1 shows that the average variance extracted is more than 0.5, to validate the results. Therefore, the composite reliability values greater than 0.7, the confirmatory level, and the values more significant than 0.8 will be considered reasonable.

Table 1

Reliability and Validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
CR	0.903	0.907	0.929	0.723
FP	0.899	0.900	0.925	0.712
IM	0.867	0.878	0.898	0.560
LT	0.898	0.902	0.922	0.664
PD	0.901	0.910	0.923	0.634
QC	0.924	0.926	0.939	0.688
QS	0.879	0.897	0.905	0.577
SN	0.886	0.895	0.912	0.599
UPL	0.871	0.882	0.899	0.561

Source: designed by the authors.

4.2 Fornell-Larcker criterion

The Fornell-Larcker criterion is one of the most popular techniques to check the measurement models' discriminant validity. According to this criterion, the square root of the average variance extracted by a construct must be greater than the correlation between the construct and any other construct. Table 2 shows the composite reliability (CR), the square root of the average variance extracted (AVE) (in bold), and correlations between constructs (off-diagonal).

Table 2

Fornell-Larcker criterion

Constructs	CR	FP	IM	LT	PD	QC	QS	SN	UPL
CR	0.850								
FP	0.798	0.844							
IM	0.633	0.783	0.749						
LT	0.703	0.768	0.620	0.815					
PD	0.741	0.688	0.520	0.773	0.797				
QC	0.783	0.672	0.642	0.756	0.601	0.830			
QS	0.690	0.718	0.677	0.626	0.714	0.740	0.760		
SN	0.711	0.649	0.666	0.759	0.674	0.635	0.699	0.774	
UPL	0.602	0.704	0.659	0.776	0.737	0.741	0.720	0.642	0.749

Source: designed by the authors.

4.3 HTMT Matrix

To investigate the validity of the discriminant of the constructs in the study, the pairs of variables should be highly correlated, and the values should be less than 1.0 (Rashid, 2016). Thus, through the test of the Heterotrait-Monotrait, suggested by Henseler et al. (2014). Table 3 explains that bootstrapping is applied to check the discriminant validity through the HTMT values, with a threshold value below 0.85, as suggested in the study of Franke and Sarstedt (2019) and Ahmed et al. (2024b).

Table 3

Heterotrait-Monotrait ratio (HTMT) – Matrix

	CR	FP	IM	LT	PD	QC	QS	SN	UPL
CR	1.000								
FP	0.815	1.000							
IM	0.845	0.827	1.000						
LT	0.822	0.780	0.846	1.000					
PD	0.832	0.769	0.832	0.835	1.000				
QC	0.797	0.843	0.734	0.734	0.780	1.000			
QS	0.741	0.795	0.837	0.892	0.818	0.785	1.000		
SN	0.780	0.734	0.785	0.812	0.836	0.812	0.821	1.000	
UPL	0.761	0.819	0.836	0.845	0.847	0.795	0.837	0.813	1.000

Source: designed by the authors.

4.4 R-Square values

The results of the R-Square Table 4 show that the dependent variable cost reduction = 0.973, which means that the variation in the dependent variable changes by 97% due to the independent variable in the model. The results indicate that the dependent variable, firm profitability, in a variation of 0.989, which is explained by 98.9% due to the independent variables, such as quick setups, uniform production level, quality control, and supplier networks. Thus, these independent variables have a significance important for the firm productivity and as well as firm profitability.

Further, results suggested that the dependent variable inventory minimization varied by 96.1% because of the independent variables. Moreover, the change in the dependent variable, lead time reduction, was 95.3% due to the quick setups, uniform production level, quality control, and supplier networks. The change in productivity was 96.1% due to these independent variables.

Table 4

R-Square statistics

Constructs	R-square	R-square adjusted
Cost Reduction	0.973	0.973
Firm Profitability	0.989	0.989
Inventory Minimization	0.961	0.960
Lead time reduction	0.953	0.953
Productivity	0.961	0.961

Source: designed by the authors.

4.5 Path Coefficient Analysis

The results of Table 5 demonstrate that the probability = 0.000, which is less than 0.05; thus, the hypothesis that quick setups positively impact lead time reduction is supported, and concluded that quick setups are an essential factor for lead time reduction. The hypothesis that quick setups positively impact inventory minimization is also supported; quick setups positively impact inventory minimization. Supplier networks are positively associated with productivity, cost reduction, lead time, and a positive impact on firm performance; inventory minimization is positively related to firm performance. Productivity has a positive effect on firm performance.

4.6 Mediating Analysis

Table 6 shows the mediating relationship, and it demonstrates that the lead time reduction mediates the relationship between the quick setups and the firm performance, and lead time reduction mediates the association with the uniform production level and the firm performance, the lead time reduction mediates the relationship of the quality control and the firm performance, and also supplier networks with firm performance, the inventory minimization mediates the relationship of the factor of quick setups and the firm performance. Also, the mediates the relationship between the uniform production level with firm performance, supplier networks, and firm performance.

Table 5

Path Coefficient Analysis (Direct relationship)

Hypotheses	Relationship	P-Value	Decisions
H1(a): Quick setups have a positive impact on lead time reduction	QC -> IM	0.000	Support
H1(b): Quick setups have a positive impact on inventory minimization	QC -> IM	0.000	Support
H1(c): Quick setups have a positive impact on productivity	QC -> PD	0.000	Support
H1(d): Quick setups have a positive impact on cost reduction	QC -> CR	0.000	Support
H2(a): A Uniform production level has a positive impact on lead time reduction	UPL -> LT	0.001	Support
H2(b): A Uniform production level has a positive impact on inventory minimization	UPL -> IM	0.003	Support
H2(c): Uniform production level has a positive impact on productivity	UPL -> PD	0.000	Support
H2(d): Uniform production level has a positive impact on cost reduction	UPL -> CR	0.039	Support
H3(a): Quality control level has a positive impact on lead time reduction	QC -> LT	0.000	Support
H3(b): Quality control level has a positive impact on inventory minimization	QC -> IM	0.000	Support
H3(c): Quality control level has a positive impact on productivity	QC -> PD	0.000	Support
H3(d): Quality control level has a positive impact on cost reduction	QC -> CR	0.000	Support
H4(a): Supplier networks have a positive impact on lead time reduction	SN -> LT	0.063	Not Support
H4(b): Supplier networks have a positive impact on inventory minimization	SN -> IM	0.113	Not Support
H4(c): Supplier networks have a positive impact on productivity	SN -> PD	0.000	Support
H4(d): Supplier networks have a positive impact on cost reduction	SN -> CR	0.000	Support
H5(a): Lead time has a positive impact on firm performance	LT -> FP	0.000	Support
H5(b): Inventory maximization has a positive impact on firm performance	IM -> FP	0.011	Support
H5(c): Productivity has a positive impact on firm performance	PD -> FP	0.000	Support
H5(d): Cost reduction has a positive impact on firm performance	CR -> FP	0.000	Support

Source: designed by the authors.

Table 6

Mediating relationship

Hypotheses	Relationship	P-value	Decisions
H6(a): Lead time reduction mediates the relationship between the quick setups and the firm's performance	QS -> LT -> FP	0.002	Support
H6(b): Lead time reduction mediates the relationship between the uniform production level and the firm's performance	UPL -> LT -> FP	0.000	Support
H6(c): Lead time reduction mediates the relationship between the quality control and the firm's performance	QC -> LT -> FP	0.000	Support
H6(d): Lead time reduction mediates the relationship between the supplier networks and the firm's performance	SN -> LT -> FP	0.086	Not Support
H7(a): Inventory minimization mediates the relationship between the quick setups and the firm performance	QC -> IM -> FP	0.017	Support
H7(b): Inventory minimization mediates the relationship between the uniform production level and the firm's performance	UPL -> IM -> FP	0.066	Not Support
H7(c): Inventory minimization mediates the relationship between the quality control and the firm performance	QC -> PD -> FP	0.000	Support
H7(d): Inventory minimization mediates the relationship between the supplier networks and the firm performance	SN -> IM -> FP	0.180	Not Support
H8(a): Productivity mediates the relationship between the quick setups and the firm performance	QC -> PD -> FP	0.000	Support
H8(b): Productivity mediates the relationship between the uniform production level and the firm performance	UPL -> PD -> FP	0.000	Support
H8(c): Productivity mediates the relationship between the quality control and the firm performance	QC -> PD -> FP	0.000	Support
H8(d): Productivity mediates the relationship between the supplier networks and the firm performance	SN -> PD -> FP	0.000	Support
H9(a): Cost reduction mediates the relationship between the quick setups and the firm performance	QS -> CR -> FP	0.000	Support
H9(b): Cost reduction mediates the relationship between the uniform production level and the firm's performance	UPL -> CR -> FP	0.043	Support
H9(c): Cost reduction mediates the relationship between the quality control and the firm performance	QC -> CR -> FP	0.000	Support
H9(d): Cost reduction mediates the relationship between the supplier networks and the firm performance	SN -> CR -> FP	0.000	Support

Source: designed by the authors.

The results indicate that productivity mediates the relationships of quick setups, uniform production levels, supplier networks, and firm performance. The results suggest that cost reduction mediates the associations of the factors of quick setups,

uniform production level, quality control, and supplier networks with the firm performance. However, the Inventory minimization mediates the relationship between the supplier networks and the firm performance not supported. The Lead time reduction mediates the relationship between the supplier networks, and the firm performance does not mediate.

5. Conclusions

Through the results, Quick setups are favorable time, supported, and it concluded that the impact of the quick setup leads to time. The hypothesis that quick setups positively impact inventory minimization is also supported; quick setups positively impact inventory minimization. Supplier networks are positively associated with productivity, cost reduction, lead time, and a positive impact on firm performance; inventory minimization is positively related to firm performance. Productivity has a positive effect on firm performance. The lead time reduction mediates the relationship between quick setups and the firm performance, and lead time reduction mediates the association between the uniform production level and the firm performance; the lead time reduction mediates the relationship between quality control and the firm performance and also supplier networks with firm performance, the inventory minimization mediates the relationship of the factor of quick setups and the firm performance. Also, the mediates the relationship between the uniform production level with firm performance, supplier networks, and firm performance. The results indicate that productivity mediates the relationships of quick setups, uniform production levels, supplier networks, and firm performance. The results suggest that cost reduction mediates the associations of the factors of quick setups, uniform production level, quality control, and supplier networks with the firm performance. However, the Inventory minimization mediates the relationship between the supplier networks and the firm performance not supported. The Lead time reduction mediates the relationship between the supplier networks, and the firm performance does not mediate.

The quantitative results were incorporated to develop manufacturing strategies and are valuable for academicians and experts. Thus, the current research study contributes knowledge regarding the supply chain operational performance and lean manufacturing methodology to the firm's performance. The current research study has some limitations regarding the research study, regarding time frame and budget constraints. Further research studies more factors of the supply chain management operational performance and the lean manufacturing approaches (Chavez et al., 2013). The current research study includes the mediating factors of operational performance; thus, the moderating variables may be incorporated into the research model to better understand firm performance.

Acknowledgements

The authors would like to thank all colleagues and experts who provided valuable insights and feedback during the preparation of this study.

References

Ahmed, R. R., Streilkowski, W., Štreimikienė, D., Salman, F., Asim, J., & Streimikis, J. (2024a). "Enhancing Environmental Sustainability in Asian Textile Supply Chains: Insights from Agile Practices and Mediating Variables. Journal of Business Economics and Management, 25(5), 872–891. https://doi.org/10.3846/jbem.2024.21789

Ahmed, R. R., Štreimikienė, D., Streimikis, J., & Siksnelyte-Butkiene, I. (2024b). A Comparative Analysis of Multivariate Approaches for Data Analysis in Management Sciences. E a M: Ekonomie a Management, 27(1), 192–210. https://doi.org/10.15240/tul/001/2024-5-001

Ali, M. A. (2023). The influence of lean manufacturing on firm performance through mediation of supply chain practices. South Asian Journal of Operations and Logistics, 3(1), 39–53. https://doi.org/10.57044/sajol.2024.3.1.2424

Belekoukias, I., Garza-Reyes, J. A., & Kumar, V. (2014). The impact of lean methods and tools on the operational performance of manufacturing organisations. International Journal of Production Research, 1-21. doi: 10.1080/00207543.2014.903348

Chavez, R., Gimenez, C., Fynes, B., Wiengarten, F., & Yu, W. (2013). Internal lean practices and operational performance: The contingency perspective of industry clockspeed. International Journal of Operations & Production Management, 33(5), 562-588.

Cheng, T. C. E., & Podolsky, S. (1993). Just-in-time manufacturing: An introduction to clockspeed. International Journal of Operations & Production Management. London: Springer Science & Business Media.

Colding-Jørgensen, J. T., Muheki, E., Baayenda, G., & Harding-Esch, E. (2023). Assessing Water, Sanitation and Hygiene Access and Use in Nabilatuk District, Uganda: A Cross-Sectional Study of Different Data Collection Methods. Hygiene, 3(2), 65–84. https://doi.org/10.3390/hygiene3020008

Creswell, J. W., & Plano Clark, V. L. (2011). Designing and conducting mixed methods. 2nd Edition, Los Angeles: Sage Publications.

Daonil, & Zagloel, Y. M. (2021). The Lean Manufacturing Implementation to Eliminate Waste in Machining Cast Wheel Line Production by Using WAM dan VALSAT Method. Journal of Industrial and Engineering System, 2(1), 56–62. https://doi.org/10.31599/jies.v2i1.488

Dijk, M., & Szirmai, A. (2006). Technical efficiency and embodied technical change in the Indonesian pulp and paper industry. Journal of International Development, 18, 163–178. doi: DOI: 10.1002/jid.1189

Franke, G.R. and Sarstedt, M. (2019). Heuristics versus statistics in discriminant validity testing: a comparison of four procedures. Internet Research, 29(3). http://dx.doi.org/10.1108/IntR-12-2017-0515

Hadrawi, H. K. (2019). The impact of firm supply performance and lean processes on the relationship between supply chain management practices and competitive performance. Uncertain Supply Chain Management, 7(2), 341–350. https://doi.org/10.5267/j.uscm.2018.7.003

Hassan, B., & Pasha, U. (2023). Impact of Lean Manufacturing Practices on Sustainable Firm Performance: An Empirical Study Moderated by Lean Culture. International Journal of Business and Economic Affairs, 8(3). https://doi.org/10.24088/ijbea-2023-83002

Heizer, J., & Render, B. (2011). Operations management (10th ed.). Boston: Pearson Publications.

Jin, M., Zhao, S., & Kumbhakar, S. C. (2019). Financial constraints and firm productivity: Evidence from Chinese manufacturing. European Journal of Operational Research, 275(3), 1139–1156. https://doi.org/10.1016/j.ejor.2018.12.010

Kibisu, P., & Machoka, P. (2021). Just in Time Inventory Management Technique and Supply Chain Performance in Processing Firms in Kenya: A Case of Crown Paints Limited. International Journal of Management and Leadership Studies, 80–97. https://doi.org/10.52281/jv3i109

Kumar K. U. (2023). Factors disrupting supply chain management in manufacturing industries. Journal of Supply Chain Management Science, 4(1–2), 1–24. https://doi.org/10.18757/jscms.2023.6986 methods (8th ed.). Canada: Nelson Education Ltd.

Ochieng, B. (2021). Lean Manufacturing Practices and Supply Chain Performance of Sugar Manufacturing Firms in Western Kenya. American Journal of Supply Chain Management, 6(1), 27–43. https://doi.org/10.47672/ajscm.719

Papadopoulou, T. C., & Özbayrak, M. (2005). Leanness: experiences from the journey. Journal of Manufacturing Technology Management, 36(7), 84-807.

Park, J.-G., & Lee, H.-O. (2023). Japanese Mobility Industry Trends and Toyota Motor Corporation Strategy. The Korean-Japanese Economic and Management Association, 101, 19–37. https://doi.org/10.46396/kjem..101.2c

Psomas, E., & Deliou, C. (2023). Lean manufacturing practices and industry 4.0 technologies in food manufacturing companies: the Greek case. International Journal of Lean Six Sigma, 15(4), 763-784. https://doi.org/10.1108/ijlss-06-2023-0098

Qrunfleh, S., & Tarafdar, M. (2013). Lean and agile supply chain strategies and supply chain responsiveness: the role of strategic supplier partnership and postponement. Supply Chain Management: An International Journal, 18(6), 571–582. https://doi.org/10.1108/scm-01-2013-0015

Rashid, A. (2016). Impact of inventory management in downstream chains on customer satisfaction at manufacturing firms. International Journal of Management, IT and Engineering, 6(6), 1–19.

Saini, S., & Singh, D. (2022). Lean manufacturing practices for enhancing firm performance in medium enterprises: a case study from Indian context. International Journal of Productivity and Quality Management, 35(3), 352. https://doi.org/10.1504/ijpqm.2022.122298

Sartal, A., Llach, J., & León-Mateos, F. (2022). "Do technologies really affect that much? exploring the potential of several industry 4.0 technologies in today's lean manufacturing shop floors." Operational Research, 22(5), 6075–6106. https://doi.org/10.1007/s12351-022-00732-y

Singh, D., & Saini, S. (2020). Lean manufacturing practices for enhancing Firm performance in medium enterprises: A case study from Indian context. International Journal of Productivity and Quality Management, 1(1), 1. https://doi.org/10.1504/ijpqm.2020.10036454

Smirnov, S. A., & Sorokin, G. S. (2022). Implementation of Lean Manufacturing Methods in Russian Companies. EURASIAN INTEGRATION: Economics, Law, Politics, 4, 55–67. https://doi.org/10.22394/2073-2929-2022-04-55-67

Sundar, R., Balaji, A. N., & Kumar, R. M. S. (2019). Analyzing the performance of lean manufacturing implementation with chronological execution of lean elements using spreadsheet features: a case study. International Journal of Productivity and Quality Management, 27(1), 66. https://doi.org/10.1504/ijpqm.2019.099626

Takeuchi, N., & Kimura, T. (2022). The Institute for the Study of the Toyota Production System: Jishuken. The Toyota Production System Journey. New York: Taylor & Francis Group. https://doi.org/10.4324/9781003323310-37

Tarigan, U., Ishak, A., Sukirman, V., & Tarigan, U. P. P. (2018). Lean Manufacturing Concept: Minimizing Non-Value-Added Activities in Wood Manufacturing Process. In Proceedings of the International Conference of Science, Technology, Engineering, Environmental and Ramification Researches, Volume 1, pp. 208-212. https://doi.org/10.5220/0010076602080212

Thanki, S. J., & Thakkar, J. (2014). Status of lean manufacturing practices in Indian to date. General review, 16(7), 784-807. doi: 10.1108/17410380510626196

Wahab, A. (2022). Lean Manufacturing and Sustainable Performance with a Moderation of Organizational Culture. South Asian Journal of Operations and Logistics, 1(2), 30–52. https://doi.org/10.57044/sajol.2022.1.2.2209

Wainaina, M., & Odari, S. (2023). Lean Supply Chain Practices and the Performance of Kassmatt Supermarkets Limited. International Journal of Supply Chain Management, 8(1), 89–112. https://doi.org/10.47604/ijscm.2019

Wang, Z. (2021). Exploring the Potential of Lean Philosophy to Spread the Value of Sustainability in the Japanese Automobile Industry: The Case of Toyota Motor Corporation. Management of Development of Complex Systems, 45, 176–181. https://doi.org/10.32347/2412-9933.2021.45.176-181

Zikmund, W. G., Babin, B. J., Carr, J. C., & Griffin, M. (2010). Business Research Methods. Mason: Cengage Learning.