The effect of sustainable manufacturing on environmental performance through government regulation and eco-innovation

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Abstract

Purpose – The study aims to determine the impact of sustainable manufacturing on environmental performance through government regulation and eco-innovation in Indonesian small and medium-sized enterprises (SMEs).

Findings – The results indicate sustainable manufacturing plays a significant role in SMEs' environmental performance and regulations, and eco-innovation can moderate it. It also reveals that government regulation has a positive and significant effect on environmental performance. Moreover, eco-innovation has a positive and significant effect on environmental performance.

Practical implications – The findings of this study indicate that SMEs can embrace sustainable manufacturing practices and achieve their long-term sustainability goals by adhering to regulations, collaborating with stakeholders and implementing eco-friendly innovations.

Originality/value – This research uncovers ground-breaking perspectives on the evolution of scientific knowledge about the impact of eco-innovation, regulatory measures and sustainable manufacturing practices on the environmental performance of SMEs.

Keywords Sustainable manufacturing, Environmental performance, Government regulation, Eco-innovation

Paper type Research paper

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1. Introduction

In today's fast-paced business landscape, the establishment of an organization, be it a company or other entity, is closely related to its social environment. As businesses thrive within their social context, they assume a responsibility to contribute to the progress and well-being of society as a whole. One important aspect of fulfilling this responsibility is measuring the performance of the business environment. Companies that prioritize environmental concerns are not only concerned with sustainability but also with the longevity of their operations. In order to raise awareness about the environment and push towards an environmental-friendly sector, the application of sustainable production becomes very important. According to Moldavska and Welo (2017), manufacturing activities prioritize production systems that utilize technology to process materials to minimize energy use, greenhouse gas emissions, waste disposal and the use of non-repeatable materials which ultimately improves environmental performance company. The relationship between internal environmental practices and environmental performance is acknowledged by Zhu and Sarkis (2007), who posit a direct positive correlation. This signifies that companies that prioritize green production and adopt sustainable manufacturing practices are more likely to achieve favorable environmental outcomes. The concept of sustainable manufacturing aligns closely with the notion of green production, which is achieved by employing the principles of the 3Rs (reduce, reuse, recycle) approach throughout the product life cycle. Sustainable manufacturing encompasses the notion of creating economic value through processes that minimize negative environmental impacts, conserve energy and natural resources and ensure their availability for future generations. Moreover, it emphasizes the need for employee safety throughout the manufacturing process.

Government regulations, eco-innovation and environmental-friendly innovations play crucial roles in shaping the adoption of sustainable manufacturing and its subsequent environmental impact. Numerous prior studies discuss how sustainable manufacturing goes beyond its environmental effects and encompasses the interplay of government regulations and technological advancements. For example, Nordin *et al.* (2014) indicated that the implementation of sustainable manufacturing in Malaysian companies is influenced by factors such as environmental regulations, top management commitment and corporate image. Moreover, Kulatunga *et al.* (2013) highlight various drivers and obstacles to sustainable manufacturing, including limited awareness of sustainability, lack of government tax incentives or rewards, market pressures and government promotion and regulations. Additionally, Rashid *et al.* (2014) emphasize the connection between eco-innovation and environmental performance, emphasizing how eco-innovation affects pollution prevention, resource conservation and recycling. However, there exists a research gap in understanding the specific mechanisms through which government regulations and technological advancements interact with sustainable manufacturing practices to enhance environmental outcomes. Further investigation is needed to explore this relationship and identify effective strategies for achieving sustainable manufacturing objectives. According to the institutional theory presented by Berrone *et al.* (2013), strict external regulations encourage companies to actively adopt environmental practices and take on greater corporate environmental responsibilities.

In terms of the role of sustainable manufacturing in promoting innovation and business growth, previous studies consistently demonstrate a connection between eco-innovation in manufacturing companies and improved overall eco-efficiency, including environmental benefits. However, there is a research gap in understanding the specific ways in which the government's influence and sustainable manufacturing practices drive innovation and contribute to business growth. Nezakati *et al.* (2016) suggest that the government, as a key stakeholder, can shape the resources of businesses through regulatory power. Berrone *et al.* (2013) propose that stringent external regulations prompt companies to engage in environmental practices. Innovation is crucial for companies to thrive and remain competitive, especially in response to environmental challenges. Gupta *et al.* (2020) argue that product and process

innovation enables firms to differentiate their products, improve quality and reduce costs. Many companies are now focusing on green or eco-innovations that prioritize environmental friendliness across all activities. While innovation requires significant investments, it yields long-term positive impacts on companies. Eco-innovation optimizes productivity and cost efficiency, while product innovation creates new market opportunities. Corporate innovation, driven by environmental concerns, allows companies to strategically manage resources and transition to cleaner production methods (Hojnik *et al.*, 2018). This transition not only unlocks new business opportunities but also influences overall company performance and economic benefits.

This study addresses the following research question:

RQ. What are the specific mechanisms by which governments influence sustainable manufacturing practices that stimulate innovation and contribute to the environmental performance of small and medium-sized enterprises (SMEs)?

The rest of the paper is structured into six sections. Section 2, the literature review reviews the conceptual bibliometric research framework. Section 3 is research methods, which explains the stages of the research. Section 4 presents the results. Section 5 discusses in detail the research findings and relates them to the relevant literature. Finally, section 6 presents the conclusions and discusses the limitations.

2. Literature review

2.1 Sustainable manufacturing and government regulation

In the context of sustainable manufacturing, government regulations play a crucial role in shaping and influencing the practices and behaviors of industries. However, the existing literature primarily focuses on the general impact of regulations on sustainability initiatives without delving into the specific mechanisms through which government regulations influence sustainable manufacturing practices (Hariyani and Mishra, 2022). Several studies have explored the relationship between sustainable manufacturing and government regulation, shedding light on how sustainable manufacturing practices can influence government regulations in various industries. For instance, Kulatunga *et al.* (2013) examined the implementation of sustainable manufacturing practices in the manufacturing sector and found that government regulations play a significant role in promoting and enforcing sustainable practices. They emphasized the importance of government support and incentives in encouraging companies to adopt sustainable manufacturing methods. Similarly, Masudin *et al.* (2023) investigated the impact of sustainable manufacturing practices on government regulations in the Indonesian manufacturing industry. Their findings indicated that companies actively engaging in sustainable manufacturing practices contributed to the development of more stringent environmental regulations by the government.

Based on these previous studies, it can be hypothesized that sustainable manufacturing positively affects government regulation. The hypothesis can be stated as follows:

H1. Sustainable manufacturing practices have a positive impact on government regulations.

2.2 Sustainable manufacturing and eco-innovation

Numerous studies have explored the relationship between sustainable manufacturing and eco-innovation, shedding light on the potential influence of sustainable manufacturing practices on the development of environmental-friendly innovations. Moldavska and Welo (2017) emphasize the significance of sustainable manufacturing in minimizing energy consumption, waste generation and environmental degradation caused by production activities. They argue that sustainable manufacturing catalyzes eco-innovation within manufacturing companies. Similarly, Zhu and Sarkis (2007) assert that sustainable manufacturing practices are positively associated with environmental performance, indicating that companies that prioritize sustainability are more likely to engage in eco-innovative activities.

Previous research has extensively explored the relationship between sustainable manufacturing and eco-innovation. Sustainable manufacturing practices have been found to positively influence eco-innovation initiatives within manufacturing companies. Several studies have established the link between sustainable manufacturing and the development of environmental-friendly innovations. In addition, Afshari *et al.* (2020) conducted a study that consistently demonstrated the positive relationship between eco-innovation and increased overall eco-efficiency in manufacturing companies. Moreover, the adoption of sustainable manufacturing practices encourages companies to seek innovative strategies to reduce resource consumption and enhance productivity.

Based on the existing literature, it can be hypothesized that sustainable manufacturing positively affects eco-innovation within manufacturing companies. By integrating sustainable practices into their production processes, companies are more likely to adopt innovative strategies that prioritize environmental friendliness. The adoption of sustainable manufacturing principles may facilitate the development of eco-innovations, such as the introduction of cleaner technologies, more efficient resource utilization and the creation of environmental-friendly products. Therefore, we can hypothesize that:

H2. Sustainable manufacturing practices have a positive impact on eco-innovation.

2.3 Sustainable manufacturing and environmental performance

Numerous studies have investigated the link between sustainable manufacturing and environmental performance, revealing the positive impact of eco-conscious practices on ecological outcomes. Papetti *et al.* (2019) emphasized that sustainable manufacturing systems focusing on energy efficiency, waste reduction and greenhouse gas minimization are vital for enhancing a company's environmental performance. Moreover, Rehman Khan and Yu (2021) found a positive correlation between internal environmental practices and better environmental outcomes, emphasizing the significance of prioritizing sustainable manufacturing. Moreover, the implementation of sustainable manufacturing practices is influenced by various factors.

In the context of SMEs, previous research has explored the relationship between sustainable manufacturing and environmental performance within the context of various industry sectors. For instance, studies by Dzikriansyah *et al.* (2023) have investigated sustainable manufacturing practices and their impact on the environment. In addition to the direct relationship between sustainable manufacturing and environmental performance, the mediating role of government regulation and eco-innovation should be considered. However, the specific mediating effects of these variables on the relationship between sustainable manufacturing and environmental performance in SMEs have not been extensively explored. This research aims to bridge this gap by examining the mediating effects of government regulation and eco-innovation on the relationship between sustainable manufacturing and environmental performance in SMEs. Therefore, this study investigates the hypothesis:

H3. Sustainable manufacturing practices have a positive impact on environmental performance.

2.4 The role of regulations on environmental performance

The evidence from various studies suggests that regulations play a crucial role in reducing pollution levels, improving air and water quality and promoting sustainable practices across different sectors of the economy. A study conducted by Li *et al.* (2020) analyzed the effects of fuel standards on air pollution in China. The study found that the implementation of stringent regulations significantly reduced pollution levels, leading to improved environmental performance in terms of air quality. Another study by Guo and Yuan (2020) examined the effectiveness of environmental regulations on industrial pollution. The researchers used a

panel dataset of manufacturing plants in the Chinese manufacturing sector and found that stricter regulations were associated with lower emissions of pollutants, indicating a positive effect on environmental performance. Moreover, Wang *et al.* (2021) proposed a structural model, which suggests that well-designed environmental regulations can stimulate innovation and technological advancements, leading to improved environmental performance without sacrificing economic competitiveness. They argued that regulations induce firms to invest in cleaner technologies, which can result in cost savings, enhanced efficiency and overall environmental improvements. The findings from these studies support the hypothesis that stringent environmental regulations positively impact environmental performance. By enforcing compliance and incentivizing technological advancements, regulations can drive industries towards adopting cleaner practices, reducing pollution levels and promoting sustainable development. Thus, this study examines the hypothesis:

H4. Government regulations positively influence environmental performance.

2.5 The role of eco-innovation on environmental performance

Eco-innovation involves activities to reduce resource consumption, minimize waste and promote cleaner production. Studies confirm its positive impact on environmental performance across various indicators. In a study by Geng *et al.* (2021), eco-innovation practices in the manufacturing sector were analyzed, revealing a strong link between eco-innovation and reduced environmental impacts. Firms that adopted eco-innovative measures, such as energy-efficient technologies and sustainable waste management systems, witnessed notable enhancements in energy efficiency, waste reduction and overall environmental performance. Schiederig *et al.* (2012) studied eco-innovation in the automotive industry, discovering that companies developing hybrid and electric vehicles significantly reduced carbon emissions. This highlights eco-innovations importance in combating climate change and enhancing environmental performance in various sectors beyond manufacturing and transportation. Maldonado Guzmám and Pinzón Castro (2023) explored eco-innovations impact on consumer product life cycles. They found that eco-design and sustainable sourcing strategies resulted in substantial reductions in resource depletion, pollution and ecosystem impacts. Based on the reviewed literature, we posit the hypothesis:

H5. Eco-innovation positively influences environmental performance.

2.6 Mediating role of government regulation on sustainable manufacturing and environmental performance

Government regulation acts as a mediator in the relationship between sustainable manufacturing and environmental performance by encouraging organizations to adopt sustainable practices through incentives, penalties and guidelines (Alavi, 2022). Interventions such as environmental policies, financial incentives and certification programs shape organizations' behavior toward sustainability (Dzikriansyah *et al.*, 2023). These regulatory mechanisms help bridge the gap between sustainable manufacturing efforts and actual environmental performance outcomes. Several moderating factors can influence the mediating role of government regulation. The stringency and enforcement of regulations significantly impact organizations' compliance and implementation of sustainable manufacturing practices (Masudin *et al.*, 2022). The level of government-industry collaboration, stakeholder pressures and market conditions also influence the effectiveness of government regulation in mediating the sustainable manufacturing-environmental performance relationship (Masudin *et al.*, 2021c). Despite the recognized role of government regulation in mediating the relationship between sustainable manufacturing and environmental performance, there is a gap in the literature regarding the comprehensive understanding of the moderating factors that influence the

effectiveness of government regulation in this context. Previous studies have highlighted the mediating role of government regulation in the relationship between sustainable manufacturing and environmental performance. However, limited attention has been given to examining the moderating factors that influence the effectiveness of government regulation in this mediation process (Bai and Sarkis, 2014). Therefore, in this study we posit the hypothesis:

H6. Sustainable manufacturing practices affect significantly environmental performance through government regulations.

2.7 Mediating role of eco-innovation on sustainable manufacturing and environmental performance

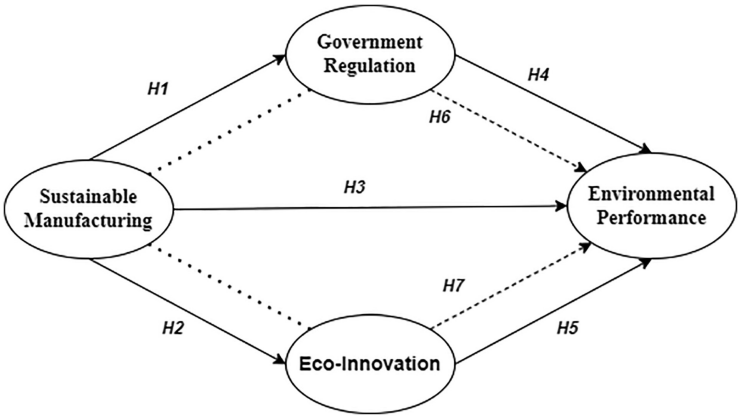
Eco-innovation is pivotal in bridging sustainable manufacturing and environmental performance. By integrating eco-friendly technologies and practices, it boosts environmental outcomes. A study by Bag *et al.* (2022) highlighted how SMEs emphasizing eco-innovation showcased superior environmental performance, affirming its role as a driving force behind sustainable manufacturing practices. The study found that eco-innovation drives sustainable manufacturing practices, enabling SMEs to achieve positive environmental outcomes. It entails developing and implementing eco-friendly technologies, processes and products that minimize environmental impacts across their lifecycle. Eco-innovation enables SMEs to create sustainable solutions, enhance resource efficiency and minimize waste generation (Ceptureanu *et al.*, 2020). It encompasses various aspects such as eco-design, eco-labeling, green supply chain management and the adoption of clean technologies.

The adoption of sustainable manufacturing practices and eco-innovation in SMEs positively impacts environmental performance. Studies show that prioritizing these practices leads to reduced energy consumption, lower greenhouse gas emissions and improved waste management (Handayani *et al.*, 2021). Integrating eco-innovative approaches allows SMEs to minimize their environmental footprint and work towards a sustainable future. However, challenges such as limited financial resources, knowledge gaps, regulatory complexities and resistance to change hinder their implementation (Marin *et al.*, 2015). Overcoming these barriers necessitates support from government agencies, collaboration with research institutions and knowledge-sharing networks and partnerships. Thus, the hypothesis tested in this study is:

H7. Sustainable manufacturing practices significantly affect environmental performance through eco-innovation.

2.8 Theoretical research framework

The framework of thinking can be used to facilitate the flow of thought carried out in this research. Based on the literature review in the previous sections, the opinions of experts and previous researchers have discussed the influence of sustainable manufacturing on environmental performance through government regulation and eco-innovation (see Figure 1). The evidence shows that sustainable manufacturing practices through government regulation and eco-innovation have a positive impact on economic growth, social well-being and environmental conservation. Fernando *et al.* (2015) stated that SMEs which promotes those sustainable manufacturing practices in production activities through eco-innovation, regulation and technology management contributed organization's financial growth. Moreover, sustainable manufacturing practices and eco-innovations can also have positive social impacts. Fernando *et al.* (2022) argued that by incorporating environmental and social considerations into manufacturing activities, companies can enhance their reputation and strengthen relationships with consumers, employees and communities. In



Source(s): Authors work

Figure 1.
Research framework

addition, Chau *et al.* (2023) indicated that regulations and eco-innovation mediate the role of sustainable production practices on environmental performance. Their study showed that environmental degradation by controlling emissions can be minimized using sustainable-oriented eco-innovation. As governments and industries continue to prioritize sustainability, further evidence and advancements are expected to strengthen the case for sustainable manufacturing in the coming years.

3. Research method

This study uses a quantitative method to examine a particular sample and research instruments. This study focuses on SMEs in the food and beverage sector in Indonesia. The purposes sampling of 115 respondents in this study are the owners and managers of SMEs who run the businesses and are responsible for implementing business strategy. The analysis uses quantitative techniques and is processed using an independent sample *T*-test and Sobel test. The Statistical Package for the Social Sciences (SPSS) statistical techniques were used in this study to evaluate the relationship between variables. Walker and Smith (2017) argued that the *T*-test using SPSS analysis is a robust measurement approach. It does not have to assume data with a specific scale measurement and the number of samples used. In addition, using those approaches can test complex relationships and influences among variables. The Likert scale is used to measure the questionnaires and analyzed using SPSS software to help descriptively test data such as the validity and reliability of the measurement sub-model. It also evaluates the influence between variables with the structural sub-model.

3.1 Research design

This study utilized a deductive approach and quantitative methodology to examine the crucial aspects of implementing sustainable manufacturing practices and their influence on environmental performance within the Indonesian manufacturing industry. The respondents of this study are the owners of SMEs in various manufacturing sectors across Indonesia. By diversifying the manufacturing sectors, we aim to capture a more comprehensive and representative sample, ranging from textile and apparel to electronics and automotive industries. The researchers selected a sample of SME owners in the manufacturing sector in Indonesia using purposive sampling techniques. This method allowed them to deliberately

choose participants who possessed valuable insights and experiences relevant to their study. The adoption of this methodology aligns with the research operationalization rooted in positivist assumptions. The study employed a sequential exploratory research design, involving a thorough literature review, quantitative data collection and analysis. Figure 2 visually represents the necessary information needed at each stage of the research design.

In the initial research phase, an exploratory study was conducted using an extensive literature review. This study examined existing models and gathered information on indicators related to sustainable manufacturing, eco-innovation, regulation and environmental performance. The investigation into environmental performance focused on energy efficiency and environmental pollution levels. Similarly, sustainable manufacturing was explored through financial, social and environmental indicators. The literature review's outcomes were crucial in developing a research framework, research objectives, questions and hypotheses. Variables for the model were selected and operationalized, guiding the development of research instruments. New items were created to measure sustainable manufacturing practices and were organized in a questionnaire based on their underlying dimensions.

In the second phase of the study, data was gathered through sequential tasks. These tasks involved assessing study dimensions, refining research instruments and conducting the main survey. The assessment of dimensionality was done before the main survey to enhance research measures. The results helped improve questionnaire items, focusing on content validity and reliability. With the refined questionnaire, the main survey was carried out, utilizing cross-sectional data to test the proposed research framework and hypotheses. The necessary sample size for this stage was determined based on the requirements of the *T*-test (comparing means of two groups) and the chosen sampling method. Dwivedi *et al.* (2017) stated that the general rule of thumb is that each group should have a minimum of 30 observations to meet the assumptions of normality and ensure reasonably reliable results.

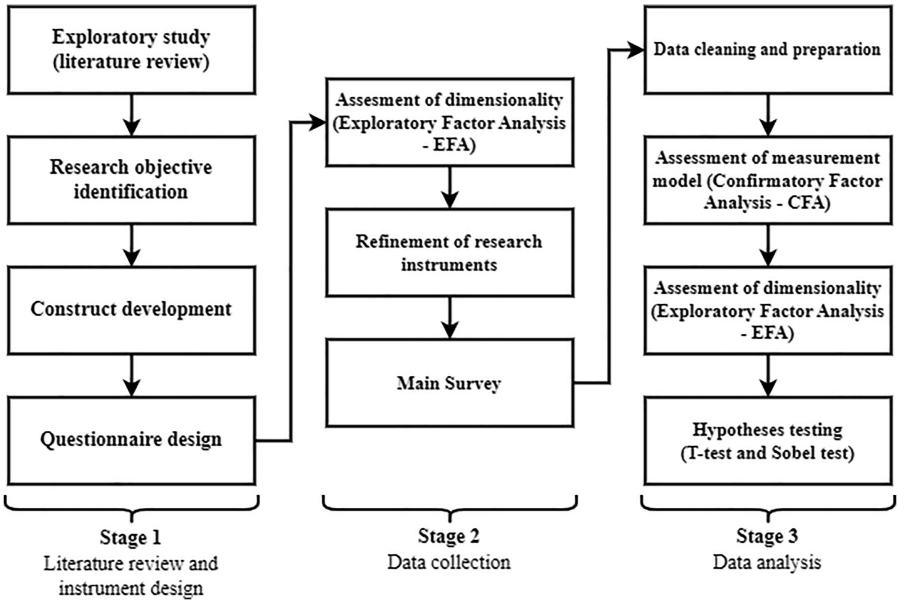


Figure 2.
Research design stage

Source(s): Authors work

In the third phase, the gathered data underwent screening to ensure accuracy, the absence of missing values or extreme outliers and confirmation of normal distribution. This step aimed to prevent model estimation failure and program crashes. After cleaning, statistical techniques like exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were applied to the data. The evaluation included checking response completeness, validating the proposed research framework and verifying results within an acceptable range.

3.2 Operational definition and measurement of variables

This study employs the Likert scale to gauge respondents' attitudes, opinions and perceptions about social phenomena. According to Hair *et al.* (2014), the Likert scale translates variables into indicator variables, which form the basis for questionnaire items presented as statements or questions. Each response intensity is scored from 1 (Strongly disagree) to 5 (Strongly agree) based on the five types of questionnaire measurement used. See Table 1.

4. Analysis and results

4.1 Respondents information

In the study, 115 respondents were sampled, with 54% males and 46% females, indicating a higher male representation. Regarding education level, respondents consisted of junior high school (10%), high school (68%), diploma (6%) and bachelor/postgraduate/master (16%). The majority had a high school education. Concerning business establishment, 3% started in less than 6 months, 60% between 6 months and 1 year, 33% within 1–5 years and 4% over 5 years, showing that most businesses were established within the 6 months to 1-year range, see Table 2.

4.2 Measurement model evaluation

This study evaluates the measurement results of the model using the outer model to establish validity and reliability. It measures the influence between each statement and its latent variables. Additionally, the paper conducts assumption tests, including normality, multicollinearity and heteroscedasticity tests. These tests ensure the accuracy and unbiased consistency of the regression equation obtained for estimation.

As for this study, using a measuring instrument questionnaire and instrument measurements are said to be valid by comparing R_{count} > from R_{table} (df=(n)-2) with a level of 5%. The minimum requirement to be considered as a valid instrument item is a validity index value ≥ 0.3. Therefore, all statements that have a correlation level <0.3 must be corrected because they are considered invalid (Hair *et al.*, 2014). Table 3 shows that if all indicators R_{count} more than R_{table}, then all indicators/items are declared valid. Thus, it can be concluded that all item indicators from the variables of sustainable manufacturing, environmental performance, government regulation and eco-innovation are valid.

Cronbach's alpha is a measure of internal consistency reliability used to assess the reliability or consistency of a scale or a set of items that are intended to measure the same construct. It ranges from 0 to 1, where higher values indicate higher internal consistency. Traditionally, a Cronbach's alpha value of 0.70 or higher is often considered acceptable for research purposes (Hair *et al.*, 2014). Table 4 reveals Cronbach's alpha scores above the recommended 0.7 thresholds for government regulation, eco-innovation, environmental manufacturing and sustainable manufacturing variables. This suggests questionnaire responses are consistently reliable for repeated use.

Variable definition	Indicator
Government regulation Regulation that effectively defines the limits of legal behavior	a. Regulations related to the environment b. Application of local regulations on the environment within the company c. Government inspections/audits of companies regularly d. Having permits that support business activities (environmental impact analysis, company Hygiene manual) e Having a Waste Management site (Laosirihongthong *et al.*, 2013)
Eco-innovation The development of products and processes that contribute to sustainable development, as well as applying the commercial application of knowledge to obtain direct or indirect ecological improvements	a. Environmental-friendly product innovations b. Sustainable advancements in processes that are kind to the environment c. Innovative approaches within organizations that prioritize environmental sustainability d. Promoting (marketing) innovative environmental-friendly solutions (Yu *et al.*, 2013)
Sustainable manufacturing Sustainable Manufacturing aims for eco-friendly products, efficient processes and positive societal impact, balancing environmental preservation with economic and social benefits	a. Production environment that prioritizes cleanliness and hygiene b. Reuse and recycling of leftover products or product components c. Engage employees in implementing sustainable manufacturing practices, both directly and indirectly d. Building strong supplier relationships fosters mutual benefit and positive environmental outcomes for the community e. Offering eco-friendly products that meet consumer demands and foster positive customer relationships f. Contributing to creating a favorable environmental condition for the surrounding residents g. The product is designed with consideration for reuse and recycling aspects h Exchange of waste or by-products with other companies in the industry for different products (Shiming *et al.*, 2011)
Environmental Performance Environmental performance considers efficiency in resource use, recycling and reduction of pollution, waste and emissions	a. Minimizing excessive water usage during production activities b. Reducing excessive utilization of non-renewable resources in production activities c. Minimizing the disposal of hazardous waste and other pollution d Minimize the emission of gas waste (Adebambo *et al.*, 2014)

Table 1.
Operational variable definition

Source(s): Authors work

Based on Table 5, it is known that the results of the normality test get a significance value of 0.480. This finding indicates that the data is normally distributed, as the significance value of the normality test is 0.480, which is greater than the conventional significance level of 0.05 (Yazici and Yolacan, 2007). Thus, there is no evidence to reject the null hypothesis, suggesting that the data follows a normal distribution.

Table 6 shows the tolerance values of sustainable manufacturing (X), government regulation (Z1) and eco-innovation (Z2) to be 0.973, 0.779 and 0.788, respectively, all exceeding

Profile	Frequency	Percentage
Gender		
Male	62	54%
Female	53	46%
Education level		
Junior high school	12	10%
High school	78	68%
Diploma	7	6%
Bachelor/master	18	16%
Business was established		
<6 Month	3	3%
6 Month–1 Year	69	60%
1–5 Year	38	33%
>5 Years	5	4%

Source(s): Authors work

Table 2.
Respondents' profile

0.1. Additionally, the VIF values for these variables are 1.028, 1.284 and 1.269, which are below 10. Therefore, the test indicates no multicollinearity among the independent variables (Buallay, 2019).

Table 7 shows that the sustainable manufacturing (X) variable has a significance value of 0.010, government regulation (Z1) has a significance value of 0.518 and eco-innovation (Z2) has a significance value of 0.251. From the results of the analysis, it has a significant value of more than 0.05. Modarres and Ouarda (2013) argued that a significant value greater than 0.05 indicates that there is no presence of heteroscedasticity in each independent variable. This explains that each independent variable in this study does not occur in heteroscedasticity.

4.3 Path analysis evaluation

Path analysis using SPSS is used in this research to test the correlation between variables directly and indirectly. Variables are analyzed through each other to find the correlation between them.

Based on Table 8, it is known that the effect of sustainable manufacturing on government regulations with a beta coefficient of 0.362, T_{count} of 4.134 and a probability of 0.000 ($p < 0.05$). According to Figueiredo Filho *et al.* (2013), the p-value is below 0.05 (α), indicating a statistically significant impact. In Table 9, the probability is < 0.05 (α), indicating a significant influence of sustainable manufacturing on government regulations. The path coefficient is 0.362, confirming the significant effect of sustainable manufacturing on government regulations. Hypothesis 1 is accepted, stating that sustainable manufacturing affects government regulations.

According to Table 9 and it has been established that sustainable manufacturing has a notable impact on eco-innovation, as evidenced by the beta coefficient of 0.816, a t_{count} of 4.797 and an extremely low probability of 0.000 ($p < 0.05$). Table 9 also confirms that the probability (α) is less than 0.05, indicating a significant relationship between sustainable manufacturing and eco-innovation. The path coefficient of 0.816 further supports these findings, demonstrating a significant effect of sustainable manufacturing on eco-innovation. Thus, the second hypothesis is accepted, which states that sustainable manufacturing affects eco-innovation.

Based on the data presented in Table 10, it is evident that sustainable manufacturing has a substantial impact on environmental performance, as indicated by a beta coefficient of 0.680,

Item	Error	R_count	R_table	Remark
Government regulation				
Z1.1	0.05	0.556	0.1832	Valid
Z1.2	0.05	0.578	0.1832	Valid
Z1.3	0.05	0.789	0.1832	Valid
Z1.4	0.05	0.824	0.1832	Valid
Z1.5	0.05	0.828	0.1832	Valid
Eco-innovation				
Z2.1	0.05	0.731	0.1832	Valid
Z2.2	0.05	0.654	0.1832	Valid
Z2.3	0.05	0.657	0.1832	Valid
Z2.4	0.05	0.717	0.1832	Valid
Z2.5	0.05	0.749	0.1832	Valid
Z2.6	0.05	0.817	0.1832	Valid
Z2.7	0.05	0.747	0.1832	Valid
Z2.8	0.05	0.772	0.1832	Valid
Sustainable manufacturing				
X1.1	0.05	0.282	0.1832	Valid
X1.2	0.05	0.620	0.1832	Valid
X1.3	0.05	0.746	0.1832	Valid
X1.4	0.05	0.600	0.1832	Valid
X1.5	0.05	0.755	0.1832	Valid
X1.6	0.05	0.676	0.1832	Valid
X1.7	0.05	0.771	0.1832	Valid
X1.8	0.05	0.739	0.1832	Valid
Environmental performance				
Y1.1	0.05	0.550	0.1832	Valid
Y1.2	0.05	0.723	0.1832	Valid
Y1.3	0.05	0.727	0.1832	Valid
Y1.4	0.05	0.703	0.1832	Valid
Y1.5	0.05	0.808	0.1832	Valid
Y1.6	0.05	0.618	0.1832	Valid
Y1.7	0.05	0.798	0.1832	Valid

Table 3.
Validity test

Source(s): Authors work

Variable	Cronbach's alpha	Criteria	Remark
Government regulation (Z1)	0.766	0.600	Reliable
Eco-innovation (Z2)	0.870	0.600	Reliable
Sustainable manufacturing (X)	0.808	0.600	Reliable
Environmental manufacturing (Y)	0.832	0.600	Reliable

Table 4.
Reliability test

Source(s): Authors work

a *t*-value of 9.846 and a probability of 0.000 ($p < 0.05$). The probability value mentioned in Table 10, being less than the significance level (α) of 0.05, further supports the notion that there is a significant relationship between sustainable manufacturing and environmental performance. The path coefficient of 0.680 revealed in the results reinforces the idea that sustainable manufacturing plays a crucial role in influencing environmental performance.

One-sample Kolmogorov–Smirnov test		Unstandardized residual
N		115
Normal parameters[a,b]	Mean	0.0000000
	Std. deviation	3.36216811
Most extreme differences	Absolute	0.078
	Positive	0.061
	Negative	−0.078
Kolmogorov–Smirnov Z		0.840
Asymp. Sig. (2-tailed)		0.480

Source(s): Authors work

Table 5. Normality test

Coefficients[a]			
		Collinearity statistics	
Model		Tolerance	VIF
1	(Constant)		
	Government regulation (Z1)	0.779	1.284
	Eco-innovation (Z2)	0.788	1.269
	Sustainable manufacturing (X)	0.973	1.028

Note(s): a. Dependent variable: Environmental Performance (Y)
Source(s): Authors work

Table 6. Collinearity test

Coefficients[a]		
Model	T	Sig
(Constant)	2.433	0.017
Government regulation (Z1)	−0.648	0.518
Eco-innovation (Z2)	1.154	0.251
Sustainable manufacturing (X)	−2.620	0.010

Note(s): a. Dependent variable: Abs_RES
Source(s): Authors work

Table 7. Heteroscedasticity test

Variable	Standardized coefficient betta	t_{count}	*Sig t*	Remark
Sustainable manufacturing (X)	0.362	4.134	0.000	Significant

Note(s): Constant = 15.484
R Square = 0.131
Source(s): Authors work

Table 8. Correlation between sustainable manufacturing and government regulation

Thus, we can confidently accept the third hypothesis, which states that sustainable manufacturing indeed affects environmental performance.

Table 11 illustrates the impact of government regulation on environmental performance through several statistical measures. The beta coefficient, measuring the strength of the relationship, is found to be 0.379. The t_{count}, representing the significance of the coefficient, is calculated at 4.350, with a probability of 0.000 ($p < 0.05$). The significance of the probability

value ($p < 0.05$) in Table 11 indicates a substantial influence of government regulation on environmental performance. The path coefficient, confirming the magnitude of this influence, is also observed to be 0.379. These findings provide robust evidence of a meaningful and positive effect of government regulation on environmental performance. As a result, the fourth hypothesis, which proposes that government regulation affects environmental performance, is confirmed and accepted. These results underscore the vital role that government policies and regulations play in positively shaping environmental outcomes (Cui and Wang, 2022). The demonstrated significance of the relationship suggests that effective regulatory measures can contribute significantly to improving environmental performance and sustainability.

Table 12 illustrates the impact of eco-innovation on environmental performance, represented by a beta coefficient of 0.637, a t_{count} value of 8.794 and a probability of 0.000 ($p < 0.05$), indicating statistical significance. This significant probability in Table 12 ($\alpha < 0.05$) signifies a strong relationship between eco-innovation and environmental performance. The path coefficient of 0.637 reinforces this finding, affirming the substantial effect of eco-innovation on environmental performance. Consequently, we can confidently accept the fifth

Table 9. Correlation between sustainable manufacturing and eco-innovation

Variable	Standardized coefficient betta	t_{count}	Sig t	Remark
Sustainable manufacturing (X)	0.816	4.797	0.000	Significant

Note(s): Constant = 8.289
R Square = 0.667
Source(s): Authors work

Table 10. Correlation between sustainable manufacturing and environmental performance

Variable	Standardized coefficient betta	t_{count}	Sig t	Remark
Sustainable manufacturing (X)	0.680	9.846	0.000	Significant

Note(s): Constant = 6.244
R Square = 0.462
Source(s): Authors work

Table 11. Correlation between government regulation and environmental performance

Variable	Standardized coefficient betta	t_{count}	Sig t	Remark
Government regulation (Z1)	0.379	4.350	0.000	Significant

Note(s): Constant = 6.312
R Square = 0.143
Source(s): Authors work

Table 12. Correlation between eco-innovation and environmental performance

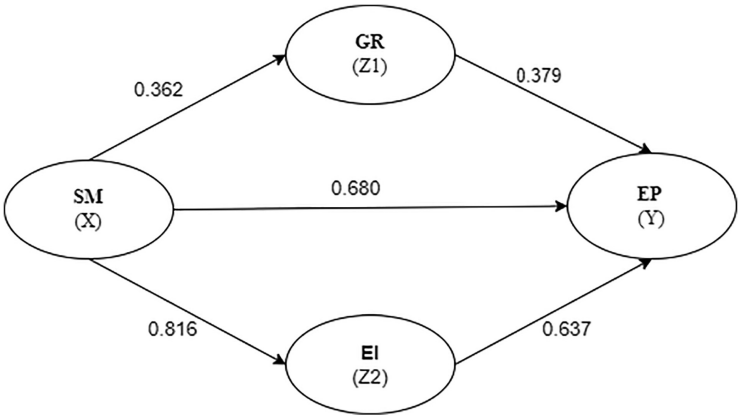
Variable	Standardized coefficient betta	t_{count}	Sig t	Remark
Eco-innovation (Z2)	0.637	8.794	0.000	Significant

Note(s): Constant = 5.406
R Square = 0.406
Source(s): Authors work

hypothesis, which asserts that eco-innovation indeed influences environmental performance. Moreover, a comprehensive path analysis was conducted to assess the direct and indirect effects of various variables. The consolidated outcomes of this model are presented in Figure 3, providing a more holistic understanding of the relationships between the examined variables.

The presented model demonstrates linkages between various research variables. Sustainable manufacturing has a direct impact of 0.362 on government regulation and a substantial influence of 0.816 on eco-innovation. Similarly, government regulation shows a direct effect of 0.379 on environmental performance, while eco-innovation directly affects environmental performance with a coefficient of 0.637. Additionally, sustainable manufacturing has a significant direct impact of 0.680 on environmental performance. Table 13 provides a comprehensive overview of the direct, indirect and total effects of the research variables, shedding light on their relationships and interdependencies. Exploring these effects further could enhance our understanding of how sustainable practices, regulations and innovations promote environmental well-being and overall sustainability.

The calculations in Table 13 show that government regulation and eco-innovation are proven to be intervening variables in the relationship between sustainable manufacturing and environmental performance. The calculation results show that the total effect is greater than the direct effect. The results of the calculations demonstrate that the overall impact of these variables surpasses the direct effect (VanderWeele, 2013). The results show that



Source(s): Authors work

Figure 3.
Results of path analysis

Variable correlation	Correlation		Total
	Direct	Indirect	
X to Y	*0.680*	–	0.680
X to Z1	0.362	–	0.362
X to Z2	0.816	–	0.816
Z1 to Y	0.379	–	0.379
Z2 to Y	0.637	–	0.637
X to Y through Z1	–	(0.362 x 0.379) + 0.680	*0.817*
X to Y through Z2	–	(0.816 x 0.637) + 0.680	*1.199*

Source(s): Authors work

Table 13.
Direct and indirect effect between research variables

variables Z1 and Z2 have a positive indirect effect on the relationship between X and Y, with coefficients of 0.817 and 1.199, respectively. This indicates a stronger influence compared to the direct relationship between X and Y.

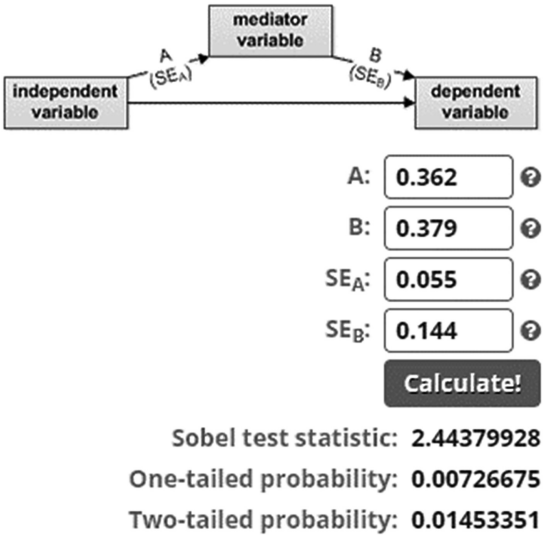
4.4 Hypothesis testing

4.4.1 T-*test.* In this research, the *t*-test hypothesis testing method is employed to examine the congruence between the obtained results and the initially proposed hypotheses. The *t*-test involves comparing the calculated t_{count} value with the critical t_{table} value, with a significance level (α) set at 0.05 and t_{table} value of 0.1658. The *t*-test is a commonly used statistical method that involves comparing the calculated t-count value with the critical t-table value, with a significance level (α) typically set at 0.05 (*P*-value <0.05 indicates statistical significance) (Faul *et al.*, 2007). The investigation of this study focuses on the impact of sustainable manufacturing on various variables. The t_{count} value for the effect of sustainable manufacturing on environmental performance is found to be 9.846, which significantly exceeds the t_{table} value (0.1658). This outcome indicates a substantial and positive effect of sustainable manufacturing on environmental performance. Similarly, the t_{count} value for the relationship between sustainable manufacturing and government regulation is calculated as 4.134, which is greater than t_{table} (0.1658). Thus, it suggests that sustainable manufacturing has a significant influence on government regulation. Furthermore, when examining the effect of sustainable manufacturing on eco-innovation, the t_{count} value is 15.029, exceeding t_{table} (0.1832). Hence, the results show that sustainable manufacturing significantly contributes to eco-innovation. Additionally, the study assesses the influence of government regulations on environmental performance, with a t_{count} value of 4.350. This value is greater than t_{table} (0.1658), indicating a significant impact of government regulations on environmental performance. Lastly, the effect of eco-innovation on environmental performance is explored, with a t_{count} value of 8.794, also greater than t_{table} (>0.658). This finding indicates a significant influence of eco-innovation on environmental performance.

The results of the *t*-test in this study demonstrate that sustainable manufacturing, government regulations and eco-innovation all have noteworthy and meaningful effects on environmental performance. These findings underscore the significance of these variables in fostering environmentally sustainable practices and policies. As a result, policymakers and industry stakeholders can better understand the critical role of sustainable manufacturing, government regulations and eco-innovation in promoting environmental sustainability. Sahoo *et al.* (2023) believed that by acknowledging the impact of these factors, organizations can develop more effective strategies to enhance their environmental performance and contribute to a greener future.

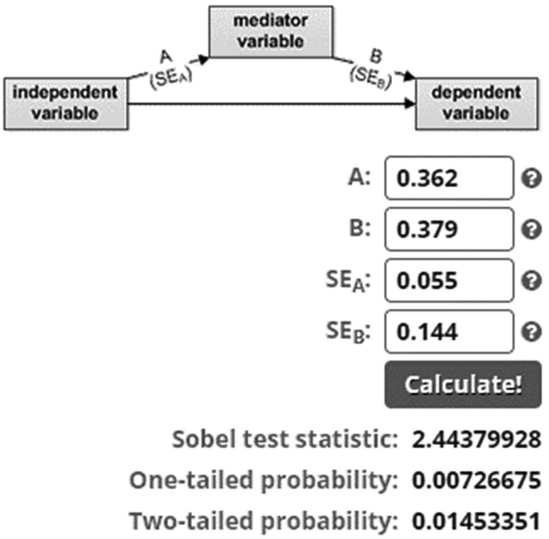
4.4.2 Sobel Test. The Sobel test serves as a crucial tool in assessing the extent to which a mediating variable can significantly influence the relationship between two other variables. The Sobel test is a widely employed statistical method used to determine the significance of a mediating variable's influence on the relationship between two other variables (Baron and Kenny, 1986). In the context of this study, the researchers aimed to examine the impact of government regulation and eco-innovation as intervening factors in the association between sustainable manufacturing and environmental performance. For the convenience of computing the mediating values of these variables, Figure 4 presents the Sobel Test calculator.

Figure 5 shows the results of a statistical analysis, indicating a Two-tailed probability of 0.01453351, which is considered significant as it falls below the conventional significance threshold of 0.05 ($p < 0.05$) (Jihadi *et al.*, 2021). Therefore, based on these findings, it can be concluded that the government regulation variable plays a mediating role in the relationship between sustainable manufacturing and environmental performance. These results offer



Source(s): Authors work

Figure 4. Sustainable manufacturing to environmental performance through government regulation



Source(s): Authors work

Figure 5. Sustainable manufacturing to environmental performance through eco-innovation

support for H4, suggesting that sustainable manufacturing has a significant impact on environmental performance, with government regulation serving as a mediator.

The findings depicted in Figure 5 reveal that the statistical analysis yielded a two-tailed probability value of less than 0.05. This result indicates that there is a significant relationship between sustainable manufacturing and environmental performance, with the eco-innovation variable playing a mediating role. Consequently, the evidence gathered from

this study supports hypothesis H5, which posits that the impact of sustainable manufacturing on environmental performance is connected through the pathway of eco-innovation. These results align with prior research indicating that Eco-Innovation serves as a crucial mechanism through which sustainable manufacturing practices can enhance environmental performance outcomes (Maldonado Guzmám and Pinzón Castro, 2023).

5. Discussion

H1: Sustainable manufacturing practices have a positive impact on government regulations.

The analysis demonstrates that sustainable manufacturing practices utilize a notable influence on government regulations. The findings suggest a strong link between sustainable manufacturing and the regulations imposed by the government. As a result, these regulations can impact the adoption and execution of sustainable manufacturing practices within SMEs. Meanwhile, if SMEs apply the concept of sustainability, the government regulation variable influences its implementation. Sustainability can be obtained by implementing the green concept (Siegel *et al.*, 2019). Sustainable manufacturing itself is defined as the creation of products that have economic value through processes that minimize negative impacts on the environment, save energy and natural resources and conserve natural resources and energy to ensure their availability in the future. The process carried out should also be safe for employees, society and consumers. The analysis by Chourasiya *et al.* (2022) demonstrates that sustainable manufacturing utilizes a notable influence on government regulations. The findings suggest a strong link between sustainable manufacturing and the regulations imposed by the government. As a result, these regulations can impact the adoption and execution of sustainable manufacturing practices within SMEs (Baah *et al.*, 2021). This alignment between sustainable manufacturing and government regulations highlights the significance of policy measures in promoting environmentally responsible practices in the manufacturing sector. Other findings by Zhu *et al.* (2019), which focused on SMEs also indicated that government regulation and sustainable manufacturing are interconnected. In their study, it is revealed that sustainable production imposed the carbon subsidy regulation by the government.

H2: Sustainable manufacturing practices have a positive impact on eco-innovation.

The study's findings reveal a clear relationship between sustainable manufacturing and eco-innovation. It strongly suggests that the adoption of sustainable manufacturing practices significantly influences the emergence of environmental-friendly innovations, encompassing technological and managerial aspects, particularly in the SME sector. This finding is in line with prior discussions by Sezen and Çankaya (2013). They revealed that the adoption of green manufacturing could impact environmental innovations for an organization. From the technology innovation perspective, (Ding *et al.* (2021) indicated that the adoption of sustainable manufacturing could encourage organizations' policies to adopt eco-technology innovation. Moreover, Stankevičienė and Nikanorova (2020) believed that the adoption of sustainable manufacturing would not only impact the practice of technological eco-innovations but also the eco-innovation mindset of the management. Other studies by Dogaru (2020) argued that sustainable manufacturing and eco-innovation have become important strategic tools to achieve sustainable development of the manufacturing industry.

H3: Sustainable manufacturing practices have a positive impact on environmental performance.

The third hypothesis indicated that implementing sustainable manufacturing practices has a notable impact on environmental performance. Introducing the idea of manufacturing

sustainability into SMEs would also influence their environmental performance. The findings of this study support other previous studies conducted by Nordin *et al.* (2014). They found that there is a positive and significant influence between sustainable manufacturing on environmental performance. Moreover, Liu *et al.* (2018) revealed that the major aspects of economic, environmental and social benefits of manufacturing systems adoption would be positively related to an organization's performance. Another study by Rehman *et al.* (2016) also found that the application of sustainable production could improve the organization's performance not only in the environmental aspect but also in the financial aspect. Finally, Despeisse *et al.* (2012) believed that the significant improvement in environmental performance is the major motivation for manufacturers to adopt sustainable production.

From the perspective of SMEs, the implications of sustainable manufacturing on the SME's environmental performance are also in line with the findings of this study. Habidin *et al.* (2016), who conducted a study on Malaysian automotive SMEs found that there is a significant relationship between environmental management of sustainable manufacturing and SMEs' environmental performance. Moreover, Lefebvre *et al.* (2003) indicated that SMEs environmental performance could be affected by multi-dimensional factors including product and process sustainability.

H4: Government regulations positively influence environmental performance.

The findings from the analysis indicate that government regulations affect a considerable influence on environmental performance. The research highlights the substantial impact that regulatory measures implemented by the government have on various aspects of the environment. The data obtained through the study supports the notion that when effective regulations are put in place, there is a noticeable improvement in the overall environmental conditions. The findings of this study are relevant to the study conducted by Adebambo *et al.* (2014). The findings of their study indicated that there is a positive and significant influence between government regulation on environmental performance. Moreover, Zhang *et al.* (2022) argued that government regulations regarding pollution and air quality control could affect corporate environmental performance. Their investigation of the Chinese-listed enterprises revealed that less environmental regulatory enforcement and poor environmental information transparency would weaken the influence of these variables.

From the perspective of SMEs, the implementation of government regulation on environmental issues practically affects environmental performance. A study by Tang and Tang (2012) on 144 Chinese SMEs showed that the regulations of the government's and media's Corporate Social Responsibility (CSR) would impact corporate environmental performance. Moreover, Chen *et al.* (2023) evidenced that bank deregulation significantly improved a firm's environmental performance. Furthermore, Graafland and Bovenberg (2020), who studied using a dataset of 2,373 SMEs from 12 European countries, indicated that hat government regulation enhances environmental performance directly but harms it indirectly by crowding out intrinsic and extrinsic motivations of business leaders.

H5: Eco-innovation positively influences environmental performance.

The presence of a notable impact suggests that the implementation of eco-innovation has the potential to make a substantial contribution to enhancing environmental performance. This means that by adopting eco-friendly and innovative practices, we can expect to witness a positive and meaningful effect on the environment. The findings of this study support previous studies by Valero-Gil *et al.* (2023) which show that there is a positive and significant influence between eco-innovation on environmental performance. Another discussion about the relationship between eco-innovation and corporate environmental performance has been also discussed by Yurdakul and Kazan (2020). In their study, it is found that eco-innovation

impact on corporate economic and environmental performance. They revealed the evidence from 219 manufacturing industries that eco-innovation has a direct effect on pollution prevention, resource-saving and recycling, while it has an indirect positive effect on cost reduction and thus on economic performance. Moreover, a study by Costantini *et al.* (2017) from the empirical findings from European enterprises shows that both the direct and indirect effects of eco-innovations help reduce environmental stress. They also believed that eco-innovation strategies should be coordinated with policy government strategies to address the goal of maximizing environmental performance.

H6: Sustainable manufacturing practices affect significantly environmental performance through government regulations.

This study reveals a clear connection between sustainable manufacturing and environmental performance, highlighting the potential benefits of adopting eco-friendly practices within industrial processes. The significant effect indicates that the implementation of sustainable manufacturing in the presence of government regulation would have a more orderly impact on environmental performance. Thus, government regulations would affect the implementation of sustainable manufacturing in SMEs which will ultimately have an impact on the environmental performance of the SMEs. Sobel's test results show the effect of sustainable manufacturing on environmental performance through government regulation. Based on the findings, more supportive regulation from the government can increase the influence of sustainable manufacturing on environmental performance. Yu and Choi (2016) argued that government is a strong stakeholder that could give pressure through regulations to push SMEs to adopt sustainable manufacturing. Moreover, Baah *et al.* (2021) believed that stakeholder pressure represented by government regulations could support the correlation between the adoption of sustainable manufacturing and a firm's environmental performance.

H7: Sustainable manufacturing practices significantly affect environmental performance through eco-innovation.

The study's findings suggest that the implementation of sustainable manufacturing has a notable impact on corporate environmental performance, which is achieved through the adoption of eco-innovation. The results demonstrate a clear and significant connection between the incorporation of sustainable manufacturing practices and the overall environmental performance of companies. This highlights the crucial role played by eco-innovation strategies in mediating this relationship. The findings of this study are in line with the work findings of Baah *et al.* (2021). They revealed that country-level eco-innovation policies could affect positively the environmental efforts of the firms operating. Other studies by Hojnik and Ruzzier (2016) and Maldonado Guzmám and Pinzón Castro (2023)found that the implementation of eco-innovation in the context of a developing country is usually more technical and costly. The barrier factors would hinder the implementation of sustainable manufacturing for SMEs. Moreover, Sobel's test results in this study indicate that eco-innovation can mediate positively the relationship between sustainable manufacturing and environmental performance. Wu *et al.* (2023) believed that the adoption of eco-innovation activities could partially impact the correlation between sustainable production adoption and environmental and economic performance, respectively. In another study by Cheng *et al.* (2014), it is also found that eco-process and eco-product innovations partially moderate the effect between eco-organization and corporate environmental performance.

5.1 Managerial implication and theoretical contribution

The findings of this study indicate the relationship between variables. The relationship between variables in this study should be considered by the involved stakeholders for

managerial implications. From the SME context, the owner and managers could start implementing sustainable manufacturing in their supply chain activities. Awan (2019) believed that supply chain activities that considered social, economic and environmental aspects would increase corporate environmental performance. The coordination between manufacturers and other involved stakeholders about the environmental corporate goals would help to achieve environmental performance. Masudin *et al.* (2021d) stated that the involvement of the involved stakeholders along the supply chain for sustainable manufacturing adoption is the key factor to achieve corporate environmental performance.

The adoption of sustainable manufacturing and eco-innovation in the firm would be challenging, particularly for SMEs. Triguero *et al.* (2018) found that SMEs lack of financial and human resources to adopt sustainable manufacturing and eco-innovations. Thus, the owner and top management play a crucial role in implementing upgrading skills training for employees regularly to improve the understanding of the importance of sustainable manufacturing implementation. Masudin *et al.* (2021b) believe that regular training for corporate staff could improve their awareness of management policy implementation. Periodic training could also involve other stakeholders such as the suppliers, government and third-party providers for better results. Koufteros *et al.* (2014) found that the involvement of management levels and cross-sectional consolidation would be impactful in implementing a new strategic policy. The cross-sectional consolidation would also show the management commitment to all stakeholders that the owner or top management is aware of the sustainable manufacturing implementation.

The findings of this study also indicated that the role of the government in implementing sustainable manufacturing in Indonesian SMEs is crucial. The government is a strong stakeholder that influences SMEs to consider sustainable manufacturing implementation. The government could release regulations that support SMEs to apply sustainable manufacturing. For example, regulations such as tax deductions for SMEs that could reduce carbon emissions and waste in their manufacturing activities could be applied. Tran *et al.* (2022) believed that financial support from the government to SMEs that apply environmentally eco-friendly manufacturing would encourage SMEs to adopt sustainable manufacturing. Another study by Masudin *et al.* (2021a) that financial and technological support from the government could help SMEs to adopt green manufacturing.

In the given context, the theoretical contribution revolves around the relationship between variables, sustainable manufacturing implementation in SMEs, the role of stakeholders and the influence of the government. The study's findings provide insights into the relationship between variables, particularly highlighting the relationship between sustainable manufacturing implementation and corporate environmental performance. This finding suggests that considering social, economic and environmental aspects in supply chain activities can enhance environmental performance for SMEs. However, the adoption of sustainable manufacturing and eco-innovation poses challenges for SMEs due to their limited financial and human resources. The findings support a study by Chege and Wang (2020) that studied 204 SMEs in a developing country and found that the financial dimension is the strongest aspect that affects SMEs' business performance. Moreover, Sardo *et al.* (2018) indicated financial and human resources are the key factors for SMEs to adopt sustainable manufacturing in enhancing corporate environmental performance.

6. Conclusions

This study investigates whether external factors such as government regulation and eco-innovation could affect the implementation of sustainable manufacturing and environmental performance in Indonesian SMEs. The findings of this study indicated that implementing sustainability in SME manufacturing would affect the environmental performance around

them. Thus, with the help of eco-innovation that may come in technology or management, the role of government as the regulator in providing policies that regulate production and its effect on the environment would affect environmental performance. This study emphasizes the relationship between variables and highlights the importance of considering this relationship for managerial implications. Specifically, the study focuses on the context of SMEs and suggests that owners and managers should implement sustainable manufacturing practices in supply chain activities. SMEs can improve corporate environmental performance by incorporating social, economic and environmental aspects into their supply chain activities. The involvement of stakeholders along the supply chain is crucial for the successful adoption of sustainable manufacturing and achieving environmental performance.

The primary objective of this research was to examine how sustainable manufacturing, government regulations and eco-innovation practices impact the environmental performance of SMEs. Due to limited financial and human resources, the majority of SMEs face challenges in implementing sustainable manufacturing practices. To expand on future research possibilities, this study's framework could explore additional aspects of performance, including operational and financial metrics, in order to gain a deeper understanding of the intricate connections between sustainable manufacturing practices and the environmental performance of organizations in the SME sector.

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