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Integrating Lean Management, Sustainability, Circular Capabilities, and Waste Minimization to Optimise Operational Performance in Manufacturing

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Abstract: *The purpose of this study is to investigate the impact of lean production, sustainability, circular capabilities, and waste management on enhancing operational performance. Additionally, the research aims to examine the moderating influence of organisational dynamics. The present study was conducted within the framework of the manufacturing sector in Saudi Arabia. The research study has employed a quantitative research methodology. The data was gathered through the utilisation of a survey questionnaire. The study's target population consists of individuals who possess expertise in manufacturing organisations located in Saudi Arabia. The study has employed a statistical data analysis approach through the utilisation of Smart-PLS. The results of the study indicate that circular capabilities and lean production practises have a significant effect on operational performance. However, the influence of sustainability in manufacturing and waste minimization on operational performance is found to be insignificant. The results from the moderation analysis suggest that the relationship between circular capabilities and operational performance is significantly influenced by organisational dynamism. These findings can be employed by organisations to attain sustainable operational performance. Additionally, it is suggested that manufacturing firms should explore strategies for incorporating lean production practices, sustainability initiatives, circular capabilities, and waste minimization techniques to enhance the efficiency of their operations and optimise resource utilisation. Nevertheless, it is important to note that the study employed a limited sample size, and as a result, the findings may only be applicable to a specific industry. Therefore, it is advisable for future researchers to utilise a larger sample size in order to enhance the generalizability of the findings.*

Keywords: *Lean production, Sustainability, Circular capabilities, Waste management, Operational performance.*

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Introduction

Organisations are currently encountering intensified competition and dynamic industry-specific demands, which have necessitated strategic transformations in their pursuit of achieving exceptional performance (Saeed, Tasmin, Mehmood, & Hafeez, 2020). The dynamic and uncertain fluctuations in the environment have a substantial impact on an organization's functioning and outcomes. In order to maintain a competitive edge, it is imperative for the organisation to cultivate the capacity to efficiently address and adjust to the uncertainties presented by the evolving environmental circumstances (Ibrahim et al., 2021). Organisations that are driven to preserve their competitive advantage recognise the utmost importance of striving for operational excellence (Jengwa & Pellissier, 2022). Operational performance, acknowledged as a fundamental catalyst for overall organisational achievement, encompasses various elements such as efficiency, cost-effectiveness, and the critical aspect of environmental sustainability. The adoption of lean manufacturing and Industry 4.0 technologies by Saudi Arabian industries has been instrumental in fostering sustainable growth and augmenting their accomplishments in sustainability (Ghaithan, Khan, Mohammed, & Hadidi, 2021). In light of this complex situation, organisations are progressively directing their attention towards key factors that have the potential to significantly impact their operational performance.

The manufacturing sector in Saudi Arabia faces a notable obstacle in the pursuit of enhancing operational efficiency while simultaneously addressing sustainability concerns (Al-Alqam, Rehman, & Alsultan, 2022). The inefficient utilisation of resources, significant generation of waste, and adverse environmental consequences pose challenges to the achievement of Sustainable Development Goals (SDGs) such as SDG 9 (about industry, innovation, and infrastructure) and SDG 12 (concerning responsible consumption and production). The lack of an all-encompassing framework that integrates lean production, sustainability, circular capabilities, and waste reduction hinders advancements in harmonising manufacturing processes with the Sustainable Development Goals (SDGs). The primary objective of this study is to address the existing disparity by investigating the incorporation of these components. The intention is to propose remedies that can enhance operational efficiency, reduce inefficiencies, and encourage the adoption of sustainable manufacturing methods. These efforts will contribute towards the achievement of pertinent Sustainable Development Goals (SDGs).

It is projected that the manufacturing market will witness a yearly increase of 2.78% in terms of value addition from 2023 to 2028 (Statista, 2023). The implementation of strategies such as lean production, sustainable practices, circular capabilities, and waste minimization contributes to increased efficiency, reduced waste generation, and the promotion of environmentally friendly endeavours. This particular process enhances productivity, thereby making a significant contribution to the overall growth of the industry as a whole. According to Palange and Dhatrak (2021), lean production is a systematic methodology aimed at reducing inefficiencies, improving operational efficiency, and maximising the utilisation of resources. The increasing prevalence of lean production methodologies can be attributed to their capacity to enhance operational efficiency, reduce expenses, and improve product quality.

According to the findings of Buer, Semini, Strandhagen, and Sgarbossa (2021), there is empirical support for the proposition that lean manufacturing practices contribute to the improvement of operational performance. However, it is crucial to undertake a thorough investigation into the holistic impact of integrating lean production practices on operational performance. Moreover, there has been an observed increase in the importance of sustainability for organisations on the global stage (Wahab, Ismail, & Muhayiddin, 2019). A comprehensive comprehension and consciousness of environmental concerns directly contribute to the enhancement of a company's environmental performance. The identification and engagement of environmentally responsible suppliers, as well as the implementation of collaborative environmental initiatives, serve as beneficial mediators in the relationship between environmental consciousness and enhanced environmental performance (Shin & Cho, 2023).

Waste minimization has emerged as a crucial factor that is gaining greater importance within organisations. The practise of waste reduction not only facilitates cost-saving initiatives but also aligns harmoniously with sustainable principles (David, John, & Hussain, 2020). The examination of the intriguing correlation between waste minimization initiatives and their subsequent influence on operational performance can reveal crucial findings regarding the efficacy of these endeavours. Furthermore, the implementation of circular capabilities, which involve the utilisation of strategies focused on achieving closed-loop product lifecycles through the reuse, recycling, or repurposing of materials, has received considerable recognition as a sustainable business approach (Mishra, Jain, & Malhotra, 2021).

The concept of organisational dynamism plays a crucial role as a moderator within the complex interplay of lean production, sustainability, waste minimization, circular capabilities, and operational performance. It has the potential to significantly impact and shape the intricate relationships among these factors, either by enhancing or limiting their effects. Organisations that exhibit elevated levels of dynamism are widely recognised for their ability to adapt, innovate, and effectively respond to dynamic changes in their surrounding environments (Muneeb et al., 2023). A comprehensive analytical understanding of the intricate interplay and impact of organisational dynamism on the complex dynamics among these variables is crucial. Given the intricate and interconnected relationship between these variables, this research endeavour aims to undertake a thorough investigation into the combined impact of lean production, sustainability, waste minimization, and circular capabilities on the operational performance of Saudi Arabia.

The role of organisational dynamism as a moderator is expected to be significant in this investigation, as it can provide valuable insights into the ways in which it either enhances or obliges these complex relationships. This comprehensive research endeavour aims to offer valuable insights that can assist Saudi organisations in formulating strategies and implementing practises to enhance their operational performance in a dynamic and sustainable business environment. The study additionally examines the interconnectedness and potential benefits and drawbacks associated with integrating lean production, sustainability, circular capabilities, and waste minimization. Also, this study examines practical integration strategies that manufacturing organisations can employ to improve their operational efficiency using these techniques. The primary objective of this study is to examine the interconnectedness of lean production, sustainability, circular capabilities, and waste management in order to enhance operational performance within the manufacturing sector of Saudi Arabia.

The research is organised into five primary sections. The literature review conducted in Section 2 serves to establish the theoretical underpinnings of the study and identify areas where further research is needed. Section 3 provides a comprehensive overview of the research methodology employed in this study, encompassing the strategies and procedures utilised for data collection and subsequent analysis. Section 4 of the study presents the findings, with a specific emphasis on the influence of integrated approaches on operational performance. Section 5 provides a contextual framework for the findings by situating them within the current body of literature. Additionally, it discusses the practical implications that can be derived from the findings. In addition, this section provides a concise overview of the main findings, their implications, any limitations encountered during the study, and proposes potential avenues for future research.

2. Literature Review

2.1 Theoretical Background

The theoretical foundation of operations management has evolved over time in response to the increasing sustainability challenges associated with the management of resources and operations on a regular basis. The notion of operational performance is inherent in various management theories, encompassing innovation management, resource management, and HRM management. Theoretical perspectives were thus employed to examine the key management domains that underpin lean and green manufacturing practices. As stated by Inman and Green (2018), the complementarity theory, as proposed by Narasimhan, Swink, and Viswanathan (2010), posits a significant correlation between organisational practices, competencies, and the resulting competitive advantage.

In the current context, the implementation of lean and green practices necessitates a strategic emphasis and organisational dynamics in order to achieve optimal operational performance. The integration of lean and green manufacturing practices is mutually reinforcing in the adoption of various strategies, such as waste management, circular capabilities, and lean production. The synergistic effects of these practices are evident in terms of effective managerial strategies, employee engagement, process oversight, resource allocation, and operational efficiency. The correlation between these variables can also be substantiated by the sustainable production framework established by Luo et al. (2017).

Based on the theoretical framework employed, business performance at the micro-operational level is influenced by five key factors: the behavioural approach, subjective norms, willingness to engage in sustainable production, behavioural control, and sustainable production behaviour. The implementation of sustainable production behaviours serves to reinforce the principles of lean production, circular capabilities, and waste minimization. The impact can be observed collectively on performance at various levels, encompassing organisational, environmental, economic, and operational performance. The primary objective of this study is to examine the operational performance of the manufacturing sector. The theoretical framework is centred on the relationship between lean production, waste reduction, managerial awareness of sustainability, circular capabilities, and the operational performance of manufacturing companies in Saudi Arabia.

2.2 Lean Production and Operational Performance

Over the past decade, there has been a notable transformation observed in manufacturing firms and organisations. The manufacturing sector has demonstrated a notable response to environmental concerns through the implementation of lean and green production practices. The implementation of lean production as a means to achieve sustainable competitive advantage in the global manufacturing industry is increasingly becoming a significant focal point. Hardcopf, Liu, and Shah (2021) conducted a study that demonstrated a robust correlation between lean production methodologies and operational performance. Researchers argue that lean methods are effective in reducing costs, improving delivery, enhancing quality, and increasing flexibility. The successful implementation of advanced lean methods necessitates robust support from both internal and external stakeholders. Marodin, Frank, Tortorella, and Fetterman (2019) have established a correlation between lean production practices and enhanced operational performance.

The application of lean practices in supply chain management is evident across various performance metrics, encompassing maintenance practices, inventory management, and just-in-time practices. The implementation of lean production in the manufacturing industry has gained considerable traction as a prominent initiative, primarily owing to its substantial impact on operations management. The use of this tool enables manufacturing firms to effectively manage their daily productivity and performance, thereby enhancing their competitive capabilities. To adhere to global sustainability standards, firms are required to enhance their capabilities, a goal that can be achieved through the implementation of lean and green production practices (Abreu-Ledón, Luján-García, Garrido-Vega, & Escobar-Pérez, 2018).

The implementation of lean practices has significantly facilitated operational management at the field level. In the present-day business environment, lean practices have gained widespread acceptance as an effective business strategy that is closely linked to operational performance. In a lean production environment, performance is significantly influenced by various management strategies pertaining to logistics and the supply chain (Novais, Maqueira Marin, & Moyano-Fuentes, 2020). The implementation of extensive lean management and practises that prioritise quality, production flow, and maintenance can effectively control the substantial waste production in manufacturing firms, as it aligns with the objective of waste elimination.

H1: *Lean production significantly impacts the operational performance of Manufacturing Firms*

2.3 Sustainability in Manufacturing sector

The increasing attention given to environmental strategies has led to the recognition of the crucial role that management cognition plays in shaping the sustainable innovative capability of firms. The implementation of a proactive environmental strategy has been shown to be effective in influencing the performance and productivity of a firm (Yang, Wang, Zhou, & Jiang, 2019). The managerial cognition of sustainability manifests in its impact on the governance of daily operations and administrative control. The endorsement of environmental strategies and the development of sustainable capabilities within a firm have been found to enhance operational performance. Previous studies (Coatney & Poliak, 2020; Tang et al., 2018) have examined the significance of incorporating sustainability-oriented instruments within manufacturing systems. There exists a positive correlation between the utilisation of sustainable smart devices and the achievement of sustainable performance at both the organisational and operational levels. The implementation of lean production measures enhances sustainability standards and the performance of companies.

Machado, Winroth, and Ribeiro da Silva (2020) emphasise the increasing importance of sustainable manufacturing. In order to promote sustainable manufacturing practices within the industry, it is imperative to establish a strong technological foundation, implement advanced instruments and devices, and foster effective leadership that is committed to meeting sustainable standards and goals. The implementation of responsive measures aimed at achieving sustainable development has a significant influence on the advancement of industrial initiatives at both the national and international scales. The current state of the global manufacturing sector is characterised by the ongoing fourth industrial revolution, which entails the integration of advanced technologies and a unique perspective aimed at ensuring a sustainable future within the manufacturing domain (Carvalho, Chaim, Cazarini, & Gerolamo, 2018). In order to enhance operational performance, the new industrial models demonstrate increased adaptability to environmental policies and the mitigation of regular operations through the collaboration of internal managers and external stakeholders.

H2*: Sustainability significantly impacts the operational performance of Manufacturing Sector*

2.4 Waste minimization practices

The adoption of lean and green production practises in the manufacturing industry has resulted in substantial and sustainable transformations. The implementation of clean production practises has resulted in a decrease in waste generation and has also led to various environmental, organisational, and operational advantages (da Silva, de Oliveira Neto, Correia, & Tucci, 2021). Clean production is widely recognised as a significant approach for effectively managing waste and resources throughout the production phase. The manufacturing industry is currently experiencing significant levels of waste generation, which has emerged as a prominent environmental issue. The optimisation of operational performance in such instances can be achieved through the improvement of raw material efficiency and the reduction or recycling of waste during the manufacturing process.

Yuan, Wang, Shi, and Hao (2022) posited that the implementation of a sustainable strategy plays a crucial role in effectively tackling waste management challenges within major industries, such as construction and manufacturing. The efficacy and efficiency of the waste minimization system rely on various internal and external stakeholders. The implementation and enhancement of a waste minimization system at the organisational level consequently enhance the efficiency, productivity, and overall performance of the firm. Bhattacharya, Nand, and Castka (2019) conducted a study that similarly posited the positive impact of lean and green management on waste minimization and subsequent improvements in organizational/operational performance. The researchers examined the relationship between waste minimization, sustainable advantage, economic performance, and the social foundation of the working environment. They analysed this relationship from economic, environmental, and social perspectives.

The prevalence of these practices consequently leads to favourable outcomes by enhancing the operational systems of organisations. The environmental concerns in the contemporary manufacturing industry are primarily attributed to the presence of unsustainable operational practices. The implementation of lean and green practices serves as a regenerative development strategy and resource management approach, leading to enhanced operational performance and the creation of opportunities (Caldera, Desha, & Dawes, 2018). Furthermore, these waste management practices are deeply embedded in the Sustainable Development Goals (SDGs), which promote the principles of sustainable production and consumption.

H3: *Waste minimization significantly impacts the operational performance of Manufacturing Firms*

2.5 Circular capabilities of Manufacturing Industry

The introduction of various strategies for the circular economy has been noted to have a substantial impact on the operations of businesses, particularly within the manufacturing industry. Companies that are currently engaged in the development of circular business models possess significant potential and capacity to generate both economic and environmental benefits (Reim, Sjödin, & Parida, 2021). The implementation of a wide range of practices in manufacturing industrial settings holds promising potential for the sustainable development of the manufacturing industry. The trajectory of firms' capability development plays a crucial role in determining their progress and facilitating their smooth operation, ultimately leading to satisfactory operational performance. Bag, Pretorius, Gupta, and Dwivedi (2021) conducted a study that emphasised the significance of resources and institutional pressure in the implementation of sustainable practices and the development of circular economy capabilities within the manufacturing sector.

There is contention that institutional factors exert a substantial influence on the regulation of sustainable manufacturing and circular economy capabilities within the manufacturing industry. Sousa-Zomer, Magalhães, Zancul, and Cauchick-Miguel (2018) also highlighted the potential of innovative circular business models to facilitate circular capabilities. The adoption of circular business strategies in the manufacturing industry has demonstrated that enhancing circular capabilities is strongly correlated with enhanced business performance. At the operational level, the adoption of appropriate circular business models and the necessary circular capabilities for advanced sustainable development can ensure micro-level advantages and macro-level competitiveness in business performance.

In the view of Bag and Pretorius (2022), there is an argument that the implementation of a circular economy within the manufacturing sector demonstrates a strong alignment with sustainable standards. The implementation of sustainable technology has a significant impact on enhancing the capabilities of the circular economy and promoting sustainable manufacturing practices. Based on historical evidence, it can be postulated that circular capabilities are contingent upon various factors, such as institutional factors, technological advancements, and innovations in business models, which exert differential influences on operational performance.

H4: *Circular capabilities significantly impact the operational performance of Manufacturing Firms*

2.6 Moderating Effect of Organizational Dynamism

Organisational Dynamics encompasses the fields of organisational development and behaviour, as well as strategic management, which collectively capture the intricate dynamics inherent in the life of an organisation. To successfully attain the objectives of the business, it is imperative to carefully analyse and address the dynamics within the organisation. The current study examined the moderating influence of organisational dynamism on the association between lean and green practises and operational performance. Previous scholarly works (Pitelis & Wagner, 2019; Wamba, Dubey, Gunasekaran, & Akter, 2020) in the field of organisational dynamism have demonstrated that improving organisational dynamic capabilities can effectively ensure operational performance.

There exists a positive correlation between the organisational cognition and capacity of firms and their ability to sustainably implement practises over an extended duration. Further, the influence of environmental dynamism on the integration of big data analytics and sustainable organisational performance is also evident. This suggests that the incorporation of advanced technology enhances the dynamic capability of the organisation, resulting in increased productivity in routine operations. Jantunen, Tarkiainen, Chari, and Oghazi (2018) emphasise that dynamic capabilities have the ability to redefine previous organisational positions and facilitate organisational innovations, ultimately enhancing firm performance and productivity. The dynamic capabilities are thus linked to the operational-level modifications that govern the performance and advancement of the respective industry.

The manufacturing industry encounters significant challenges pertaining to supply chain management and routine operations. The firm's ability to adapt and respond to changing circumstances, known as dynamic capabilities, is enhanced by the utilisation of big data analytics. This is further supported by the firm's operational performance and the integration of sustainable technology. Previous research conducted by Dubey et al. (2020) and Zhou, Zhou, Feng, and Jiang (2019) has brought attention to the impact of environmental dynamism on the dynamic capabilities of organisations and their corresponding business objectives. The significance of organisational dynamism in enhancing firms' competitive advantage and performance is also evident. Furthermore, it facilitates the implementation of sustainable innovation management practises that oversee waste management and resource utilisation.

The integrated organisational mechanism is advanced through the dynamic nature of the organisation. Singh and Rathi (2019) emphasise that within modern business organisations, the adoption of lean principles is accompanied by various challenges. This study investigates the application of Lean Six Sigma across various sectors within the manufacturing industry. The implementation is facilitated by the dynamics within the organisation, which enhance resources and improve performance at the organisational level while also integrating operational performance. The effectiveness of sustainability and lean practices in the manufacturing sector can be enhanced through the maintenance of efficient organisational dynamism, given the extensive network of regular operations. The significance of the moderating role of organisational dynamism is thus crucial when considering environmental, economic, and organisational perspectives.

H5: *Organizational Dynamism has a significant moderating role in the relationship between lean production, sustainability, circular capabilities, waste minimization, and operational performance of Manufacturing firms.*

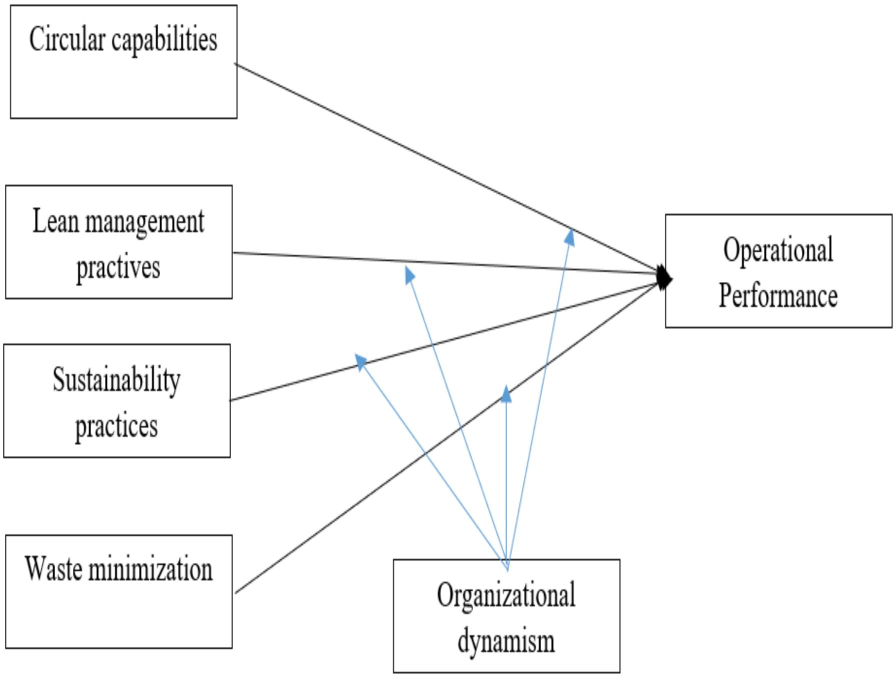

Figure 2.1: Research framework

3. Method

The current research employs a quantitative research methodology to examine the enhancement of operational performance in the manufacturing sector by integrating lean production, sustainability, circular capabilities, and waste minimization practises within Saudi Arabian industries. Furthermore, the research is grounded in the positivist philosophical framework and employs a deductive approach, thereby providing support for the utilisation of quantitative analysis in the current study.

3.1. Research Instrument

The data utilised in this study was obtained via a survey questionnaire, which is a suitable research tool for gathering data from a sizable sample in a cost-efficient manner (Martin & Thomaschewski, 2019). The current study focused on employees working in the operations department of manufacturing firms in Saudi Arabia. The participants for this study were chosen using convenience and purposive sampling methods. The utilisation of purposive sampling facilitated the deliberate selection of research participants who possessed specialised knowledge and practical experience in the domains of interest, including lean production, sustainability, circular capabilities, and waste minimization. The rationale for employing convenience sampling in this study was predicated upon the ready availability and ease of access to manufacturing organisations and experts within the context of Saudi Arabia.

The study involved a total of 280 participants. The independent variables in the present study include *lean production*, *sustainability in the manufacturing sector*, *waste minimization*, and *circular capabilities* while the *operational performance of* *manufacturing firms* is the dependent variable. In addition, *organizational dynamism* serves as a moderating variable in the study. The measures utilised in this study were obtained from previous research, selected based on their validity and alignment with the current study's objectives. Furthermore, the researchers employed a 5-point Likert-type scale to assess the measurement of items. Table 3.1 presents a comprehensive overview of the measures utilised in this study, along with the corresponding number of items, which have been adapted from previous scholarly investigations.

Table 3.1: Measures of the Study

Construct	Sources	No. of Items
Lean production practices	(Yang, Hong, & Modi, 2011)	6
Sustainability in manufacturing	(Ibrahim, Hami, & Abdulameer, 2020)	7
Waste minimization	(Al-Hajj & Hamani, 2011; Al-Sari, Al-Khatib, Avraamides, & Fatta-Kassinos, 2012; Awang & Iranmanesh, 2017; Bekr, 2014; Chen, Li, & Wong, 2002; Kulatunga, Amaratunga, Haigh, & Rameezdeen, 2006; Nagapan, Rahman, & Asmi, 2012; Oko John & Emmanuel Itodo, 2013; Poon, Ann, & Ng, 2001)	5
Circular capabilities	(Zeng, Chen, Xiao, & Zhou, 2017)	10
Organizational dynamism	(Ricciardi, Zardini, & Rossignoli, 2016)	5
Operational performance	(Domenek, Moori, & Vitorino Filho, 2022)	4

3.5. Data Analysis

The data analysis methodology employed in the current study, which aims to enhance operational performance in the manufacturing sector by integrating lean production, sustainability, circular capabilities, and waste minimization in Saudi Arabian industries, was characterised by a methodical and meticulous approach to extracting meaningful findings from the collected data. The data analysis process involved the application of Structural Equation Models (SEM) to test the hypotheses formulated in the study, aligning with the research objectives. Furthermore, the questionnaire items underwent thorough testing to assess their reliability and validity.

4. Analysis

4.1 Demographics

In this study there were a total of 280 participants, among them 146 were male and 134 were female. 20% respondents were between 21-30 years, 27.9% were between 31-40, 34.6% were between 41-50 and 17.5% were above 50 years. 37 respondents have experience of less than 2, 123 had of 2-5, 102 had of 5-8 and 18 had more than 8 years.

Table 4.1: Demographic Profile

		Frequency	%
Gender			
	male	146	52.1
	female	134	47.9
Age			
	21-30	56	20.0
	31-40	78	27.9
	41-50	97	34.6
	more than 50 years	49	17.5
Experience			
	less than 2 years	37	13.2
	2-5	123	43.9
	5-8	102	36.4
	more than 8 years	18	6.4

4.2 Outer Loadings

According to Haji-Othman and Yusuff (2022), for the measurement of indicator reliability, outer loadings are utilized. Its significant value ranges between 0-1. Table 4.2 shows the results of outer loadings. All outer loadings of the observed constructs; CC, LPS, OD, OP, SM and WM are above the cut-off value 0.708, it indicates a significant level of indicator reliability.

Table 4.2: Outer Loadings

	CC	LPS	OD	OP	SM	WM
CC1	0.854					
CC10	0.778					
CC2	0.775					
CC3	0.768					
CC4	0.82					
CC5	0.788					
CC6	0.794					
CC7	0.74					
CC8	0.756					
CC9	0.716					
LPS1		0.816				
LPS2		0.847				
LPS3		0.837				
LPS4		0.836				
LPS5		0.818				
LPS6		0.775				
OD1			0.789			
OD2			0.756			
OD3			0.756			
OD4			0.725			
OD5			0.704			
OP1				0.876		
OP2				0.894		
OP3				0.851		
OP4				0.822		
SM2					0.728	
SM3					0.715	
SM4					0.776	
SM6					0.777	
WM1						0.903
WM2						0.857
WM3						0.766
WM4						0.817
WM5						0.842

"CC= Circular Capabilities, LPS=Lean production practices, OD= Organizational dynamism, OP=Operational Performance, SM= Sustainability in manufacturing, and WM= Waste Minimization."

4.3 Measurement Model

Figure 4.1 presents the measurement model of study. This figure shows constructs and their items.

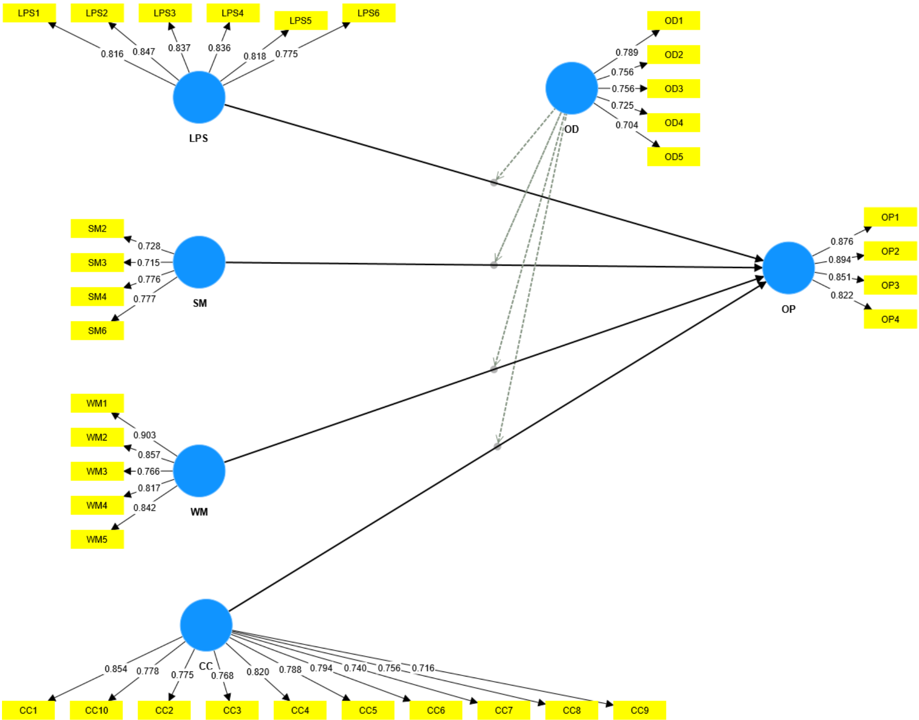

Figure 4.1: Measurement Model

4.4 Validity Analysis

To measure the reliability and validity, researcher has computed Cronbach alpha and convergent validity with two indicators "Composite reliability and AVE." The cut-off value of alpha is 0.7 (Guo et al., 2023). AVE value must be above 0.5, and CR value must be above 0.7 (Husna & Sofyan, 2023; Shrestha, 2021). The findings displayed in Table 4.3 indicate that the alpha and CR values surpass the threshold of 0.7, while the AVE values exceed 0.5. Consequently, these results suggest that the data exhibits both reliability and validity.

Table 4.3: Reliability Analysis

	α	Composite-reliability (rho_a)	Composite-reliability (rho_c)	Average variance extracted. (AVE)
CC	0.928	0.931	0.939	0.608
LPS	0.904	0.91	0.926	0.675
OD	0.801	0.802	0.863	0.558
OP	0.884	0.889	0.92	0.742
SM	0.748	0.758	0.836	0.562
WM	0.893	0.901	0.922	0.703

"CC= Circular Capabilities, LPS=Lean production practices, OD= Organizational dynamism, OP=Operational Performance, SM= Sustainability in manufacturing, and WM= Waste Minimization."

4.6 Discriminant Validity

Discriminant validity pertains to the extent to which a given assessment effectively captures and measures the specific construct it is designed to evaluate (Rönkkö & Cho, 2022). It is measured in this study using "HTMT analysis, and Fornell-Larcker criterion."

4.6.1 HTMT

Discriminant validity, as determined by HTMT analysis, assesses the extent to which the construct in question is distinct from others, with a recommended threshold value of 1. The acceptable range for discriminant validity typically falls between 0.80 and 0.90 (Waris et al., 2022). Results of HTMT shown in table 4.4 confirms establishment of discriminant validity in the study.

Table 4.4: HTMT

	CC	LPS	OD	OP	SM	WM
CC						
LPS	0.689					
OD	0.49	0.633				
OP	0.616	0.635	0.609			
SM	0.09	0.064	0.159	0.102		
WM	0.338	0.478	0.667	0.396	0.086	

"CC= Circular Capabilities, LPS=Lean production practices, OD= Organizational dynamism, OP=Operational Performance, SM= Sustainability in manufacturing, and WM= Waste Minimization."

4.6.2 Fornell-Larcker criterion

According to the criterion proposed by Fornell-Larcker, discriminant validity is achieved when the average variance extracted (AVE) of a construct exceeds the correlation value between that construct and any other construct (Mandagi, Rantung, & Mandagi, 2022). The results of Fornell-Larcker's criterion are presented in table 4.5. These findings provide confirmation of the establishment of discriminant validity, as the square root values of the average variance extracted (AVE) are higher than the correlations.

Table 4.5: Fornell-Larcker

	CC	LPS	OD	OP	SM	WM
CC	0.78					
LPS	0.64	0.822				
OD	0.427	0.546	0.747			
OP	0.57	0.574	0.515	0.861		
SM	0.053	0.001	-0.102	-0.086	0.749	
WM	0.313	0.433	0.568	0.354	-0.036	0.838

"CC= Circular Capabilities, LPS=Lean production practices, OD= Organizational dynamism, OP=Operational Performance, SM= Sustainability in manufacturing, and WM= Waste Minimization."

4.7 Variance Inflation Factor

The presence of multicollinearity was evaluated by employing the Variance Inflation Factor (VIF) method. When the Variance Inflation Factor (VIF) exceeds a threshold of 5, it indicates the presence of collinearity (Hair, Ringle, & Sarstedt, 2011). In response to the findings presented in Table 4.6, it can be observed that there are no values that are equal to or greater than 5. This suggests that the dataset under consideration is devoid of multicollinearity.

Table 4.6: VIF

	VIF
CC1	3.282
CC10	2.51
CC2	2.441
CC3	2.222
CC4	2.844
CC5	2.371
CC6	2.476
CC7	2.233
CC8	2.495
CC9	2.318
LPS1	2.378
LPS2	3.077
LPS3	2.7
LPS4	2.46
LPS5	3.217
LPS6	2.709
OD1	1.962
OD2	2.051
OD3	1.905
OD4	1.794
OD5	1.746
OP1	2.422
OP2	2.909
OP3	2.275
OP4	1.944
SM2	1.355
SM3	1.564
SM4	1.385
SM6	1.476
WM1	3.34
WM2	2.379
WM3	1.772
WM4	2.189
WM5	2.452

“CC= Circular Capabilities, LPS=Lean production practices, OD= Organizational dynamism, OP=Operational Performance, SM= Sustainability in manufacturing, and WM= Waste Minimization.”

4.8 Coefficient of Determination(R-square)

The coefficient of determination, commonly referred to as R-square, quantifies the proportion of variability in the dependent variable that can be accounted for by the predictors included in the model under investigation (Chicco, Warrens, & Jurman, 2021). The adjusted R-square is a modified version of the R-square. The findings presented in Table 4.7 demonstrate that the observed results account for a significant proportion of the variance, specifically 45.3%, in the relevant construct.

Table 4.7: R-Square

	R-square	R-square adjusted
OP	0.471	0.453

"OP=Operational Performance."

4.9 Model Fitness

The evaluation of model fitness was conducted by employing various statistical measures, including SRMR (Standardised Root Mean Square Residual), d_ULS (difference in the Unweighted Least Squares), d_G (difference in the Geodesic), Chi-square, and NFI (Normed Fit Index). The results of model fitness are presented in Table 4.8, which provides confirmation that all obtained values indicate the model is a suitable fit.

Table 4.8: Model Fitness

	Saturated model	Estimated model
SRMR	0.064	0.064
d_ULS	2.472	2.461
d_G	1.067	1.067
Chi-square	1620.75	1611.984
NFI	0.752	0.753

4.10 Structural Equation Modelling

In order to perform path analysis, structural equation modelling (SEM) was utilised. The outcomes of the structural equation modelling (SEM) analysis are presented in Table 4.9. The direct hypotheses of the study confirmed a significant relationship between CC and OP, as evidenced by a t-statistic value of 3.15 and a p-value of 0.002. Additionally, the association between LPS and OP was found to be statistically significant, with a t-statistic value of 2.92 and a p-value of 0.004. Also, the acceptance of the moderation of OD between CC and OP is based on the observation that its t-statistic holds significance, while the remaining indirect hypotheses were determined to be insignificant.

Table 4.9: Path Analysis

	Original sample	Sample mean	Standard deviation	T-statistics	P-values
CC -> OP	0.254	0.261	0.081	3.15	0.002
LPS -> OP	0.273	0.274	0.094	2.921	0.004
SM -> OP	-0.08	-0.087	0.06	1.329	0.184
WM -> OP	0.027	0.029	0.076	0.353	0.724
OD x WM -> OP	0.04	0.037	0.069	0.584	0.559
OD x LPS -> OP	0.13	0.128	0.086	1.512	0.131
OD x CC -> OP	-0.144	-0.139	0.056	2.601	0.009
OD x SM -> OP	0.079	0.079	0.066	1.209	0.227

"CC= Circular Capabilities, LPS=Lean production practices, OD= Organizational dynamism, OP=Operational Performance, SM= Sustainability in manufacturing, and WM= Waste Minimization."

5. Discussion

This section presents an analysis of the findings and explores the theoretical and practical implications of the current study, which focuses on enhancing manufacturing operational performance in Saudi Arabian industries. The study examines the integration of lean production, sustainability, circular capabilities, and waste minimization as key factors in achieving this optimisation. The following section provides an outline of the constraints inherent in the current study and proposes potential avenues for future research in the field of operational performance within manufacturing companies.

5.1. Discussion of Findings

Five hypotheses were formulated based on the objectives of the present study. The initial hypothesis posited a substantial influence of lean production on the operational performance of manufacturing firms. The findings confirm the substantial influence of LPS on OP, thereby providing support for Hypothesis 1, which posits that the implementation of lean practices enhances the operational performance of manufacturing companies. Therefore, this discovery expands upon the findings of previous studies that have examined the effects of lean production on operational performance (Buer et al., 2021; Hardcopf, Liu, & Shah, 2021). In their study, Buer et al. (2021) focused on Norwegian manufacturing companies and examined the relationship between lean production practices and the operational performance of these organisations. The research findings indicated a favourable influence of lean production on the operational performance of the organisation.

However, the findings indicated that the implementation of lean production practises has a noteworthy influence on operational performance solely in cases where the level of digitalization within the organisation is substantial. Therefore, the findings of the study suggest that the absence of digitalization in lead production did not have a statistically significant effect on the operational performance of the organisation. In contrast, the current study demonstrates a notable individual influence of lipopolysaccharide (LPS) on oxidative phosphorylation (OP). The study conducted by Hardcopf, Liu, and Shah (2021) similarly found evidence supporting the positive influence of lean production on operational performance. Yet the research conducted by the authors placed significant emphasis on the mediating role played by organisational culture in the association between lean production and operational performance. Furthermore, the findings of the study indicated that a supportive organisational culture has the potential to optimise the positive effects of lean production.

The second hypothesis suggested that sustainability has a notable influence on operational performance. The findings of this study provide support for hypothesis H2 and confirm the significant influence of sustainable manufacturing (SM) on operational performance (OP). These results suggest that the implementation of sustainable practices in manufacturing firms has a positive effect on their operational performance, which aligns with previous research conducted by Magon, Thomé, Ferrer, and Scavarda (2018). In their study, Magon et al. (2018) found evidence supporting the positive influence of sustainable practices on various aspects of operational performance. These include cost reduction, improved product delivery and quality, as well as enhanced volume and mix flexibility. The third hypothesis posited a substantial influence of waste minimization.

Nevertheless, the findings indicate a lack of significant influence of working memory (WM) on organisational performance (OP), thereby refuting hypothesis H3 and contradicting the conclusions drawn by da Silva et al. (2021) and other related studies. In their study, da Silva et al. (2021) examined the textile industries and investigated production practices that specifically aimed at minimising waste. The researchers also assessed the influence of these practices on the operational performance of the industry. The study findings indicate that the implementation of cleaner production practices, which resulted in waste reduction, had a noteworthy and favourable influence on the operational performance of the industry. The fourth hypothesis posited that circular capabilities have a substantial influence on organisational performance. The findings demonstrate a noteworthy influence of circular capabilities (CC) on operational performance (OP), thereby providing support for hypothesis 4 (H4).

This implies that circular capabilities, including resource efficiency, waste reduction, and sustainable practices, play a significant role in improving the operational performance of manufacturing firms. The fifth hypothesis posited that organisational development (OD) plays a significant moderating role in the relationship between leadership style (LPS), strategic management (SM), corporate culture (CC), workforce motivation (WM), and the organisational performance (OP) of manufacturing firms. Still, the findings demonstrate the noteworthy moderating influence of organisational development (OD) solely in the association between corporate culture (CC) and organisational performance (OP). This partially confirms Hypothesis 5 (H5), indicating that OD plays a moderating role in the CC-OP relationship. However, it does not exhibit a comparable moderating impact on the relationships involving leadership style (LPS), strategic management (SM), and workforce motivation (WM). In alternative terms, it can be observed that organisational design (OD) holds significant sway over the extent to which the circular capabilities of a manufacturing company contribute to its operational performance.

5.2. Theoretical Implications

This study examines various aspects of the manufacturing sector in Saudi Arabia that collectively influence the operational performance of manufacturing industries. The analysis is based on the complementarity theory's theoretical foundation, as put forth by Narasimhan, Swink, and Viswanathan (2010). The research has significant theoretical implications that enhance our comprehension of how organisations can effectively leverage their resources and capabilities to attain sustainable operational performance. The incorporation of complementary theory highlights the significance of internal resources and capabilities, such as lean production, sustainability, circular capabilities, and waste minimization, in order to improve the operational performance of organisations.

This is consistent with the fundamental principle of the complementary theory, which posits that various practises or components within an organisation can mutually reinforce each other, thereby improving overall performance. The research also investigates the notion of organisational dynamism as a moderator in the correlation between lean production, sustainability, circular capabilities, and waste minimization. Therefore, this study provides significant theoretical contributions regarding the cultivation of an organization's dynamism in order to improve its operational performance.

5.3. Practical Implications

The current investigation pertaining to the enhancement of operational performance within the manufacturing sector in Saudi Arabia presents a number of practical implications that can serve as guidance for manufacturing organisations operating in the region. This study emphasises the importance of incorporating the principles of sustainability and circular economy into the strategies of organisations. It suggests that companies should include lean production, sustainability, circular capabilities, and waste minimization in their strategic plans. The integration of various components can potentially result in improved competitive advantage and increased resilience within the supply chain for manufacturing firms. Furthermore, the study also suggests the importance of identifying the available resources that can be utilised in order to attain a sustainable and circular economy. The research also emphasises the importance of the company's commitment to developing and enhancing their dynamic capabilities, which enable them to effectively respond and adjust to evolving circumstances.

It is advisable for organisations to actively pursue avenues for incorporating the principles of lean production, sustainability, circular capabilities, and waste minimization into their operational strategies in order to enhance resource efficiency. The notion of organisational dynamism as a moderator underscores the importance of possessing flexibility and adaptability. It is imperative for organisations to cultivate the ability to promptly adapt to fluctuations in the business landscape. The practical implications encompass the allocation of resources towards employee training, the cultivation of an innovative organisational culture, and the adoption of agile management practises. Therefore, it is imperative for manufacturing companies to comply with environmental regulations in light of the worldwide transition towards sustainability and the circular economy. In order to achieve this objective, companies have the option to establish industry networks that facilitate the exchange of best practises pertaining to the circular economy.

5.4. Conclusion

The primary objective of this study was to examine the complex interplay between lean production, sustainability, waste reduction, circular capabilities, organisational agility, and operational performance in the manufacturing industry. The analysis has produced significant findings pertaining to the enhancement of operational performance in Saudi Arabian manufacturing firms. The incorporation of lean practises within manufacturing operations has the potential to enhance overall performance. Additionally, the research indicates that the implementation of environmentally responsible practises can act as a catalyst in enhancing the operational performance of manufacturing firms. The study additionally proposes the benefits of incorporating the principles of circular economy into the strategic agendas of manufacturing enterprises. Moreover, the adoption of circular capabilities by manufacturing firms is heavily influenced by their dynamic capabilities. The present study proposes that lean production, sustainability, and circular capabilities are important indicators of operational performance. Additionally, the study recognises the moderating impact of organisational dynamism on these measures.

5.5. Limitations and Future Research

The current investigation also possesses a number of limitations that may be addressed in subsequent research endeavours. A notable constraint of this study pertains to the limited response rate observed among the organisations surveyed.

There may be various factors contributing to the hesitancy of manufacturing firms in Saudi Arabia to engage in research surveys. These factors encompass time limitations as well as apprehensions surrounding the divulgence of confidential operational data. The limited size of the sample may restrict the ability to apply the findings to a broader population and may not adequately capture the range of manufacturing practises prevalent in the region. An additional constraint of the current study pertains to its narrow scope, which is limited to a particular sector within the manufacturing industry. While this methodology facilitates comprehensive examination within a specific industry, it may not encompass the entirety of manufacturing practises in Saudi Arabia. Hence, it is important to note that the generalizability of the study's findings may be limited to the specific industries that were included within the study's scope. Additionally, it is possible that the study may fail to consider certain variables or factors that have the potential to impact operational performance within manufacturing firms. Capturing all variables within the manufacturing landscape poses a significant challenge, given its multifaceted nature.

Future research may consider investigating various strategies aimed at enhancing response rates, including the incorporation of follow-up interviews as a means to collect more comprehensive and in-depth data. In addition, it is suggested that future research endeavours may consider employing a cross-industry perspective as a means to overcome the constraint of focusing solely on a particular industry. This approach has the potential to provide a comprehensive evaluation of the Saudi manufacturing sector. Furthermore, it is recommended that future research endeavours strive to incorporate a broader spectrum of variables, including but not limited to technology adoption and regulatory compliance, in order to assess their impact on operational performance.

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