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Unveiling the synergy of sustainable manufacturing practices and lean for sustainable manufacturing competitiveness

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Abstract
The present study investigates the integration of Lean and Sustainable manufacturing (LSM) practices to improve the market competitiveness of Indian manufacturing organizations. The study aims to explore the critical role of stakeholder commitment to drive both sustainable manufacturing and lean practices with their impact on manufacturing competitiveness. In the study a survey-based approach was used, the data was collected from 152 Indian manufacturing firms and analyzed using Principal component analysis (PCA) and Structural equation modelling (SEM) approach with IBM SPSS and AMOS software. The sampling approach focused on the consideration of medium and large enterprises of India across various sector using the structure questionnaire to assess the key constructs such as: stakeholder commitment, lean practices, and sustainable manufacturing. The result of the study reveals that stakeholder commitment significantly influences the adoption of both sustainable and lean manufacturing practices which help to drive manufacturing competitiveness. The SEM analysis conducted in the study reveals that there is structural relationship between the variables which further provides the evidence that organization ability to integrate lean and sustainable manufacturing practices improves the market competitiveness in dynamic business environment.

Keywords Lean manufacturing, Sustainable manufacturing, Manufacturing competitiveness, Stakeholder commitment, India, Manufacturing

1 Introduction

The rising focus on environmental sustainability is driven by increasing energy costs, environmental degradation, and demand for eco-friendly practices, has forced businesses to adopt greener strategies. At the same time, manufacturing organizations are focusing on waste reduction from their processes. Therefore, the concept of lean manufacturing and sustainable manufacturing is widely discussed in literature [81]. The concept of lean is not new for manufacturing sector. As the organizations are focusing on economic stability are facing challenges due to shifting customer mindsets and cost practices. To adapt and enhance profitability, many manufacturers adopted lean

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manufacturing [82]. Lean manufacturing helps to enhance organizational performance by focusing on customer value through waste elimination and flow improvement [25]. Existing literature discusses comprehensive list of lean practices, tools, and metrics, such as defect rate for quality management, cycle time for Kanban, and breakdown frequency for Total Productive Maintenance [25]. Lean social practices, such as leadership and continuous improvement culture, positively impact all three dimensions of sustainability, while lean technical practices, like continuous flow improves economic performanceLean manufacturing was initially introduced. The concept of lean and sustainable manufacturing is less explored in the economies like India. Their structural relationship is underexplored. India's manufacturing sector is considered as a key contributor to economic growth which accounted for 16–17% of Gross Domestic Product pre-pandemic and is projected to expand rapidly. With advancements in technology and digital transformation, manufacturing organizations are embracing automation to boost efficiency and productivity 2024; [77, 78]). Therefore, understanding the structural relationship among lean management practices and sustainable manufacturing is important for Indian manufacturing organizations to remain competitive in global market competition. With this focus the present study aims to answer two key research questions:

RQ1: What are critical factors of stakeholder commitment, lean manufacturing practices, sustainable manufacturing practices, and sustainable manufacturing competitiveness?

RQ2: How are stakeholder commitment, lean manufacturing practices, sustainable manufacturing practices, and sustainable manufacturing competitiveness related to each other?

To address the first research question, principal component analysis, a technique for dimension reduction, is employed. The second research question is tackled using structural equation modeling (SEM). The structural relationship framework developed in this research enables production managers of various manufacturing organizations to reassess their existing drivers of success in line with those discussed in this study.

The remainder of the paper is organized as follows: we explain the various constructs, their exclusive relationships, a theoretical framework, and the hypotheses derived from them in Sect. 2; the approach executed to carry out the complete research (research methodology) is explained in Sect. 3; the results of principal component analysis and SEM are presented in Sect. 4 on data analysis; these results are discussed in line with hypotheses in Sect. 5; the research implications are discussed in Sect. 6, and the complete research work, along with limitations and future research directions, is concluded in Sect. 7.

2 Literature review

The literature review was conducted based on publications that were identified from Scopus, Web of Science, and online databases. the various studies were identified in the databases by searching article titles and keywords for the terms: “lean practices”, “lean manufacturing” OR “lean system”, “sustainable operations”, “sustainable manufacturing”, and “manufacturing competitiveness”. From the literature, The various practices of sustainable manufacturing and lean systems were identified.

2.1 Sustainable manufacturing concept and trends

Sustainable manufacturing integrates processes to produce high-quality products while using less sustainable resources, ensure safety of employees and communities, and minimizing environmental and social impacts across the product lifecycle [50]. Sustainable manufacturing is a growing research area with an expanding knowledge base, evidenced by research in product design, supply chains, production technologies, and waste reduction [12]. Societies are increasingly recognizing the need for production and consumption models that address environmental and social impacts, pressuring manufacturing industries to adopt transparent, sustainable practices. Sustainable manufacturing aims to minimize resource use and environmental harm while remaining socially responsible and economically viable [69]. Manufacturers are facing rising compliance, energy, and material costs alongside growing stakeholder demands for sustainability. Therefore, adopting sustainable manufacturing practices is essential for maintaining competitiveness in the global market [10]. Existing studies have discussed the good adoption growth in developing countries.

2.2 Lean manufacturing

Over time, the lean philosophy has gained popularity to achieve a competitive advantage. It provides higher value to customers by eliminating non-value-adding activities [60, 71]. Lean manufacturing was initially introduced to maximize resource utilization through waste minimization. Lean manufacturing is widely adopted in both manufacturing and service industries, focusing on waste elimination which enable firms to improve quality and productivity (Wahab et al., 2013). In recent years, many manufacturing industries have adopted lean practices, but inadequate understanding has led to misapplication of tools. A systematic approach linking organizational issues to appropriate lean tools remains lacking in literature [63]. Lean manufacturing is applicable across industries, including SMEs. It combines the cost-efficiency of mass production with quality and flexibility, offering significant cost and quality advantages over traditional methods (Rose et al., 2009). At present, SMEs are adopting manufacturing paradigms from larger industries for sustainable development. Therefore, Lean manufacturing practices are widely recognized by SMEs globally. The Government of India also highlights manufacturing as a key economic driver and employment source. To boost Micro small and medium enterprises (MSMEs) competitiveness, the National Manufacturing Competitiveness Programme (NMCP) was launched, featuring ten schemes, including the "Lean Manufacturing Competitiveness Scheme," which improves productivity through pilot clusters in a Public–Private Partnership (PPP) model [5]. SMEs often adopt lean manufacturing to address operational challenges, but sustaining lean practices remains a concern [26].

2.3 Sustainable manufacturing and lean manufacturing

Lean and green manufacturing are emerging topics in academia and industry. Lean manufacturing focuses on value creation by eliminating non-value-added activities to enhance quality, productivity, and customer satisfaction. On other hand, green manufacturing aims to minimize environmental impacts, promote sustainability while increasing profits and market share [19]. The environmental and social dimensions of sustainability are closely aligned with lean social practices such as continuous improvement, leadership, and employee involvement. These practices enhance resource efficiency

while promoting employee well-being, health, and safety [47]. León & Calvo-Amodio [45] identified the synergy between lean and sustainable operations. The association between the lean practices and sustainable operations was analyzed. The integration of lean and sustainable operations can lead the excellent system performance. Kovilage [40] also discussed the concept of integrated lean and green practices to enhance the system performance. Singh et al. [72] identified the various barriers of integration of lean and green operations. It may lead to improvement in the performance of the firm. Bilancia & Agrawal (2025) discussed that the lean practices are the way to achieving sustainability in the organizations and they are also helpful in promoting the circular economy. In the current completive era, the concept of lean 4.0 also plays a significant role for sustainable manufacturing [66, 67, 76].

2.4 Stakeholder's commitment

Over the past 25 years, organizations have explored lean and green manufacturing principles, yet significant sustainability challenges exist. This demands further research and practices to identify gaps and propose effective solutions [6]. Stakeholder pressure and international market are driving industries in South Asia, particularly in India and China, to incorporate sustainable practices into their manufacturing systems [52]. Therefore, the role of stakeholder is also important in this context. Early research on sustainability has identified significant environmental and economic benefits of lean and sustainable manufacturing practices. They are interlinked by stakeholders' commitment to reduce cost and risk and produce competitiveness.

2.5 Sustainable manufacturing competitiveness

Manufacturing industries must balance economic, environmental, and social factors to sustain market presence. While focusing on quality and economic benefits, industries often overuse non-renewable resources, leading to waste and pollution. In this context, both Sustainable manufacturing and lean practices help to improve productivity, quality, and customer focus while eliminating waste. Combining lean principles with Industry 4.0 can address production variability and simplifying operations, which provide organization with a competitive edge [15]. Implementation of sustainability in manufacturing, high value-added systems can lead to Sustainable manufacturing competitiveness [36, 37, 54]. Use of scientific tools and methods can help in achieving competitive advantage [49]. Smart manufacturing systems that enabled the smart life cycle analysis of the product can help with the timely analysis of carbon footprints and energy usage. These smart and sustainable manufacturing systems can lead to sustainable manufacturing competitiveness [27].

In the past decade, manufacturers have faced growing pressure to balance economic goals with environmental and social responsibilities. The growing need to reduce environmental impacts while enhancing financial and social benefits drives manufacturing companies to adopt lean manufacturing Lean manufacturing. This shift, driven by customer demand for sustainable products, has pushed enterprises to adopt sustainable manufacturing practices [35]. Lean and sustainability interrelationships are widely studied in literature, but most of these studies lacking in the triple-bottom-line aspects, which results in fragmented understanding of their synergies [45].

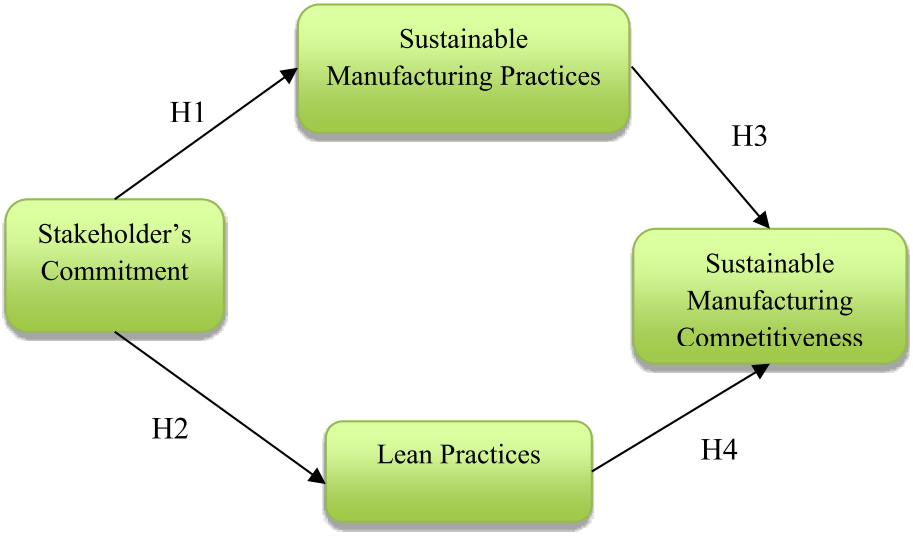


Fig. 1 Theoretical framework

Table 1 Formulated hypothesis

H_1: SHC → SMP	Stakeholders' commitment leads to sustainable manufacturing practices
H_2: SHC → LP	Stakeholder's commitment leads to the lean practices
H_3: SMP → SMC	Sustainable manufacturing practices lead to sustainable manufacturing competitiveness
H_4: LP → SMC	Lean practice leads to sustainable manufacturing competitiveness

Based on the given premise in literature, this research studies the relationship between Stakeholder's Commitment Sustainable (SHC), Sustainable Manufacturing Practices (SMP), Lean Practices (LP), and Manufacturing Competitiveness (SMC) for Indian manufacturing firms. Further, grounded on these relationships, we have developed a theoretical framework, shown in Fig. 1. It consists of all four factors referred to as constructs in this research.

Based on the theoretical framework, we formulated four hypotheses: SHC and SMP, SHC and LP, SMP and MC, and LP and MC. These are detailed in Table 1.

The hypotheses H1, H2, H3, and H4 is proposed to explore the relationship between SHC, SMP, LP, and SMC. This study considers all the constructs to study sustainability. This research work addresses this gap by simultaneously studying four constructions and 25 critical factors.

3 Research methodology

The research aims to generate tangible insights that would be advantageous to Indian manufacturing industries. Figure 2 illustrates the organization of the research design. The conclusions of this study are derived from the published literature of esteemed research articles, providing the conceptual basis for the current research. The research design aims to investigate the relationship between Sustainable Manufacturing Practices (SMP), Lean Practices (LP), Manufacturing Competitiveness (SMC), and Stakeholder's Commitment (SHC).

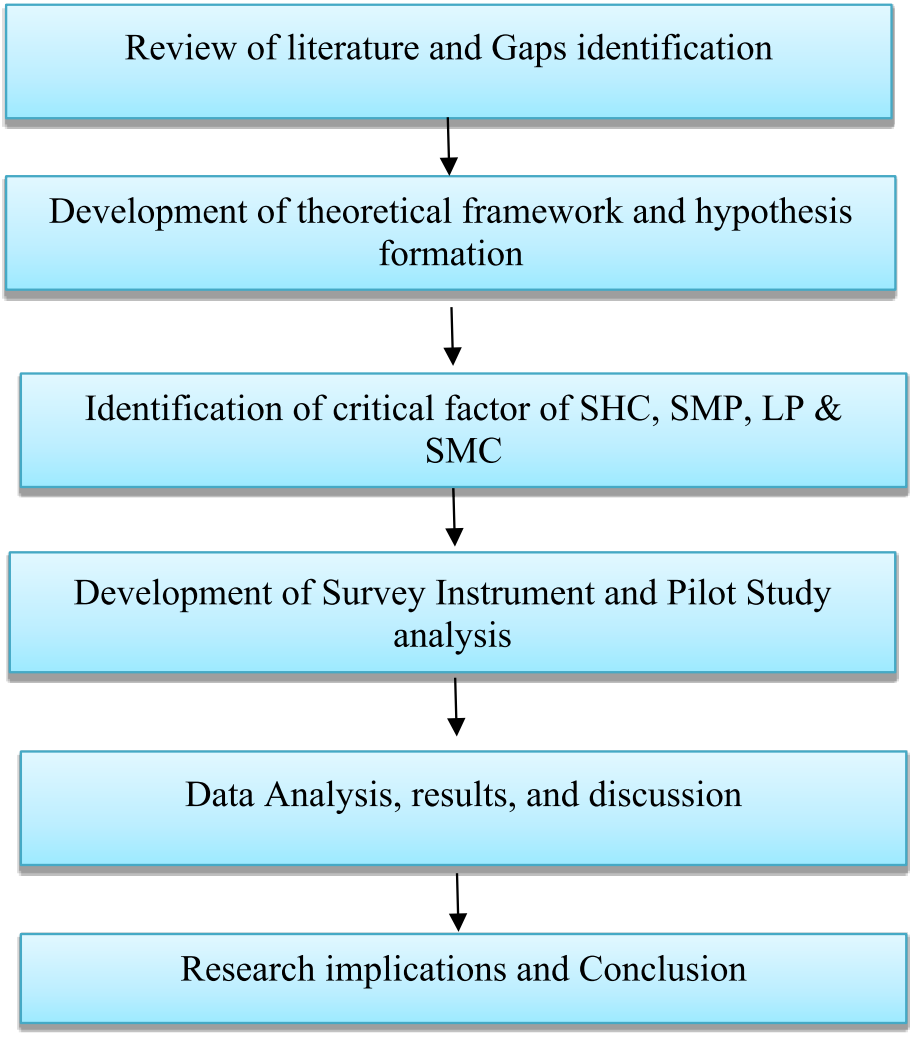


Fig. 2 Research design

3.1 Identification of critical factor of SHC, SMP, LP & SMC

To test the proposed hypotheses, critical factors of Stakeholder's Commitment Sustainable (SHC), Sustainable Manufacturing Practices (SMP), Lean Practices (LP), and Manufacturing Competitiveness (SMC) were identified form the literature and validated through the pricple component analysis. Table 1 presents the critical factors of the research. The 25 critical factors presented in Table 2 were drawn from the literature to measure the relationship between constructions and validate the hypotheses.

3.2 Development of survey instrument and pilot study analysis

To test our proposed hypotheses, survey data is used which is collected on the Likert scale from Indian manufacturing sector. The questionnaire was designed on a five-point Likert scale. Industry professionals provided their answers to each question on a scale of 1 to 5. A pilot research phase was conducted, where early questions were submitted to academics to ensure the correctness of the questionnaire and to gauge individuals' responses. Following that, the questionnaire was distributed to experts from various industries for review and suggestions. Expert suggestions were used to enhance the questionnaire. This process ensured that the questionnaire had been double-checked

Table 2 List of Constructs and critical factors

S. No	Construct	No. of critical factors	critical factors	Literature Source
1	Stakeholder's commitment (SHC)	6	1. Environmental compliances as per governmental policies are strictly adhered 2. Cross-functional cooperation for sustainable manufacturing 3. Motivation towards Sustainability 4. Emphasis on improving eco efficiency 5. Stakeholders Expertise 6. Total quality environmental management	Moneva et al. [56], Sarkis et al. [68], Lam et al. [43], Theyel & Hofmann [79], Matos & Silvestre [53], Blome et al. [7, 8], Nejati et al. [57], Zuraidah Raja Mohd Rasi et al. [86], Yu & Ramanathan [85], Betts et al. [4]
3	Sustainable Manufacturing Practices (SMP)	6	1. Minimizing waste during machining process 2. Energy efficiency during production process 3. Improve resources utilization (materials, water, manpower) on shop floor 4.Use of efficient and clean technology to reduce carbon di oxide footprint 5.Improving the utilization of vegetable oil-based metalworking fluids/cryogenic machining 6. Use of additive Manufacturing	Nowosielski et al. [61], Kopac [39], Pusavec et al. [64], Boubekri et al. [9], Duflou et al. [18], Ngai et al. [58], Despeisse et al. [13], Agan et al. [1], Severo et al. [70], Chuang & Yang [11],Qureshi et al. [65]
4	Lean practices (LP)	6	1. Value Stream Mapping (VSM) 2. Continuous improvement /Kaizen/ Poka-yoke/ Mistake proofing 3. 5S (Sort, Shine, Set in order, Standardize, and Sustain) 4. Total productive maintenance (TPM) 5. Just-in-Time (JIT) 6. Kanban/Pull Production	Lee et al. [44], Hajmohammad, et al. [32], Duarte & Cruz-Machado [16], Habidin et al. [30], Dhingra et al. [14], Glover et al. [24], Alves et al. [2], Longoni et al. [48]
5	Sustainable manufacturing competitiveness (SMC)	7	1. Reduced product manufacturing cost 2. Improvement in product and process quality 3. On time delivery of customer products 4. Innovation in product and process design 5. Adoption of advanced technology 6. Increase in profitability 7. Improve Corporate Social Responsibility and organizational growth	Noble [59], Avella et al. [3], Markley et al. [51], Jovane et al. [36, 37], Kristianto et al. [41], Tan et al. [75], Joshi et al. [34], Jin et al. [33], Vanpoucke et al. [80], Gallardo-Vázquez et al. [23]

and was ready to be used for collecting data from respondents from Indian manufacturing sector. The four constructions consisting of 25 critical factors were used to design a research instrument.

This structured questionnaire was administered among five industry managers and five academicians to test content validity. Based on their feedback and suggestions, the questionnaire was refined for clarity and purpose. A pilot study was conducted to improve the quality and efficacy of the research instrument. The Cronbach's alpha coefficient of 0.97 and a KMO value of 0.6 confirmed the reliability and sample adequacy of the questionnaire [17]. Each construction was checked individually for internal consistency. The Cronbach's alpha coefficient values of 0.907, 0.871, 0.891, and 0.870 for Stakeholder's Commitment (SHC), Sustainable Manufacturing Practices (SMP), Lean Practices (LP), and Sustainable Manufacturing Competitiveness (SMC) respectively ensured the reliability of each construct.

4 Data analysis

For the study, a questionnaire was administered among electrical, electronic, metal, machinery, rubber processing, and other automotive SMEs located in the northern region of India. The respondents, constituting 85.8%, possess experience of 10 years and above with the same organization. They hold positions either at the middle level or in senior management within their respective organizations. All these firms are ISO9000 certified for quality management and quality assurance. Additionally, 84.9% of the participating firms have an environmental policy in place, and 15.1% of the companies are in the process of adopting it.

Out of 152 responding firms, 75.7% have adopted sustainable manufacturing practices in their processes. The 152 usable responses from a survey sample of 1091 were obtained, of which 38.2% are automotive, 15.1% are electrical and electronics, 18.4% are machinery, and 28.3% are process-based firms. This yielded a response rate of 13.93%, which is sufficient to perform further analysis. The IBM Statistical Package for Social Sciences (SPSS) version 22.0 software package was used for data analysis.

4.1 Principal component analysis

Factor analysis was applied to reduce the 26 critical factors into the minimum number of manageable critical factors Upon initial rotation, in the rotated component matrix, all critical factors with factor loadings of 0.5 and above were taken for further analysis [31]. Two critical factors, namely SM3 and SMC1, which cross-loaded onto the original variable (as shown in Table 3), were removed from further analysis to ensure maximum validity of the construct.

4.2 Multifactor structural equation model

In order to examine the relationship between Stakeholder's Commitment (SHC), Sustainable Manufacturing Practices (SMP), Lean Practices (LP), and Sustainable Manufacturing Competitiveness (SMC) the confirmatory factor analysis was performed. A multifactor congeneric structural model was developed to test the formulated hypotheses using the AMOS 22.0 software package.

4.2.1 Assessment of measurement model

To check the reliability and validity of the model, the Content validity, Content validity, Construct Validity, Convergent validity and Discriminate validity were examined.

Content validity: In the current research the content validity was examined by the expert opinion about the constructs [21]. The constructs were identified from literature followed by expert opinion from the academicians and industry professionals.

Construct Validity: The construct validity was estimated using principal component analysis [29]. KMO measure of sample adequacy is > 0.6 for all items of each construct with Eigen value greater than 1, therefore the items for each construct are suitable for factor analysis.

Convergent validity: The convergent validity of the model was examined by average variance extracted (AVE). The value of AVE for the Stakeholder's Commitment (SHC), Sustainable Manufacturing Practices (SMP), Lean Practices (LP), and Sustainable Manufacturing Competitiveness (SMC) is greater than 0.5 [22], which shows the significant convergent validity of construct.

Table 3 Rotated Component Matrix

Rotated Component Matrix[a]				
	Component			
	1	2	3	4
SHC1	0.807			
SHC2	0.798			
SHC3	0.800			
SHC4	0.811			
SHC5	0.786			
SHC6	0.866			
SMP1				0.722
SMP2				0.756
SMP3	0.866			
SMP4				0.659
SMP5				0.638
SMP6				0.625
LP1		0.653		
LP2		0.781		
LP3		0.709		
LP4		0.770		
LP5		0.696		
LP6		0.588		
SMC1				0.510
SMC2			0.526	
SMC3			0.702	
SMC4			0.682	
SMC5			0.722	
SMC6			0.692	
SMC7			0.550	

Extraction Method: Principal Component Analysis

Rotation Method: Varimax with Kaiser Normalization

a. Rotation converged in 5 iterations

Discriminate validity: The discriminant validity of the construct examined by the comparison of Cronbach's alpha the constructs with its mean correlations [62]. In the current research, the value of Cronbach's alpha is higher than the mean correlation of the constructs. This confirmed the discriminant validity.

4.2.2 Assessment of structural model

To test hypotheses H1: SHC –› SMP; H2: SHC –› LP; H3: SMP –› SMC and H4: LP –› SMC as shown in Fig. 1, a structural model was developed by Confirmatory factor analysis (CFA) using SPSS version 22.0 software package as shown in Fig. 3.

The structural model was analyzed based on the fit between the theoretical model and the data, assessed through goodness-of-fit indices. The computed model fit indices revealed the values of $(\chi 2)/df = 1.701$, GFI = 0.808, AGFI = 0.789, RMR = 0.044, NFI = 0.815, CFI = 0.911, and RMSEA = 0.046. All the obtained values are within the recommended range, suggesting an acceptable fit and relationship among structural variables, i.e., SHC, SMP, LP, and SMC [62].

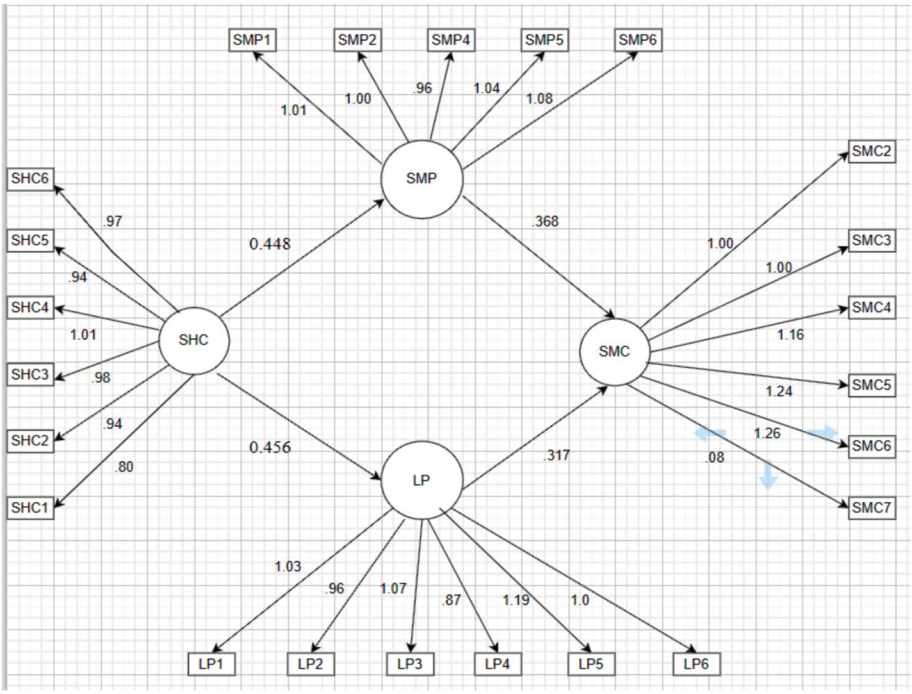


Fig. 3 Structural model of research constructs

Table 4 The results of the structural model

Hypothesis	Estimates (Standardized) (β)	Standard Error (S.E.)	Critical Ratio (CR)	P	Results
H_1: SHC → SMP	0.448	0.065	6.845	***	Supported
H_2: SHC → LP	0.456	0.07	6.552	***	Supported
H_3: SMP → MC	0.368	0.07	5.289	***	Supported
H_4: LP → MC	0.317	0.062	5.122	***	Supported

Path loadings are significant at ***P < 0.001; *P < 0.5

5 Results of hypothesis testing and discussion

The SEM result validates the multifactor congeneric model by analyzing the relationship among four constructs i.e. stakeholder's commitment, sustainable manufacturing practices, lean practices, and manufacturing competitiveness. The estimates of structural models as shown in Table 4 indicate the result. Based on these results of SEM analysis, the following inferences are derived:

- The first hypothesis-H1 can be explained by the fact that in manufacturing-based organizations stakeholders are adopting sustainable manufacturing practices. They are striving for sustainability through IoT, clean energy, flexible manufacturing systems and artificial intelligence. Automobile companies are redesigning products, reusing materials, and choosing standard components to reduce the material wastage. Many large-scale auto manufacturers like Toyota, Tata, and Volkswagen are developing their upstream supply chain partners in India in implementing digital technology to enables sustainability in end-to-end manufacturing process. They ensure compliance with global norms at these suppliers and enhance eco-efficiency in their processes. Such critical role of stakeholders leads to supply chain competitiveness [38, 46]. Wankhede & Agrawal [83] stated that the lean six sigma play a vital role in achieving sustainability in manufacturing.

- The second hypothesis-H2 emphasizes the critical role of stakeholders in achieving lean practices. Stakeholders, across the supply chain group activities as value-added, non-value-added and necessary non-value-added through control techniques like value stream mapping, visual control, 5 S, six sigma etc. and implement mutually agreed measures to deliver end-to-end results [42, 53, 73]. Firms like Chrysler and Mitsubishi ensure lean strategies within projects. They integrate feedback upon wastages to achieve goals of lean process. In order attain end-to-end efficiency firms incorporate lean practices within the structure [4, 55]. Large scale members provide technological support and help in skilling the employees of their downstream partners. Ultimately, they perpetrate strategies and policies to attain lean processes and products.
- The third hypothesis supports the adoption of environmentally conscious manufacturing practices for competitiveness. Manufacturing firms adopt innovative operational practices like lifecycle assessment and digital technologies like supply chain twins lead to manufacturing effectiveness. Through collaboration supply chain members optimize each process, improve material sourcing, and augment digital skill of its employees. Ultimately, such worthwhile practices lead to an optimal utilization of resources and plant capacities that ultimately bring competitiveness in manufacturing. On the market side, customers receive an environmentally and socially safe product. In present, firms like Apple and Samsung in electronics sector and GM and Ford in automotive sector have developed a circular manufacturing process to attain environmentally viable products [74, 84]. The balance of sustainable manufacturing with an objective to improve competitive priorities derives manufacturing competitiveness.
- The fourth hypothesis H4 explains the importance of lean practices like Kanban system, Kaizen and Heijunka to attain manufacturing competitiveness. Firms like Toyota Motor Company perform value stream mapping, estimates Takt time, follow 5S techniques to improve production performance [20]. It improves manufacturing performance by eliminating waste from processes and thus brings competitiveness in the manufacturing system [81]. Firms are relying upon data driven life cycle assessment techniques to attain sustainability goals [28]. Such systematic control improves operational performance, which ultimately reflects in improved productivity and quality. Thus, excel among the competitors in the industry.

6 Implications of the study

The findings highlight the importance of stakeholder engagement to improve manufacturing competitiveness through sustainable and lean manufacturing practices. These insights will assist managers in making informed decisions related to the implementation of LSM practices to achieve long-term sustainability and operational efficiency. The present study contributes to the existing literature of lean and sustainable manufacturing by providing an integrated framework that examines the impact of lean and sustainable manufacturing practices on market competitiveness. The study also offers practical recommendations for Indian manufacturers which will be helpful to enhance the sustainability initiatives while maintaining competitiveness in the global market.

7 Conclusion, limitation and future research direction

This study developed and validated stakeholder's commitment (SHC) to achieve manufacturing competitiveness (MC) through lean practices (LP) and sustainable manufacturing practices (SMP). The novelty of the study is to assess sustainable manufacturing competitiveness through lean and sustainable manufacturing. In short, this study provides a framework consisting of 25 critical factora that can operationalize and decode manufacturing competitiveness while being lean and sustainable. The research result supports the four-hypothesis formulated at the initial stage of this research work. It fortifies the fact that stakeholder's commitment influences the lean practices and sustainable manufacturing practices. In turn, this results in manufacturing competitiveness. While conducting this study numerous challenges faced by researchers limited the scope of its application. Despite the fact that the questionnaire was administered among the respondents from diverse manufacturing firms located in India, but it was nearly impossible to get equal responses and representation from all types of manufacturing firms. The research work on sustainability through competitive manufacturing practices is burgeoning. Future research on countries other than India can help to understand that how efficient manufacturing techniques of developed nations can help to attain bottom line of the millennium goals. Precisely, it will help to locate the difference in policies and practices can be replicated in other locations.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1007/s42452-025-07451-x.

Additional file 1.

Author contributions

S.G.—Conceptualization; S.G., D.J., A.J. and N.B.—Resources; S.G., D.J., A.J. and N.B.—Data curation; S.G., D.J., A.J., N.B. and S.J.—Formal analysis; S.G., D.J., A.J. and N.B.—Investigation; D.J.—Methodology; D.J., A.J. and N.B.—Software; S.G., D.J., A.J. and N.B.- Writing—original draft preparation; S.J.—Writing—review and editing; S.G., D.J., A.J. and N.B.—Visualization; S.G., D.J., A.J., and N.B.—Validation; D.J., A.J. and N.B.- Resources; S.J.—Supervision; S.J.- Project administration; S.J.—Funding acquisition. All authors have read and agreed to the published version of the manuscript.

Funding

Open access funding provided by Lund University.

Data availability

Data generated and/or analyzed during this study are available from authors upon reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 2 March 2025 / Accepted: 4 July 2025

Published online: 28 August 2025

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2025-08-28
Springer
https://doi.org/10.1007/s42452-025-07451-x
Gupta S, Joshi D, Jamwal A, et al., (2025) Unveiling the synergy of sustainable manufacturing practices and lean for sustainable manufacturing competitiveness. Discover Applied Sciences, Volume 7, August 2025, Article number 1005

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