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The influence of eco-design, green information systems, green manufacturing, and green purchasing on manufacturing performance

Florencia Angela Wungkana[a], Hotlan Siagian[a] and Zeplin Jiwa Husada Tarigan[a*]

[a]*School of Business and Management, Petra Christian University, Indonesia*

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A B S T R A C T

Companies today strive to integrate manufacturing processes with the environment to strike a balance. This study aims to examine the impact of green implementation for companies on the performance of manufacturing companies. Data was collected using Google Forms distributed online to the manufacturing companies domiciled in East Java. The criterion for the companies is that they have been committed to implementing a green approach to the production process, procurement of environmentally friendly raw materials, and green products. The partial least square technique analyzed data from as many as 115 respondents, with the position as senior staff level and higher, who have worked for at least two years and are permanent employees. The results showed that the implementation of eco-design has an impact on green purchasing and green manufacturing. Eco-design and green information systems implemented by the company can improve manufacturing performance by producing adequate overall product quality, and the number of products produced varies according to market demand. Therefore, the green information system affects green manufacturing and purchasing in manufacturing companies. Therefore, green manufacturing and green purchasing can impact manufacturing performance. The research results contribute to practitioners, especially top management, in committing to implementing Green which affects the performance of manufacturing companies. The theoretical contribution of the research is to enrich green supply chain management and sustainable performance for manufacturing companies.

1. Introduction

Global Warming has caused anxiety from people worldwide, including Indonesia because it has a destructive environmental impact. Pollution in Indonesia is worsening more than predicted, which is not as it should be (Jumaidy & Fajriah, 2020). This condition could affect the existing overall manufacturing performance in Indonesia. The most hazardous waste is toxic waste which is very harmful to human life. To participate in preserving the environment, scientists have also been highly concerned about its impact on the environment. Supply chain management has also recently started to integrate practices in environmental management in the form of green supply chain management and, at the same time, can also maintain a competitive advantage, increase business profits, and meet market objectives (Setiawan et al., 2023). The Manufacturing industry's role is vital in maintaining environmental sustainability because this industry contributes approximately 20% of environmental pollution. According to Jumaidy and Fajriah (2020), several activities in implementing green supply chain management (GSCM) include eco-design, information systems, manufacturing, and purchasing. Furthermore, for many companies, manufacturing performance is an essential measure of success and cost base, so it is crucial to understand how to be more sustainable in operations that affect manufacturing performance (Adebanjo et al., 2016).

* Corresponding author.
E-mail address: zeplin@petra.ac.id (Z. J. H. Tarigan)

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The first factor that affects manufacturing performance is eco-design. Using eco-design is beneficial because it can help manufacturers know how their products can impact the environment. The eco-design significantly affects manufacturing viability and plays a role in building a sustainable competitive advantage in the market (Khan & Qianli, 2017). Eco-design is a success factor in GSCM's strategy to determine the environmental impact of products at the design stage (Abdullah et al., 2019). In addition, eco design can help improve resource efficiency in supply chain partnerships, resulting in green supply chain performance benefits (Li & Sarkis, 2021; Choong et al., 2013). The use of eco-design is an action taken in the product development process that targets to minimize the environmental impact during the life cycle of the product itself, from obtaining raw materials to manufacturing, use, and final disposal without sacrificing other essential product criteria such as performance and cost (Younis et al., 2015).

The second factor that can affect manufacturing performance is the green information system. Manufacturers use green information systems for essential corporate purposes (Tarigan et al., 2021). The practice of green information systems is the most important thing because most companies use them to make transactions (Dezdar, 2017; Zadeh et al., 2020). Businesses face higher energy costs and are also subject to additional taxes from the government if they cannot address the environmental implications of the practice (Waris & Hameed, 2020). Therefore, implementing green information systems is essential for manufacturers/companies. The Green information system (GIS) significantly influences manufacturing performance (Khan & Qianli, 2017).

The green information system is an information system that encourages sustainable development and operation of eco-design (Khan & Qianli, 2017). GIS facilitates waste and energy reuse, which can serve as a tool for industrial symbiosis involving mutualistic interactions of different industries in beneficial reuses of waste streams or energy streams, resulting in more resource-efficient production systems and less loss on environmental impact (Gholami et al., 2013). Success in implementing GSCM practices depends on the ability of the organization's information systems to capture data related to the environment and sustainability efforts regarding the results of manufacturing, purchasing, sales, and logistics processes (Wijaya, 2022).

The third factor that can affect manufacturing performance is green manufacturing. This practice of green manufacturing is essential to ensure environmental sustainability, especially in the manufacturing sector (Acquah et al., 2021; Al-Shboul, 2017). Applying green manufacturing can help reduce production costs because it shortens the product's life cycle (Paul, 2014). Implementing green manufacturing helps companies become deeply aware of the responsibility to protect the natural environment by redesigning operational systems to comply with strict environmental laws (Afum et al., 2020; Seyedhosseini et al., 2019). Green manufacturing can produce remarkable results if effectively integrated across all functional departments of the company. Manufacturing companies adopt green manufacturing and configure manufacturing strategies and operations to reduce industrial pollution, material and energy consumption, and waste (Shukla & Fair, 2021).

The fourth factor that can affect manufacturing performance is green purchasing. Green purchasing focuses on manufacturing efforts to develop purchasing policies to select suppliers that are eco-designed as well as provide raw materials and parts that are eco-designed and safe for sustainable environmental purposes, such as pollution reduction and resource reservation (Wang et al., 2021; Mujahidin, 2020). Green purchasing is an effort made by companies to form environmentally conscious supplier panels and the operating performance of the purchasing function, which is understood as the ability to ensure suppliers provide products and services that are of good quality with shorter delivery times and at lower costs (Lannelongue et al., 2016; Nugroho et al., 2024).

Based on the description above, this study sets five primary goals to be investigated: first, eco-design influences green manufacturing, green purchasing, and performance manufacturing. Second, it examines the impact of green information systems on green manufacturing, green purchasing, and manufacturing performance. Third, assess the effect of green purchasing on green manufacturing and manufacturing performance. Finally, the fourth is to examine the influence of green manufacturing on manufacturing performance. The structure of research writing is determined in the second section of the literature review, the third section of research methods, the fourth section of data analysis and discussion, and finally, the fifth section is research conclusions.

2. Literature Review

Supply Chain Management is defined as planning, controlling, and running the current process to minimize the supply chain cost and deliver the product on time (Setiawan et al., 2023; Al-Shboul, 2017). Well-managed supply chain management can produce cheap, quality, and timely products to meet the target market and generate profits for the company (Siagian et al., 2020). In addition, this Supply Chain Management aims to maximize customer value and gain a competitive advantage in the market (Siagian et al., 2022). Green Supply Chain Management is an innovation in implementing supply chain strategies that depend on the environment, including reducing, recycling, reusing, and substituting materials (Younis et al., 2015; Jumaidy & Fajriah, 2020). GSCM practice is an innovative strategy in flexible operational management to increase economic, environmental, and social benefits (Le, 2020). GSCM (green supply chain management) is an integration of ecological perspectives into supply chain management which includes product design, selection of raw material sources, manufacturing

processes, delivery of final products to consumers, and product management after their useful life expires (Jumaidy & Fajriah, 2020).

2.1. Eco Design

Eco-design is a sustainable design approach, considering the product's environmental impact during the entire life cycle (Cimatti et al., 2017). The eco-design practice addresses product functionality while minimizing lifecycle environmental impacts (Li & Sarkis, 2021). The eco design, also recognized as design for the environment and green design, refers to the actions taken during product development as well as aims to minimize the environmental impact of a product during its entire life cycle from material acquisition, manufacturing, use, and finally to final disposal, without sacrificing other essential product criteria such as performance and cost (Abdullah et al., 2019; Romli et al., 2015). Sumanti & Inkiriwang (2011), eco design indicators are as follows: material management, minimizing material utilization, recycling materials, extended service life, and energy utilization.

2.2. Green Information System (GIS)

According to Brooks et al. (2012), a green information system is defined as an initiative to utilize information technology infrastructure to change organizational processes and practices to increase energy efficiency and reduce environmental impact, as well as introduce a healthier environment in products and services (Esfahani et al., 2016; Gholami et al., 2012). The green supply chain is the study and practice of designing, manufacturing, and using environmentally sustainable computers and servers is the key to future success (Dezdar, 2017). According to Esfahani et al. (2016), the indicators that affect the green information system are as follows: installing software to reduce overall greenhouse emissions by my company, changing my company's business processes to paperless, communicating in some aspects of my work that require me to travel, install software to make the distribution and delivery of my company's products more environmentally friendly, Install software to make my company's material sourcing and acquisition more ecologically friendly.

2.3. Green Manufacturing (GM)

Green Manufacturing is a process that uses inputs with relatively low environmental impact, is very efficient, and produces less waste or pollution (Basana et al., 2022). Afum et al. (2020) that green manufacturing can be explained as using appropriate and highly efficient materials to produce that can reduce negative impacts on the environment. According to Shukla & Adil (2021), green manufacturing is critical today because it can integrate all manufacturing problems to minimize environmental impact and resource consumption (Paul, 2014). According to Acquah et al. (2021), the indicators of green manufacturing are as follows. Green Procurement, Green Product Innovation, Green Process Innovation.

2.4. Green Purchasing (GP)

Green purchasing is a behavior that considers environmental and social factors to minimize the impact of these two factors in purchasing and using products that are beneficial to the environment, recyclable, and sensitive to the environment (Prawitha & Rastini, 2016; Nugroho et al., 2024). Green purchasing refers to integrating environmentally conscious decisions into the purchasing process, from product and process design to disposal (Wang et al., 2021). According to Vazifehdoust et al. (2013), green purchasing is also defined as the affirmative choice and acquisition of products and services that most effectively minimize adverse environmental impacts during the life cycle from manufacturing, transportation, use, and recycling or disposal (Amoako et al., 2020). In addition, green purchasing has been defined as environmentally conscious purchasing practices that reduce sources of waste and promote the recycling and reclamation of purchased materials without affecting the performance requirements of those materials (Lannelongue et al., 2016). According to Prawitha & Rastini (2016), there are three measurements in green purchasing, which are as follows: Raw materials, Products, Quality

2.5. Manufacturing Performance (MP)

Khan and Qianli (2017), manufacturing performance shows a company's marketing and financial performance compared to the industry average. Manufacturing performance is a composite construction that shows the company's business performance (Al-Shboul, 2017). Manufacturing performance is the result of manufacturing in a certain period that is influenced by operational activities and resources that have been owned (Choi & Hwang, 2015; Siagian et al., 2020). Indicators of green purchasing, according to Zadeh et al. (2020), our customer service level: assessment of customer satisfaction regarding orders sent and whether they are on time and appropriate, Overall product quality Products produced following their functions, Product support: evaluation of manufacturing whether it builds long-term relationships with customers., Delivery dependability: reliability of manufacturing in maintaining its promises to customers regarding agreements. Predetermined delivery, Presale customer service have adequate presale service to preserve the good name of the manufacturer. Presale service is a process before the sales process occurs (when the customer decides to make a purchase, there is a more detailed process that must be carried out, such as marketing the products offered, Delivery speed: manufacturing reliability in delivering products on time, Volume flexibility: manufacturing produces a variety of products.

2.6. Relationships Between Concepts

2.6.1.Eco Design's Relationship with Green Manufacturing

Eco-design is implemented as a form of green improvement in making packaging systems in manufacturing companies more friendly to reduce waste (Molina-Besch et al., 2019). Eco-design is set up by the company with innovations in packaging so that companies can pay attention to the manufacturing process environment to produce reduced waste safe for consumption by individuals (Zeng et al., 2020; Aagerup et al., 2019). Meanwhile, Shaikh and Roy (2016) examined the eco-design impact on green manufacturing. Eco-design can reduce the environmental impact of manufacturing processes by reducing material waste, improving energy efficiency, and minimizing the use of hazardous substances (Waris & Hameed, 2020). Eco-design practices can lead to cost savings and improved product quality. (Romli et al., 2015) conducted a literature review on eco-design and its effect on green manufacturing. Another researcher, Seyedhosseini et al. (2019) conducted a study investigating eco-design's influence on the automotive industry. Eco-design can lead to more sustainable manufacturing practices by reducing waste, increasing resource efficiency, and minimizing the use of hazardous materials. Therefore, Eco design can enhance a company's reputation for sustainability and provide a competitive advantage (Choong et al., 2013). Razalli et al. (2016) comprehensively reviewed the literature on eco-design and green manufacturing. Borges et al. (2018) conducted a case study of a furniture company implementing eco-design practices. Companies can significantly reduce environmental impact and costs by reducing material waste, improving energy efficiency, and minimizing the use of hazardous materials. So, it can be concluded that eco design affects green manufacturing with the following hypothesis.

H_1: *Eco design affects green manufacturing.*

2.6.2. Eco design's Relationship with Green Purchasing

According to research conducted by Mujahidin (2020), there is an influence between eco design and green purchasing. Research by Darmawan and Suasana (2020) proves that green packaging positively and significantly affects the green purchase intention of Tumbler products at Starbucks Griya Santrian Bali. Aagerup et al. (2019) suggest that individuals are more likely to buy a product if the packaging has a green claim than a neutral one. Ansar (2013) states that ecological packaging affects purchase intention with a low correlation. Consumers will likely buy green products in environmental packaging if they meet the cost-benefit analysis (Darmawan & Suasana, 2020; Ansar, 2013). Hotels that use ecolabels for green purchasing are determined by coordinating with suppliers through eco-design (Tarigan et al., 2020). Eco-design increases purchase value according to the existence of environmentally friendly products. Research conducted by Siagian et al. (2022) states that green innovation carried out by manufacturing companies positively affects product purchase intentions for company customers. Waris & Hameed (2020) conducted a study on the home appliance sector, with the findings that eco-design practices can lead to more eco-design product development and influence consumers' green buying behavior.

Another researcher Choong et al. (2013), conducted a study in the United Kingdom and found that eco design can effectively promote green buying behavior. In addition, it was found that eco-design practices can increase consumers' perceived value of eco design products and positively influence purchase intent. Finally, Melnyk et al. (2003) propose a framework for integrating eco-design considerations into Green Purchasing. Eco-design can help organizations achieve environmental sustainability goals and lead to cost savings through increased efficiency and reduced waste. In addition, Ciriminna et al. (2013) presented a case study of consumer electronics manufacturers who practice eco design. Eco-design can lead to the development of more eco-design products and can positively influence the green buying behavior of consumers. Razalli et al. (2016) have studied the relationship between eco design and green purchasing. Eco-design can be an effective strategy to promote eco's consumption patterns and can help organizations achieve environmental sustainability goals.

This study shows that eco design can be essential in promoting environmentally sustainable consumption patterns and influencing Green Purchasing behavior. Eco-design can help organizations achieve environmental sustainability goals and lead to cost savings through increased efficiency and reduced waste. So, it can be concluded that eco design affects green purchasing and can be formulated with the following hypothesis.

H_2: *Eco-design affects green purchasing.*

2.6.3. Eco design's Relationship with Manufacturing Performance

Research by Khan and Qianli (2017) states that eco-design significantly improves the global competitive position of suppliers and manufacturers. The study by Green et al. (2012) also says a positive relationship between the green supply chain and manufacturing performance through the environment. Innovation in eco design improves manufacturing's image and leads to more significant sales development (Choi & Hwang, 2015). Eco-design on packaging set by the company in the food supply chain impacts efficient transport and reduces waste (Molina-Besch et al., 2019). Eco-design is set by the company with innovation in packaging as a strategy to achieve eco-efficiency in improving manufacturing performance (Zeng et al., 2020).

Salehnejad and Yin (2018) conducted a literature review and found that eco-design can improve manufacturing performance through increased efficiency, reduced waste, and improved environmental sustainability. Li et al. (2014) conducted a case study of automotive manufacturing in China. They found that eco-design can improve manufacturing performance through reduced material use, increased process efficiency, and reduced energy consumption. Li et al. (2016) studied China's electronics industry and found that eco-design can improve manufacturing performance through increased efficiency, reduced waste, and improved environmental sustainability. Meanwhile, Coda and Matta (2019) studied small and medium-sized enterprises in the UK. They found that eco design can improve manufacturing performance through increased efficiency, reduced waste, and improved environmental sustainability. Finally, Zhang et al. (2016) conducted a literature review and proposed a future research agenda investigating the relationship between eco-design and manufacturing performance. The study shows that eco design positively influences Manufacturing Performance, including increased efficiency, reduced waste, and improved environmental sustainability. The study also suggests that eco design can lead to cost savings for manufacturing organizations through increased efficiency and reduced waste. So, it can be concluded that the application of eco design can affect manufacturing performance so that it can formulate hypotheses as follows.

H_3: *Eco-design affects manufacturing performance.*

2.6.4. The Relationship of Green Information Systems with Green Manufacturing

Research conducted by Setiawan et al. (2023) showed that digitalization as a green information system positively influences green manufacturing in the green supply chain process. Green information in manufacturing companies can impact green manufacturing by using environmentally friendly raw materials, energy efficiency, and reducing company waste (Akman & Mishra, 2015). The reason is that by using technology, the manufacturing production process will run more effectively and not waste much time (Wijaya, 2022). Mardani et al. (2019) systematically reviewed the GIS and green supply chain management literature, including studies on GM. GIS can be used to support a variety of GM practices, including waste reduction, energy efficiency, and pollution prevention. The authors also note that GIS could facilitate collaboration between supply chain partners, leading to more sustainable manufacturing practices (Zadeh et al., 2020). Research conducted by Kannan and Ramanathan (2015) reviewed the literature on green manufacturing practices, including GIS. GIS can be used to support a variety of GM practices, including product design, process improvement, and environmental monitoring. The authors also note that GIS could facilitate data sharing and collaboration between manufacturing companies, leading to more sustainable manufacturing practices. The literature review by Gunasekaran et al. (2017) indicates the use of big data analytics in supply chain management, including in green manufacturing. Big data analysis can be used to identify and mitigate supply chain risks, including environmental hazards, and this can support more sustainable manufacturing practices. The authors also note that big data analytics can improve supply chain visibility and transparency, which could lead to more sustainable manufacturing practices. Based on the above arguments, the following hypothesis can be proposed.

H_4: *Green information system affects green manufacturing.*

2.6.5. The Relationship of Green Information System with Green Purchasing

Research conducted by Green Jr. et al. (2012) said that green information system positively affects green purchasing. Adekoya et al. (2021) conducted a study on Nigerian manufacturing SMEs. Green information systems positively influence Green Purchasing by increasing green awareness, facilitating green decision-making, and improving green communication. Liu et al. (2021) conducted a study in a manufacturing company in China. Green information systems positively influence green purchasing through the mediating effect of green trust and green innovation. The same researcher, Li et al. (2019), also conducted a study in a Chinese manufacturing company. The green information system positively influences green purchasing through the mediating effects of green organizational culture and innovation. Finally, Bellal et al. (2019) propose a theoretical framework for the impact of green information systems on green purchases. Green Information systems positively influence green purchasing by increasing green awareness, facilitating decision-making, and improving communication. So, it can be concluded that the green manufacturing system affects green purchasing and can be concluded with the following hypothesis.

H_5: *Green information system affects green purchasing.*

2.6.6. The Relationship of Green Information Systems with Manufacturing Performance

Green information system (GIS) refers to using information systems that promote a product that eco design (Khan & Qianli, 2017). Research conducted by Khan & Qianli states that green information systems improve organizational performance. A study conducted by El-Gayar & Fritz (2006) also said that green information systems / GIS is an effort in green management in fulfilling the company's supply chain. Green information systems (GIS) positively impact coordination and integration with supply chain practices and significantly affect the environment and economy to affect manufacturing performance (Schniederjans & Hales, 2016). Companies implementing a green information system can improve company performance by efficiently using raw materials because it can reduce waste (Akman & Mishra, 2015). So, it can be concluded that green information systems can affect manufacturing performance (Tarigan et al., 2021), and the hypotheses that arise are as follows.

H6: *Green information system affects manufacturing performance*.

2.6.7. The Relationship of Green Manufacturing with Manufacturing Performance

Green manufacturing describes manufacturing practices that cannot damage the environment through industrial processes to reduce/prevent air, water, and soil pollution and minimize waste through product and process design. According to Khan & Qianli (2017), Green manufacturing will be able to create high-quality products at low cost. Research by Khan & Qianli (2017) states that green manufacturing significantly improves the global competitive position of suppliers and manufacturers. The study that has been made by Subramanian & Gunasekaran (2014) explains that green manufacturing can dramatically increase the company's manufacturing process. This result proves that there is an influence of green manufacturing on manufacturing performance, so hypotheses like this appear.

H7: *Green manufacturing affects manufacturing performance.*

2.6.8. Relationship between Green Purchasing and Green Manufacturing

According to Foo et al. (2018), in their research, there is a significant influence between green purchasing and green manufacturing. Green purchasing in the hotel industry can significantly impact the implementation of green hotels by minimizing hotel waste and making efficient energy use (Tarigan et al., 2020). Other studies have also been conducted in various countries and industries, including the electrical and electronics industry in Taiwan by Chien and Shih (2007), the manufacturing industry in India by Luthra and Garg (2016), and literature reviews from various industries and countries by Sousa-Zomer and Sarkis (2019) and Srivastava (2007). In general, the study revealed that green purchasing supports implementing green manufacturing. So, it can be concluded that green purchasing and green manufacturing influence each other and can be finished with the following hypothesis.

H8: *Green purchasing affects green manufacturing.*

2.6.9. The Relationship of Green Purchasing with Manufacturing Performance

Green purchasing is the implementation of reducing waste by recycling which can make green supply chain management a solution to lowering resources in the supply chain (Khan & Qianli, 2017; Nugroho et al., 2024). Green purchasing using eco design materials and ecolabel products can provide green performance through efficient energy use (Tarigan et al., 2020). Research conducted by Khan and Qianli (2017) states that green purchasing significantly improves the global competitive position of suppliers and manufacturing. The study conducted by Chuang and Yang (2014) says that green purchasing can be divided into five dimensions: supply chain management, environmental authentication, ecology, design operations management, and external environmental management that directly impact manufacturing performance. Research on 81 manufacturing companies in East Java, Indonesia, revealed that green purchasing affects operational performance (Siagian et al., 2021). According to this study, it is proven that green purchasing affects manufacturing performance, so the hypothesis that arises is as follows.

H9: *Green purchasing affects manufacturing performance.*

Based on the explanation in the introduction, theoretical studies, and the relationship between concepts, the research conceptual framework can be set in Fig. 1.

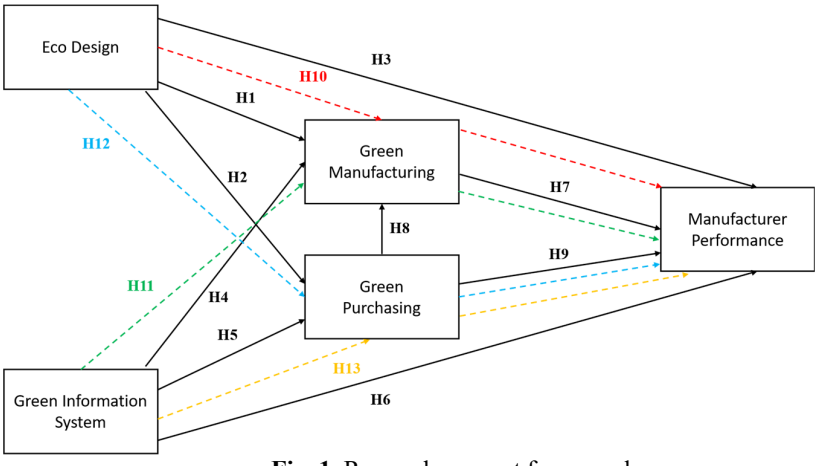

Fig. 1. Research concept framework

H_1: *Eco-design affects green manufacturing in manufacturing companies.*
H_2: *Eco-design affects green purchasing in manufacturing companies.*
H_3: *Eco-design affects manufacturing performance in manufacturing companies.*
H_4: *Green information system affects green manufacturing in manufacturing companies.*
H_5: *Green information system affects green purchasing in manufacturing companies.*
H_6: *Green information system affects manufacturing performance in manufacturing companies.*
H_7: *Green manufacturing affects manufacturing performance in manufacturing companies.*
H_8: *Green purchasing affects green manufacturing in manufacturing companies.*
H_9: *Green purchasing management affects manufacturing performance in manufacturing companies*.
H_{10}: *Eco-design affects manufacturing performance through green manufacturing in manufacturing companies.*
H_{11}: *Green information system affects manufacturing performance through green manufacturing in manufacturing companies.*
H_{12}: *Eco-design affects manufacturing performance through green purchasing in manufacturing companies.*
H_{13}: *Green information system management affects manufacturing performance through green purchasing in manufacturing companies*.

3. Research Methods

This study examines the effect of eco-design, green information systems, green manufacturing, and green purchasing on manufacturing performance in manufacturing companies in Indonesia. The research approach carried out is quantitative. Quantitative research is a process to build and test hypotheses (Ferdinand, 2014). The population combines all elements in the form of events, things, or people with similar characteristics. The center of attention is manufacturing companies in Indonesia that have implemented green. The central statistics agency in East Java stated that in 2021 the number of existing manufacturers was 5,783 manufacturing. Research data was collected from 115 manufacturing companies in East Java. This research focuses on green supply chain implementation in the manufacturing industry. Eco-design measurement items are a sustainable design approach, considering the product's environmental impact during the entire life cycle. Measurement items for eco design are material management, minimizing material utilization, recycling materials, extending service life, and energy utilization.

A green information system is an initiative to utilize information technology infrastructure to change organizational processes and practices to increase energy efficiency, reduce environmental impact, and introduce a healthier environment in products and services. The measurement items of the green information system are using information technology to reduce emissions, using paperless business processes, implementing information technology in meeting product demand, and implementing information technology in production capacity planning. Green manufacturing is a process that uses inputs with relatively low environmental impact, is very efficient, and produces less waste or pollution. Green manufacturing measurement items procure raw materials from suppliers that comply with environmental regulations and guidelines, making appropriate technological investments in product development and redesign. Efficient use of resources in production/manufacturing processes. Green purchasing is a behavior that considers environmental and social factors intending to minimize the impact of these two factors in the purchase and use of products that are beneficial to the environment, recyclable and sensitive to the environment. The indicators of green purchasing are as follows: buying environmentally friendly raw materials, setting criteria for product specifications produced ecologically friendly, and maintaining adequate quality in procuring raw materials. Manufacturing performance is the result obtained through manufacturing activities in a certain period and is influenced by operations and resources owned. The indicators measured through manufacturing performance are as follows: customer service level, overall product quality, product support, delivery dependability, presale customer service, delivery speed, and volume flexibility. Data analysis is used with smart partial least square software to process and analyze data in answer to all research hypotheses.

4. Results and Discussion

Data was collected by distributing questionnaires through Google Forms to respondents from the manufacturing companies studied. The results of the distribution of this questionnaire resulted in respondents as many as 115 manufacturers. The respondent profiles are shown in Table 1. Table 1 shows the characteristics of respondents based on company type. The majority came from the food and beverage sector, amounting to 37 respondents (32%). This finding shows that the proportion of the manufacturing company sector is mainly in the food and beverage sector, which is the basic need of the community. The characteristics of research respondents were generally divided into 12 departments. The most significant respondents were in the operational/production department, amounting to 29 respondents (25%), while the most minor respondents were in the human resources department, amounting to 2 respondents (2%). This result shows that the proportion of employees in manufacturing companies is mainly in the operational/production department, which is the spearhead for the company in selling products. The characteristics of respondents with the most positions are managers, who number 38 respondents (33%). This finding shows that most respondents are managers and are considered to know the company's condition both from a technical and strategic side. Finally, the characteristics of respondents based on the length of work in the company show that most respondents have worked long enough and are considered to understand the company's conditions well.

Table 1
Respondent Profile

Profile	Description	Sum	%
Industry type	Chemical	14	12 %
	Food and Beverage	37	32 %
	Wood and Leather	27	23 %
	Paper, Printing & Packaging	9	8 %
	Household	10	9 %
	Clothing/Garment	11	10 %
	Mining	7	6 %
Department	Accounting and Finance	6	5%
	Engineering	3	3%
	Marketing and Sales	26	23%
	Operational and Production	29	25%
	Production Planning &; Inventory Control (PPIC)	7	6%
	Purchasing/ Export-Import	19	17%
	Quality Assurance/Control	4	3%
	R&D (Research and Development)	3	3%
	Warehouse/Logistic	8	7%
	Human Resources	2	2 %
	Supply Chain	3	3 %
Position	Director/Owner	12	10 %
	General Manager (GM)	14	12%
	Manager	38	33%
	Supervisor (SPV)	27	23%
	Senior Staff	24	21%
Length of Work	2 to less than 4 years	19	17%
	4 to less than 6 years	34	30%
	more than 6 years	62	53%

Descriptive statistical analysis is performed to measure the mean score and standard deviation of each indicator. Then, the Partial Least Square (PLS) technique using SmartPLS software assesses the research model, which results are shown in Table 2. The goodness of fit evaluation in PLS is examined for the outer and inner models. The outer model connects all indicators with their latent variables. The outer model will be tested for validity and reliability. A measurement item can meet convergent validity with an outer loading value of ≥ 0.5. The assessment of composite reliability determines the reliability of a block of indicators, and the indicators are considered reliable for a composite reliability value of more than 0.7. The greater the composite reliability value indicates, the better the variables' accuracy, consistency, and reliability in these indicators.

Table 2
Mean, Validity, and Reliability Test

Item Measurement	Mean	Loading	Composite Reliability	Cronbach Alpha	AVE
Eco-design (ED)	**3. 9843**				
Reduce the use of excessive materials used (ED1)	4.1391	0.711			
Using recyclable materials (ED2)	3.9217	0.864	0.900	0.861	0.644
Using minimal material variety (ED3)	3.9652	0.758			
Replacing parts with a new generation (ED4)	3. 9217	0.841			
Energy use in the manufacturing process (ED5)	3. 9739	0.828			
Green Information System (GI)	**4.0826**				
Using information technology to reduce emissions (GI1)	4.0261	0.904			
Using paperless business processes (GI2)	4.1478	0.885	0.938	0.912	0.791
Implementation of information technology in meeting product demand (GI3)	4.0000	0.887			
Implementation of information technology in production capacity planning (GI4)	4.1565	0.882			
Green manufacturing (GM)	**3.9710**				
Procurement of raw materials from suppliers that comply with environmental regulations and guidelines (GM1)	3.9565	0.863	0.853	0.741	0.659
Make appropriate technology investments in product development and redesign (GM2)	4.0000	0.851			
Efficient use of resources in the production/manufacturing process (GM3).	3. 9565	0.819			
Green Purchasing (GP)	**3.9623**				
Buying environmentally friendly raw materials (GP1)	3.9130	0.903			
Establish criteria for the specification of environmentally friendly products produced (GP2)	3.9652	0.855	0.922	0.872	0.797
Maintain adequate quality in the procurement of raw materials (GP3)	4.0087	0.919			
Manufacture Performance (FP)	**4.0124**				
Increased customer service level (MP1)	4. 0087	0.720			
Produce adequate overall product quality (MP2)	4.00 00	0.867			
Customer product support (MP3)	4.0261	0.712	0.914	0.891	0.605
Manufacturing can produce Delivery dependability (MP4)	3. 9652	0.805			
Manufacturing has presale customer service (MP5)	4. 0696	0.760			
Products shipped according to the estimated time set (MP6)	4.1043	0.749			
The number of products produced varies according to market demand (MP7)	3.9130	0.819			

The discriminant validity is done to test how far different a variable is from other variables. The recommended Fornell-Larcker

Fornell-Larcker Criteria

Forner Larcker Criterion	Eco Design	Green Inf. System	Green Manufact.	Green Purchasing	Manufact. Performance
Eco-design	0.803				
Green Information System	0.688	0.889			
Green Manufacturing	0.726	0.679	0.812		
Green Purchasing	0.732	0.663	0.704	0.893	
Manufacturing Performance	0.764	0.733	0.768	0.745	0.778

The inner model uses R-square, Q-square, and research hypothesis tests. The R-Square value of PLS indicates the sum of variances of the construct described by the model. The greater the R-Square value, the greater the percentage of variance that can be explained. The R-square value of each dependent variable is Green Manufacturing (GM) at 0.623, Green Purchasing (GP) at 0.584, and Manufacturing Performance (MP) at 0.732. A Q-Square value greater than 0 indicates that the model has predictive relevance. The suitability of structural fashion can be seen from Q-Square.

$$\text{Q-Square} = 1 - [(1 - R_1^2) \times (1 - R_2^2) \times (1 - R_3^2)] = 1 - [(1 - 0.623) \times (1 - 0.584) \times (1 - 0.732)] = 1 - [0.042] = 0.9580$$

Testing the research hypothesis is examined using a t-statistical value. The hypothesis is accepted if the t-statistic value is above 1.96 or the significance value (p-value) is below 0.05 (5%). Otherwise, the hypothesis is rejected. The results using partial least squares (PLS) are shown in Fig. 2 and Table 4.

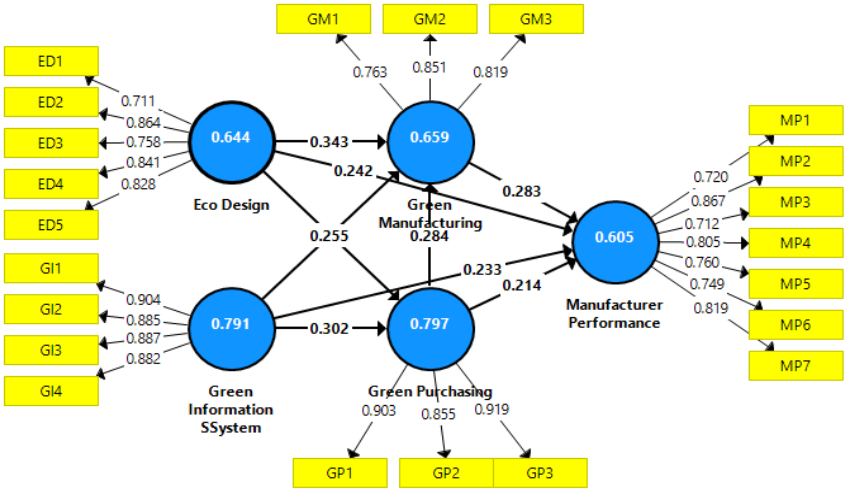

Fig. 2. Path Coefficient Test Results

Table 4
Direct Effect Hypothesis Test Results

Direct Coefficient	Original Sample	T-Statistics	P Values
Eco-design→ Green Manufacturing (H1)	0.343	2.718	0.007
Eco-design→ Green Purchasing (H2)	0.524	5.623	0.000
Eco-design→ Manufacturing Performance (H3)	0.242	2.200	0.028
Green Information System → Green Manufacturing (H4)	0.255	2.737	0.006
Green Information System → Green Purchasing (H5)	0.302	2.997	0.003
Green Information System → Manufacturing Performance (H6)	0.233	2.648	0.008
Green Manufacturing → Manufacturing Performance (H7)	0.283	3.287	0.001
Green Purchasing → Green Manufacturing (H8)	0.284	2.987	0.003
Green Purchasing → Manufacturing Performance (H9)	0.214	2.535	0.012
Eco-design→ Green Manufacturing → Manufacturing Performance (H10)	0.097	2.477	0.014
Green Information System → Green Manufacturing → Manufacturing Performance (H11)	0.072	1.832	0.068
Eco-design→ Green Purchasing → Manufacturing Performance (H12)	0.112	2.091	0.037
Green Information System → Green Purchasing → Manufacturing Performance (H13)	0.065	1.974	0.049

The first hypothesis test indicated the path coefficient value on the influence of eco design (ED) on green manufacturing (GM) is 0.343, with a t-statistic of 2.718 and a p-value of 0.007. Therefore, eco-design, with the use of easily recyclable materials (ED2) and replacement of parts with a new generation (ED4), can form a manufacturing company in supporting the company in adopting green manufacturing by procuring raw materials from suppliers complying with environmental regulations and guidelines (GM1) and investing in appropriate technology in product development and redesign (GM2). This condition shows that eco design can improve the green manufacturing process. This research is in line with previous research, which states that there is an influence between eco design and green manufacturing (Molina-Besch et al., 2019; Zeng et al., 2020; Shaikh

& Roy, 2016; Romli et al., 2015; Seyedhosseini et al., 2019; Razalli et al., 2016; Borges et al., 2018).

The second hypothesis, eco design affects green purchasing, is supported by a coefficient of 0.524, a t-statistic of 5.623, and a p-value of 0.000. Therefore, eco design set by the company can pay attention to purchasing environmentally friendly raw materials (GP1) and buying raw materials from suppliers (GP1) and maintaining adequate quality in the procurement of raw materials (GP3). This condition shows that eco design can improve the green purchasing process. This research is in line with previous research, which states that there is an influence between eco design and green purchasing (Mujahidin, 2020; Darmawan & Atmosphere, 2020; Aagerup et al., 2019; Ansar, 2013; Hartmann & Ibanez, 2006; Tarigan et al., 2020; Siagian et al., 2022; Waris & Hameed, 2020; Choong et al., 2013; Melnyk et al., 2003; Razalli et al., 2015).

Furthermore, the third hypothesis, eco design influences Manufacturing performance, was accepted with a coefficient of 0.242, with a t-statistic of 2.200 and a p-value of 0.028. Therefore, using easily recyclable materials and replacing parts with new-generation parts (ED4) can improve manufacturing performance. This finding shows that the products produced are non-perishable (MP2), and the number of products made varies according to market demand (MP7). Therefore, eco design can improve the process of manufacturing performance. This research is in line with previous research, which states that there is an influence between eco design on manufacturing performance (Khan & Qianli, 2017; Choi & Hwang, 2015; Molina-Besch et al., 2019; Zeng et al., 2020; Salehnejad & Yin, 2018; Li et al., 2014; Coda & Matta, 2019; Zhang et al., 2016).

The fourth hypothesis also supported that green information system (GI) affects green manufacturing (GM). There is a significant influence between the green information system on green manufacturing in manufacturing companies in Indonesia. Green information systems described by manufacturing using programs or software to reduce greenhouse emissions (GI1) and using programs or software to distribute and deliver company products (GI3) impacts green manufacturing. This finding can demonstrate that manufacturers are making the necessary investments in acquiring the right technology to regularly assist in product development and redesign (GM2) and encourage eliminating wasteful production/manufacturing processes to increase the use of resources and raw materials (GM3). This condition shows that the green information system can improve the green manufacturing process. This research is in line with previous research, which states that there is an influence between green information systems on green manufacturing (Setiawan et al., 2023; Akman & Mishra, 2015; Mardani et al., 2019; Kannan & Ramanathan, 2015; Gunasekaran et al., 2017).

Besides the fifth hypothesis is also supported that green information systems (GIS) affect green purchasing (GP). Therefore, the green information system can improve the green purchasing process. This research is in line with previous research, which states that there is an influence between green information systems on green purchasing (Khan & Qianli, 2017; Adekoya, 2019; Li & Sarkis, 2021; Li et al., 2019). Moreover, the sixth hypothesis, green information system (GIS) influences manufacturing performance (MP), was supported. Green information systems with the use of paperless business processes (GI2) and the implementation of information technology in meeting product demand (GI3) can improve manufacturing performance (MP) with an increase in adequate product quality (MP2) and the number of products produced varies according to market demand (MP7). This research is in line with previous research, which states that there is an influence between green information systems on manufacturing performance (Khan & Qianli, 2017; El-Gayar & Fritz, 2006; Schniederjans & Hales, 2016; Akman & Mishra, 2015).

The seventh hypothesis was supported. Green manufacturing (GM) improves manufacturing performance (MP). Green manufacturing is described by the ability to make the necessary investments in acquiring the right technology to assist regularly in product development and redesign (GM2) and encouraging the elimination of wasteful production/manufacturing processes to increase the use of resources and raw materials (GM3), impacting manufacturing performance. This research is in line with previous research, which states that there is an influence between green manufacturing on manufacturing performance (Khan & Qianli, 2017; Subramanian & Gunasekaran, 2014). The eighth hypothesis also supports that green purchasing (GP) affects green manufacturing (GM). This condition shows that green purchasing can improve the green manufacturing process. Again, this research is in line with previous research, which states that there is an influence between green purchasing and green manufacturing (Foo et al., 2018; Tarigan et al., 2020; Luthra and Garg, 2016; Sousa-Zomer and Sarkis, 2019).

In addition, the ninth hypothesis stating that green purchasing (GP) affects manufacturing performance (MP) is accepted. This condition shows that green manufacturing improves green purchasing. This research is in line with previous research, which states that there is an influence between green purchasing on manufacturing performance (Khan & Qianli, 2017; Nugroho et al., 2024; Khan & Qianli, 2017; Tarigan et al., 2020; Chuang & Yang, 2014; Siagian et al., 2021). Finally, the tenth hypothesis states that eco design (ED) affects manufacturing performance (MP) through green manufacturing (GM). This hypothesis was supported by the fact that the influence of eco design (ED) on manufacturing performance (MP) through green manufacturing (GM) is significant. Furthermore, the impact of green information system (GI) on manufacturing performance (MP) through green manufacturing (GM), the eleventh hypothesis, is supported at a 10% significant level since the p-value is 0.068 <0.10. These results show that the green information system (GI) affects manufacturing performance (MP) through green manufacturing (GM) significantly.

The twelfth hypothesis states that eco design (ED) affects manufacturing performance (MP) through green purchasing (GP).

This hypothesis is supported by a coefficient of 0.112, a t-statistic of 2.091, and a p-value of 0.037. Therefore, there is a significant influence between eco design (ED) on manufacturing performance (MP) through green purchasing (GP) in the manufacturing Industry in Indonesia.

The last hypothesis, the effect of green information systems (GI) on manufacturing performance (MP) through green purchasing (GP), is supported. The coefficient is 0.065, with a t-statistic of 1.974 and a p-value of 0.049. Therefore, there is a significant influence of green information systems (GIS) on manufacturing performance (MP) through green purchasing (GP). Based on the results of data processing, it was found that thirteen hypotheses could be accepted at a significance of 5%, and one hypothesis (H11) was accepted with a significance level of 10%.

5. Conclusion

Based on the discussion of research, research results can be determined as a form of contribution, among others, eco design affects green manufacturing. This result shows that eco design can improve the manufacturing process in producing its products to build eco design manufacturing and have competitiveness with other manufacturers. Second, eco design affects green purchasing. Eco-design in manufacturing will influence the purchase of the manufacturing company itself. By practicing eco-design, the manufacturer automatically buys any item with environmentally friendly systems from suppliers. Third, eco design affects manufacturing performance. This result shows that the eco design on manufacturing performance will make the manufacturer create products designed to compete with competitors. An environmentally friendly design will produce products with minimal waste and not pollute the environment. Fourth, the green information system affects green manufacturing, purchasing, and manufacturing performance. This finding shows that applying information systems used in the manufacturing process can help companies create programs or software to facilitate the manufacturing process to produce optimal products and obtain more significant profits than before. Finally, green manufacturing and green purchasing affect manufacturing performance. This result shows that green manufacturing processes in the supply chain system can help optimize manufacturing performance. Based on the conclusions of the study's results above, several improvements can be made, including manufacturing companies' need to allocate costs for the development needs of green supply chain management in manufacturing companies. Manufacturing companies must improve their purchasing processes in the green supply chain process so that manufacturing companies can run well. Manufacturing companies must use eco design information systems to compete with competitors, especially in today's modern era, which requires all businesses to use the best information systems to advance their companies.

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