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Green Manufacturing and Performances in Apparel Export Industry: Mediating Role of Green Innovation

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Implementing green manufacturing in the production process of garment export-oriented enterprises not only contributes to environmental well-being but also enhances competitiveness in the global market and boosts overall company performance. Furthermore, it is critical to take immediate action to improve sustainable production levels via green innovation. This study aims to investigate the impact of green manufacturing on operational performance, environmental performance, and economic performance in the apparel manufacturing export industry. The study also investigates the mediating role of green innovation as a mediator between the green manufacturing and types of performances. A survey method is used to collect data from 123 garment export units, and structural equation modelling (SEM) is used to analyze the results. This study delivers empirical evidence of the impact of the implementation of green manufacturing on green innovation and economic performance. Moreover, green innovation has a significant impact on economic performance and environmental performance. The results signify that green innovation partially mediates green manufacturing and economic performance. Green innovation fully mediates green manufacturing and environmental performance, and also green manufacturing and operational performance. This study is unique in its focus on the use of green manufacturing and green innovation in garment export production units. It provides insights into how these green practices might improve firm performance and the environment.

Keywords: sustainability, green manufacturing, garment, performance.

Introduction

Countries aim to capture a share of the global market in order to establish a presence in the economic world. To reduce the environmental effect of their products and manufacturing processes, businesses utilize greener ways of production (Hens et al., 2018). Greener methods preserve natural resources, lower waste production, and maintain operational quality, all of which contribute to the triple bottom line of sustainability (dos Santos and Campos, 2022). The adoption of sustainable practices can provide a strategic edge

for gaining competitive advantages (Li et al., 2016), mitigating resource scarcity (Desore and Narula, 2018) and promoting the sustainable growth of the fashion industry (Todeschini et al., 2019). Therefore, formalizing a model with strategic methods that prioritize sustainability is crucial for both firm growth and strategic advantage (Macchion et al., 2018). However, a number of analysts predict that in the near future, China's fashion companies would have unique challenges when implementing green manufacturing, including capacity constraints and rising costs (Choi et al., 2017).

Literature Review and Hypothesis Development

Resources-based view (RBV) theory

The resource-based view (RBV) framework has been employed to analyze the significance of resources and capabilities in the context of product innovation, as well as the relationship between product innovation and the entire performance of a corporation (Hart, 2011). According to the resource-based view viewpoint, green innovation is a valuable intangible asset for organizations. Green innovation helps firms improve sustainability and gain a competitive edge in the long run. This study utilized this theory to establish the connection between green manufacturing, green innovation, and performance.

Green manufacturing and green innovation

The literature study demonstrates how green manufacturing has become more popular due to society's increased knowledge of environmental and sustainable development challenges. Green innovation helps businesses become more sustainable by cutting expenses while boosting output, efficiency, and product quality (Albort-Morant et al., 2016). Innovations in products and processes are introduced to produce products with better manufacturing methods which reduce the adverse effects on the environment. Cradle-to-cradle design (Braungart et al., 2007), closed loop fashion, circularity (Moorhouse and Moorhouse, 2017), and eco-design (Kozlowski et al., 2018) are a few examples. In order to achieve sustainable development in textile and apparel, designers are crucial (Kozlowski et al., 2018). The research by Pandey and Saluja (2023) investigates significant aspects of environmentally friendly production from the perspective of the apparel industry and gives creative and innovative solutions to problems. In line with the previously cited research on green manufacturing, we claim that there is a considerable correlation between green innovation and green manufacturing in the fashion business. Therefore, the interconnection between green manufacturing (GM) and green innovation (GI) is investigated with the following hypothesis:

(H1): Green manufacturing (GM) has a significant positive impact on green innovation (GI).

Green manufacturing and performance

Fashion companies are implementing sustainable strategies in their supply chains to incorporate economic, social, and environmental factors while adopting green manufacturing techniques (Nayak et al., 2019). Thorisdottir and Johannsdottir (2019) claim that the apparel sector has implemented the concept of a sustainable business model to help businesses achieve both financial performance and sustainability goals at the same time. The study by Herath and Rajumesh (2022) looks at how Green Supply Chain Management practices affect organizational performance in the garment industry in Sri Lanka. Meena et al. (2022) divide sustainability issues into several categories, including social, environmental, and economic, and apply them to the textile and clothing business in India. The adoption of green supply chain methods was found to have a (direct) beneficial influence on operational, economic, and environmental performance as well as an indirect positive effect on organizational performance, according to Habib et al. (2022). In the context of Chinese fashion firms, green manufacturing significantly improves practice performance (Li et al., 2020). Numerous scholarly studies have been released, outlining the advantages of implementing these strategies. According to a study, using GSCM would improve an organization's performance (Yildiz and Sezen, 2019). Therefore, on the basis of the existing literature review, the study examines the connections between green manufacturing and three types of performance in apparel manufacturing export industry, namely, operational performance, environmental performance, and economic performance. The research hypotheses are as follows:

(H2): Green manufacturing has a significant impact on economic performance.

(H3): Green manufacturing has a significant impact on environmental performance.

(H4): Green manufacturing has a significant impact on operational performance.

Green innovation and performance

According to Pandithasekara (2022), organizational performance is driven by green innovation. The innovation and proactive measures have an important and positive effect on the export performance of the clothing sector (Azmi and Hossain, 2021). Additionally, this study contends that green innovation has an impact on three types of performance in the garment manufacturing export industry. As a result, the following hypotheses are used to investigate the interconnections between the constructs:

(H5): Green innovation has a significant impact on economic performance.

(H6): Green innovation has a significant impact on environmental performance.

(H7): Green innovation has a significant impact on operational performance.

Green manufacturing, green innovation and performance

Green manufacturing, green purchasing, eco-design, customer collaboration, and green information systems are examples of GSCM activities that have a significant impact on a firm's financial performance both directly and through environmental performance (Kalyar, 2020). Businesses that embrace innovation expand and create environmentally friendly production techniques, as well as boost their market share. Additionally, the study contends that green innovation plays an important mediating role between green manufacturing and three types of performance in the garment manufacturing export industry, adding to the pool of knowledge on green manufacturing. As a result, the following hypotheses are used to investigate the interconnections between the constructs:

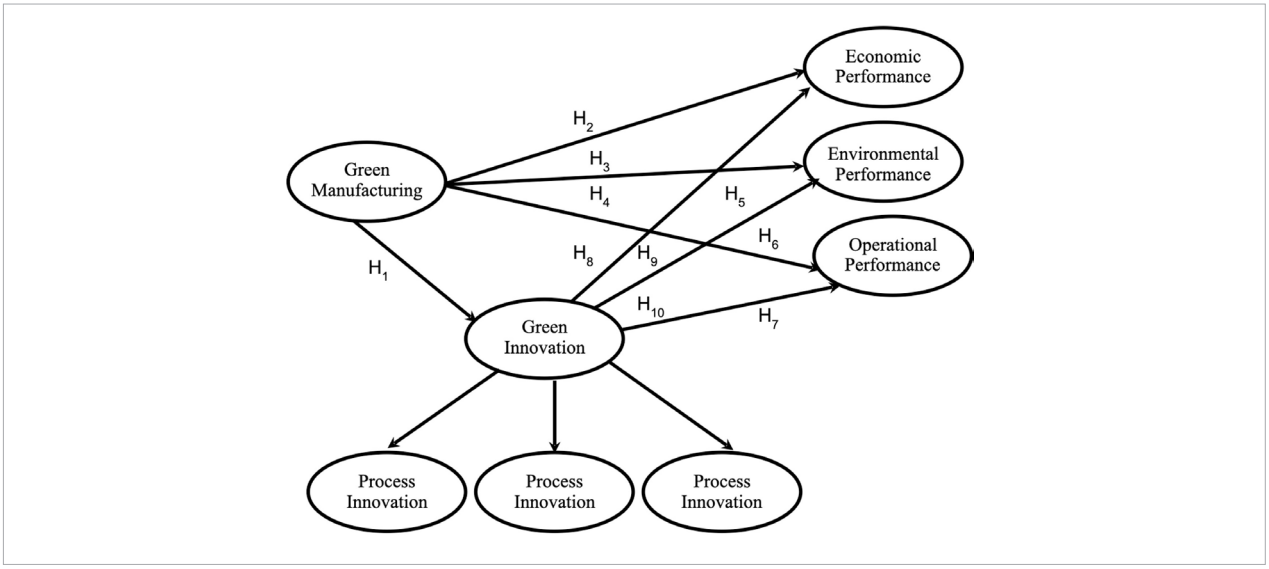
(H8): Green innovation has a significant mediating effect on green manufacturing and economic performance.

(H9): Green innovation has a significant mediating effect on green manufacturing and environmental performance.

(H10): Green innovation has a significant mediating effect on green manufacturing and operational performance.

Despite the abundance of research on green manufacturing and performance, none of it specifically addresses to apparel export industry. In the particular context of export-oriented garment manufacturing companies, the correlation between green manufacturing, three types of performance, and the mediating impact of green innovation has not been studied. In addition, quite a few previous research studies on green manufacturing were conceptual, qualitative, literature surveys, or investigations with other variables. As a result, studies based on quantitative data are still required (Jabbour and Jabbour, 2016). According to Mitra and Datta (2014), export-oriented businesses face increased demand from foreign clients to implement Green Manufacturing Practices for this reason, the study only looks at export-oriented clothing companies. The study is distinctive because it fills a gap and offers a worthwhile opportunity for further investigation. As indicated by the literature review and the research gap identified, the conceptual research framework is presented (refer to *Fig. 1*).

Fig. 1. *Conceptual framework*



Methodology

Sample and collection

The research employs a deductive approach, quantitative analysis, and a questionnaire survey method for data collection (Forza, 2002). The population of the study consists of companies that produce apparel for export from the southern Indian state of Karnataka. Karnataka has 176 export houses that manufacture clothing, according to Apparel Export Promotion Council so the sample size for the population under study is 123 (Krejcie and Morgan, 1970). The research population is selected based on the type of a firm (export) and the type of a manufacturing sector (apparel manufacturing). Using random sample techniques, the data is gathered from export houses that manufacture clothing. After contacting 159 possible respondents for the electronic survey, 127 businesses returned completed questionnaire. Consequently, the rate of return is 79.8%.

Variable measurement

The developed questionnaire was evaluated by academicians and business experts. The first section of the questionnaire included objectives of the study and instructions to complete the questions. Respondents were asked for personal details, including demographics, in the second section. A seven-point Likert scale (1–7), with 1 denoting "strongly disagree" and 7 denoting "strongly agree", is used in the third section to describe the constructs of the research. Five constructs are included in the study: Green Innovation, Green Manufacturing, and three types of performances. Shang et al. (2010) validated the Green Manufacturing construct, which included 15 items. The study employs three-forms of innovation: green process innovation, green product innovation, and green managerial innovation. The scales used for validation of Green Process Innovation construct includes 4 item; Green Product Innovation includes 7 items; Green Managerial Innovation construct includes 4 items (Chen et al., 2006; Chen, 2008; Chi et al., 2011). Hajmohammad et al. (2013) and Rao (2002) validated the construct of Environmental Performance (6 items). Zhu et al. (2005) validated Operational Performance (5 items). Rao (2002), Rao and Holt (2005), Green et al. (1998), Melnyk et al. (2003), Theyel (2000), and Zhu and Sarkis (2004) validated Economic Performance (5 items).

Data analysis method

Since Smart PLS 4.1 software is a useful tool that provides high flexibility between the linkages between the data and the theory, it was employed for the data analysis (Vanalle et al., 2017). According to Hair et al. (2016), PLS-SEM is frequently utilized in the social science, marketing, and business strategy research domains where it produces dependable results. A two-step procedure was used, whereby the suggested theoretical model assessed the outer model for reliability, convergent and discriminant validity first, and then the inner model was assessed for testing hypotheses.

Results

Characteristics of respondents

Data collected from July to November of 2023 were used in the study. The demographics of 123 respondents are listed in *Table 1*.

Common method variance (CMV) has been shown to have a substantial impact on study outcomes if it is not adequately controlled by statistical and procedural remedies (Tehseen et al., 2017). Harman one-factor test (1976) can be used to test the common method bias, and variance inflation factors (VIF) test for collinearity. According to Podsakoff et al. (2003), the single construct's total variance below 50% is acceptable (Podsakoff et al., 2003). The research has a CMB of 42% and VIF is less than the recommended level of 3.4 (Kock, 2015). As a result, the data are free of common method bias.

Measurement model assessment

As recommended by Hair et al. (2016), a number of statistics were used to determine the validity and reliability of the study outer model. Among these statistics are "discriminant validity", "convergent validity", "composite reliability" (CR), and "internal consistency reliability" (Cronbach's alpha). As shown in *Table 2*, the scale exhibits good internal reliability, with Cronbach's alpha (α) values ranging from 0.881 to 0.946 and composite reliability (CR) values ranging from 0.909 to 0.947 (Hair et al. 2016). The standardized factor loading (SFL) values for each of the factors were larger than 0.70, providing further evidence that the study's dimensions have a satisfactory degree of reliability.

Table 1. *Demographic characteristics of the companies*

Demographics	Categories	Frequency	Percentage
Job title of the respondents	Director	9	7.3
	Manager	103	83.7
	Product developer	3	2.4
	Vice president	8	6.5
	Total	123	100.0
Firm's turnover	1000 crore and above	8	6.5
	greater than 1 crore and less than 100 crore	64	52
	greater than 100 crore and less than 500 crore	14	11.4
	greater than 500 crore and less than 1000 crore	27	22.0
	I crore below	10	8.1
	Total	123	100.0
Age of company	> = 21	52	42.3
	0–5 years	16	13.0
	11–20 years	37	30.1
	6–10 years	18	14.6
	Total	123	100.0
Number of employees	Between 100 and 299	29	23.6
	Between 300 and 599	19	15.4
	Between 500 and 699	14	11.4
	Between 700 and 999	12	9.8
	Between 700 and 999	1	0.8
	Over 1000	48	39.0
	Total	123	100.0
Implement GM practices	0 ~ 2 years ago	37	30.1
	2 ~ 4 years ago	29	23.6
	More than 4 years	57	46.3
	Total	123	100.0

The AVE values greater than 0.5 were used to determine whether or not convergent validity had been retained (Fornell and Larcker, 1981). In addition, three primary criteria were used in order to confirm that the scale possesses sufficient discriminant validity, as recommended by Hair et al. (2006). These criteria comprised the heterotrait-monotrait method ratio (HTMT), the cross-loading matrix, and the Fornell-Larcker criterion method. HTMT levels are to be less than 0.90 (Henseler et al., 2015). The fundamental basis of the Fornell-Larcker criterion (FLC) for a specific construct exhibits a higher magnitude when compared with the

relationship it has to every other construct (see *Table 3*). The study's HTMT levels were substantially below the recommended value of .9 (refer to *Table 4*).

The cross-loading values are higher than the intervariable correlation coefficient, indicating good discriminant validity. When combined, the findings of the study validate and support the convergent validity, discriminant validity, and scale reliability, that are acceptable for the outer measurement model.

Table 2. *Construct reliability and validity analysis*

Construct	Item code	SFL	Cronbach's alpha	Composite reliability (rho_a)	Average variance extracted (AVE)
Economic Performance (EP)	EP 1	0.912	0.921	0.929	0.762
	EP 2	0.896			
	EP 3	0.763			
	EP 4	0.873			
	EP 5	0.912			
Operational Performance (OP)	OP 2	0.764	0.881	0.913	0.673
	OP 3	0.857			
	OP 4	0.862			
	OP 5	0.833			
	OP1	0.780			
Environmental Performance (EnP)	EnP 1	0.794	0.899	0.909	0.665
	EnP 2	0.864			
	EnP 3	0.757			
	EnP 4	0.849			
	EnP 5	0.776			
	EnP 6	0.845			
Green Manufacturing (GM)	GM1	0.838	0.946	0.947	0.695
	GM10	0.842			
	GM11	0.861			
	GM12	0.834			
	GM13	0.818			
	GM14	0.841			
	GM2	0.744			
	GM3	0.787			
	GM4	0.813			
	GM5	0.867			
	GM6	0.878			
	GM7	0.869			
	GM8	0.786			
	GM9	0.875			
Green Innovation (GI)	GMI	0.948	0.915	0.916	0.855
	GPI	0.929			
	GPRI	0.897			

Table 3. *Fornell–Larcker criterion (FLC)*

	EP	EnP	GI	GM	OP
EP	**0.87**				
EnP	0.40	**0.81**			
GI	0.81	0.57	**0.92**		
GM	0.77	0.56	0.84	**0.83**	
OP	0.28	0.58	0.47	0.40	**0.82**

Note(s): EP, Economic Performance; OP, Operational Performance; EnP, Environmental Performance; GI, Green Innovation.

Table 4. *Heterotrait–monotrait ratio (HTMT)*

	EP	EnP	GI	GM	OP
EP					
EnP	0.424				
GI	0.874	0.611			
GM	0.809	0.575	0.894		
OP	0.292	0.634	0.508	0.411	

Note(s): EP, Economic Performance; OP, Operational Performance; EnP, Environmental Performance; GI, Green Innovation.

Structural model assessment

To verify the study's presented hypotheses, a structural equation investigation was used. Using 10 000 samples and bootstrapping, the direct path coefficient value in smart PLS was determined. Next, we examined the effects of mediation between the constructs. In addition, minimum recommended R^2 value is 0.10 to ensure an acceptable model fit. Green innovation, the endogenous variable, showed an R2 value of 0.762. The R2 values for Operational Performance, Environmental Performance, and Economic Performance were 0.209, 0.336, and 0.674, respectively (see *Table 7*). All R2 values were higher than the suggested threshold score, indicating that the study model adequately captured the gathered data. The P values, path coefficient (β), and t-statistics were used in the research study to assess the interconnections among the constructs. The relationship in H1, GM on GI (t = 27.649, β= 0.841, $P < 0.000$), was significant; successively for all other hypotheses, see *Table 5*.

Table 5. *Path coefficient*

Hypothesis	Constructs Path	O	STDEV	TS	*P* values	Results
H1	GM -> GI	0.841	0.030	27.649	0.000	Supported
H2	GI -> EP	0.568	0.127	4.475	0.000	Supported
H3	GI -> EnP	0.343	0.145	2.372	0.018	Supported
H4	GI -> OP	0.465	0.222	2.097	0.036	Not supported
H5	GM -> EP	0.287	0.131	2.194	0.028	Supported
H6	GM -> EnP	0.270	0.151	1.788	0.074	Not supported
H7	GM -> OP	0.007	0.229	0.031	0.975	Not supported

Note(s): CP, Construct Path; O, Original sample; STDEV, standard deviation; TS, T statistics; PV, *P* Value.

Table 6. *Mediation table*

Hypothesis	Direct effect	Coff.	*P* values	Indirect effect	Coff.	*P* values	LCL 2.5 %	UCL 97.5%	Total effect	Mediation
H 8	GM -> EP	0.289	0.026	GM -> GI -> EP	0.477	0.000	0.261	0.656	0.765	Partial mediation
H 9	GM -> EnP	0.271	0.060	GM -> GI -> OP	0.388	0.041	0.078	0.557	0.559	Full mediation
H 10	GM -> OP	0.015	0.947	GM -> GI -> EnP	0.288	0.018	0.046	0.789	0.402	Full mediation

Note(s): EP, Economic Performance; OP, Operational Performance; EnP, Environmental Performance; GI, Green Innovation.

As a result, research hypotheses H1, H2, H3, and H5 are supported, while H4, H and H7 are not. This signifies that except for Operational Performance, Green Innovation constructs directly and considerably impact the Environmental Performance and Economic Performance. Green Manufacturing constructs also directly and significantly impact Economic Performance. Green Manufacturing constructs have no significant impact on Operational Performance and Environmental Performance.

According to Preacher (2008), bootstrapping with 10 000 samples is done to assess the mediating effect of the Green Innovation. By examining the *P* values, path coefficient (β), and T statistics of indirect specific effects, the study evaluates the significance of the influence of mediation of the constructs.

As shown by the test results of specific indirect effect (β = 0.477, *P* = 0.000), there is a positive significant partial mediation of GI on GM and EP. There is a positive significant full mediation of GI on GM and EnP (β = 0.388, *P* < 0.041). Also, there is a positive significant full mediation of GI on GM and OP (β = 0.288, *P* < 0.018) (see *Table 6*). Therefore, research hypothesis H8 shows a partial mediation, and H9 and H10 show a full mediation.

Predictive power of constructs

The values of LV predictive are mentioned in *Table 7*, which shows that the predictive power of constructs is good. Similarly, the Green Innovation value from the Stone-Geisser Q^2 calculation was 0.705, while the Economic, Environmental, and Operational Performance values were 0.582, 0.296, and 0.140, respectively. *Table 7* shows that all values are greater than zero, suggesting that the structure model has a good degree of predictive ability. In conclusion, in order to ensure a good model fit to the data, the SRMR value should be less than 0.08 and the NFI value should be greater than 0.90. In this case, the SRMR value is 0.070 and the NFI value is 0.810, confirming a good of fit (GoF).

Table 7. *LV predictive summary*

	Q^2predict	R square
EP	0.582	0.674
EnP	0.296	0.336
GI	0.705	0.762
OP	0.140	0.209

Note(s): EP, Economic Performance; OP, Operational Performance; EnP, Environmental Performance; GI, Green Innovation.

Discussion

The findings of the study demonstrated that green innovation has significant impact on green manufacturing in apparel manufacturing industry (H1). The results support the study by Zehir and Ozgul (2020), who demonstrate that environmental orientation fosters green innovation. The results support the findings of Albort-Morant et al. (2016) who demonstrate that green innovation helps businesses become more sustainable. In line with the previously cited research on green manufacturing, we claim that there is still a considerable correlation between green innovation and green manufacturing in the fashion business.

This study signifies that the Green Manufacturing construct directly and considerably impacts the Economic Performance only. Further, this research partially supports the study by Nayak et al. (2019) who emphasize that fashion companies are implementing sustainable strategies in their supply chains to incorporate economic, social, and environmental factors while adopting green manufacturing techniques. Also, this research supports the study by Herath and Rajumesh (2022), who find that GSCM practices positively impacted a number of organizational performance factors in Sri Lanka. The research partially corroborates the findings of Habib et al.'s study (2022), which highlights the

positive effects of implementing green supply chain strategies on operational, economic, and environmental performance. However, this research contradicts the above study by providing empirical evidence that green manufacturing has no significant impact on operational performance and environmental performance. Hypothesis H5 supports the existing literature.

This study signifies that Green Innovation construct directly and considerably impacts Economic Performance and Environmental Performance. This research supports the study by Azmi and Hossain (2021) who emphasize that innovation and proactive measures have an important and positive effect on the export performance of the clothing sector. This research supports the study by Shim et al. (2016) who emphasize that green innovation procedures enhance market positioning and raise the firm's worth. The study findings also support the study by Hossain and Azmi (2021), who conclude that innovation and aggressive actions have a favorable and significant influence on the export performance of the apparel sector. Therefore, hypothesis H5, H2 and H3 support the existing literature. This study adds to current research on green manufacturing by providing empirical proof of the full mediation of green innovation in implementation of GM and its impact on environmental performance and operational performance. Additionally, it demonstrates that green innovation has a significant partial mediation on implementation of GM and its impact on economic performance. Therefore, H1, H2, H3 and H5 are supported and H4, H6 and H7 are rejected.

Implication, Conclusions and Limitation

Implication

Theoretical implication: The research makes several contributions to the body of knowledge on environmentally friendly production in the apparel industry. Both academics and researchers will benefit from the study. According to the research, clothing manufacturing companies who export their products should concentrate on green innovation to encourage companies to adopt green practices. The study's analysis of the mediating effects between the components significantly expands the pool of knowledge on green manufacturing. The study adds to the pool of information by showing that green innovation alone is adequate to support green manufacturing; and the mediation impact of green innovation is also significant. This study provides support for the resource-based view (RBV) paradigm that implementing green innovations in the garment, its manufacturing process and management may provide substantial beneficial effects on environmental performance and economic performance.

Managerial implication: First, the research enables experts in the apparel sector to comprehend the significance of numerous concepts, such as green innovation and demands for green manufacturing implementation at the firm level, and to reset environmental resources appropriately. Second, garment export companies competing for orders from other nations may utilize green innovation to adopt green manufacturing and plan business strategies to achieve organizational goals. Third, the research will assist garment exporters in growing their apparel export companies by getting certifications like LEED and ISO 14000 after implementing green manufacturing practices. Finally, this finding will help the worldwide garment manufacturing industry. Understanding GM practices and formulating strategic plans to include innovation in green practices will be made easier for management, practitioners, and the organization's environment manager with the support of the research to improve performance. Finally, in a competitive and complicated business environment, the research aids management in building strategic competencies in green manufacturing to improve overall performance of the company.

Conclusion

The findings of the study demonstrated that green innovation has a significant impact on green manufacturing in apparel manufacturing industry. This study signifies that Green Manufacturing construct directly and considerably impacts Economic Performance. This study adds to current research on green manufacturing by providing empirical proof of the full mediation of green innovation in implementation of GM and its impact on environmental performance and operational performance. Additionally, it demonstrates that green innovation has a significant partial mediation on implementation of GM and its impact on economic performance. Both academics and researchers will benefit from the study. According to the research, clothing manufacturing companies

that export their products should concentrate on green innovation to encourage companies to adopt green practices. Also, garment export companies competing for orders from other nations may utilize green innovation to adopt green manufacturing and plan business strategies to achieve performance goals.

Limitation

One of the study's limitations is that it was conducted in Karnataka's clothing manufacturing export-oriented firms. Second, the study's generalizability is constrained by the fact that the data were gathered from top or middle management at the firm level. The study also examines how the constructs interact and influence one another directly and indirectly. Future studies may examine the moderating impact of constructs, including various business stakeholders in the textile and apparel industries. Potential avenues for further study might involve utilizing a qualitative approach through focus groups, interviews, and observation techniques to develop a deeper understanding of this subject.

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