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COST INFORMATION AND ENERGY EFFICIENCY: EXPERIMENTAL STUDY ON IN THE DESIGN OF NEW SUSTAINABLE PRODUCTS

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Abstract

This study explores the influence of cost information and energy efficiency in sustainable new product development. With a 2x2 factorial experimental design, the study involved Accounting students of Universitas Muhammadiyah Yogyakarta. Data were collected through experimental tasks based on the type of cost information and the level of energy efficiency. The ANOVA results showed that energy efficiency had a significant effect on green product design, while cost information had no direct effect. These findings emphasize the importance of energy efficiency in product development for sustainability. Green products can reduce production costs, minimize waste, and increase competitiveness. The application of green technology also attracts investment, creates jobs, and supports industrial innovation. In addition, compliance with environmental regulations strengthens sustainable economic growth and improves people's quality of life. Thus, this study contributes to encouraging business practices that support sustainability and industrial innovation.

Keywords: ***Cost Information, Energy Efficiency, Eco-Friendly Design, Sustainable Product Development***

INTRODUCTION

Nowadays, sustainability is an interesting issue due to its complexity that focuses on academic and industrial fields (Delaney & Liu, 2023). Its relevance through sustainability issues includes three main pillars, namely, environmental, economic, and social aspects (Claudy et al., 2016). Sustainability in this context means focusing on environmentally friendly product design and making it an important priority for modern industries. New product development design is the main activity of a company as an essential source of competitive advantage (Magnacca & Giannetti, 2024).

The main goal of the design of new environmentally friendly product development is to reduce air pollution and negative impacts on the environment during the product cycle developed (Guo, 2021). New product development can help a company meet the needs and desires of consumers more effectively than their competitors, through competitive advantage and marketing strategy as its primary source (Claudy, Pagell, & Peterson, 2016).

In the development of new environmentally friendly products, cost considerations play a crucial role in determining the competitiveness and sustainability of the product. Companies face the challenge of balancing cost efficiency with environmentally friendly innovation. The cost of developing sustainable materials, the cost of cleaner production processes, the cost of environmental certification, as well as the potential cost of recycling at the end of its life and research costs are the costs associated with new environmentally friendly products (Stoneham, 2009). Effective cost management is the key for companies to ensure profitability of environmentally friendly products. Collaboration with other stakeholders in the supply chain can help reduce costs through joint innovation and sustainable practices (Bohldar, 2007).

As a continuation of the explanation regarding the consideration of new products, the challenge in considering the cost must also be considered. By looking at cost quality can affect various aspects related to efficiency and process effectiveness. Resource selection and investment can prevent defective products so that companies can ensure that new products are designed following the set standards (Lesmana, 2021). Proper management of cost quality not only improves product reliability design, but also maintains a competitive advantage in the market. The valuation fee used to test a new product before launch can help in minimizing the risk of loss after the product enters the market.

According to Jatiningsih and Sholihin (2015), one of the important roles in the development of new products is cost information. Cost information refers to financial data to assess and control all costs associated with the new product development process. This information includes direct costs such as raw material costs and labor costs, as well as indirect costs such as overhead costs and distribution costs (Blocher et al., 2021). The role of cost information is to provide information to management in making efficient and effective cost planning in the development of new products (Kholmi, 2019). In addition, cost information can also optimize product design to fit the target market and available budget (Horngren, 2009).

In addition, the development of new products involves not only the aspect of cost information, but also ensures sustainable design choices related to energy efficiency factors (Brezet et al., 1999). Eco-design requires the involvement of various functions, such as design, engineering, and production, and emphasizes the importance of effective collaboration to overcome obstacles in its implementation (Singhal et al., 2024). According to Ron (1998) Sustainable production will minimize all types of waste and the use of natural resources in the form of raw materials and energy to create environmentally friendly products. An important aspect of achieving the sustainability of eco-friendly products is to utilize sustainable cost information, especially when it comes to energy efficiency.

In the new product development cycle, it is important to examine the influence of cost information and energy efficiency on the creation of environmentally friendly and sustainable products. Example: Ahmad et al. (2018) and Waage (2007) It was concluded that design decisions can affect up to 80% of the sustainability of the final product, but there has been no research that specifically links labor costs to worker productivity in the context of energy efficiency. Moreover, although Delaney & Liu (2023) have identified factors that support sustainability in design, they have not yet explored how cost information affects performance measurement and energy efficiency in the development of new products. Therefore, this study aims to fill this gap by analyzing the impact of cost and energy efficiency information on the development of new sustainable and environmentally friendly products, as well as providing deeper insights for practitioners and academics in the field of product management design.

This study aims to fill the gap in previous research by expanding the reference regarding the relationship between cost information and energy efficiency in sustainable product development. This research develops an in-depth framework on the interaction of the two elements in the design of environmentally friendly products. In addition, this research encourages innovation in design practices by combining cost considerations and energy efficiency, thereby creating products that are superior in environmentally friendly concepts.

LITERATURE REVIEW

The Effect of Cost Information on Sustainable New Product Development Design

According to Citrin et al., (2007) the success of an organization can be achieved by focusing on the use of cost information that supports the development of new products, with contingency theory that plays a role in regulating the use of cost information. The contingency theory approach emphasizes that the process of developing new products must be adapted to the specific conditions or contexts faced by an organization (Otley, 1980). New product development should become more responsive when an organization operates in a competitive industry and competitors produce new products. Cost information users will certainly choose the right and accurate cost information. This is in line with research by Hapuwatte & Jawahir (2019) demonstrate that accurate and relevant cost information can improve decision-making in the development of new sustainable products, resulting in more efficient and environmentally friendly product designs.

Research by Rahatulain et al., (2021) disclosing cost information is a tool that helps decision-making in the development of new products in a company. In the development of new products, designers are directed to consider sustainability and technical aspects through cost information from the beginning of the design process (Kerga et al., 2023). In addition, cost information affects designer behavior, i.e., how they are affected by cost information and its impact on the type of product designed against the cost information stipulation (Booker et al., 2007). The role of cost information in product development is not only that. Proven through research conducted by (Jaelani & Purnama, 2022) An understanding of the cost information structure allows companies to design products that not only meet customer needs but are also efficient in the use of resources and production costs.

Thus, cost information is a determining factor that assists companies in decision-making, ensuring designer behavior in measuring sustainability aspects, as well as measuring and managing costs associated with the development of new environmentally friendly products. The following hypotheses are proposed:

H1: Cost Information Affects Sustainable New Product Development Design

The Effect of Energy Efficiency on Sustainable New Product Development Design

In the industrial era, like today, energy efficiency was one of the factors in the process of developing new products. Energy efficiency is not only concerned with measuring power consumption but also about optimizing resources at every stage of the product life cycle, from initial design to production and use by consumers (Gustaf, 2005). The purpose of implementing energy efficiency strategies in product design is to improve environmental performance.

An organization needs to formulate an effective strategy in achieving sustainable energy efficiency with an understanding of open innovation theory. According to (Chesbrough, 2003) Organizations that use the open innovation theory can leverage outside knowledge and technology to improve energy efficiency in the products they develop. The statement was reinforced by Research conducted by Gasman et al. (2010), which shows that companies that apply the open innovation model tend to be more successful in developing innovative and efficient products. By involving consumers in the design and testing process, companies can understand market needs and preferences, thereby creating more precise and effective solutions (Lichtenthaler, 2011).

Research by Hameed et al. (2018) shows that collaboration with research institutions and suppliers can result in new technologies that are more efficient in energy use, thus supporting the company's sustainability goals. In addition, research by Adiprama and Ciptomulyono (2020) revealed that companies that adopt an open innovation approach tend to be more able to integrate energy efficiency practices in their product development processes. Thus, the development of this hypothesis not only provides insight into the potential for improved energy efficiency but also highlights the importance of collaboration in innovation to achieve sustainability goals.

To reduce environmental impacts, such as the use of plastics contained in products and improve product performance, it can be done by optimizing energy efficiency that reduces energy consumption during the product life cycle, thereby reducing carbon footprint and operational costs. Energy efficiency strategies also allow companies to carry out product sustainability by adopting environmentally friendly technologies (Herrmann & Thiede, 2009). By understanding the dynamics of energy efficiency as it relates to the development of new products, organizations can formulate more effective strategies to improve energy efficiency and achieve better sustainability (de Sousa Jabbour et al., 2018).

Thus, energy efficiency in the development of new products can create added value for companies and also support compliance with increasingly stringent environmental regulations, and the following hypotheses can be formulated:

H2: Energy Efficiency Affects Sustainable New Product Development Design

METHOD

With research that sulks on the influence of cost information and energy efficiency in the sustainability of a product, the research method that is suitable to be used is an experiment with a 2x2 factorical design between subjects, aiming to test the influence between independent variables such as cost information and energy efficiency, on dependent variables, namely environmentally friendly sustainable product design. Through experimental methods, empirical data is collected to identify changes in cost and energy efficiency information in influencing product design and final results. In addition, it can control external variables that can interfere with research results, thereby increasing the certainty of the findings obtained.

The experimental method is considered effective in testing the causal relationship hypothesis and meeting internal validity (Hardani et al., 2020). This method makes it possible to test several hypotheses simultaneously to answer a variety of questions. According to Mentgomery, D.C. (2017), this method involves systematic steps, starting from initial observation, hypothesis formation, experimental planning, data collection, and data analysis to find patterns and conclusions that can be drawn.

This research involved students from the Accounting Study Program, Faculty of Economics and Business, University of Muhammadiyah Yogyakarta as a substitute for professional designers in the development of new products. Students involved in the research have completed cost accounting and management accounting courses, so they have the relevant knowledge for this research. The selection of students as participants is based on the assumption that they can serve as a non-professional variable gauge in the industry, provided that the researcher adjusts the complexity of the task according to their abilities and insights (Elliott et al., 2019).

Table 1. Experimental Design

		Energy Efficiency	
		High	**Low**
Cost Information Type	**Specific**	Cell 1	Cell 3
	Relative	Cell 2	Cell 4

In the research matrix above, participants will be given various tasks. The following is the explanation in this research table:

1. In Cell 1, participants with a specific type of cost information and with relatively high energy efficiency.
2. In Cell 2, participants with a relatively high cost information type and with relatively high energy efficiency.
3. In Cell 3, participants with a specific type of cost information and with relatively low energy efficiency.
4. In Cell 4, participants with a relatively low cost information type and energy efficiency.

Variable measurement regarding the influence of independent variables, namely cost information and energy efficiency on dependent variables, new product development. The first independent variable is cost information. According to Wijaya et al. (2022), cost information is information containing data used by an organization to make decisions and measure the activities being carried out. The level of measurement of cost information is manipulated using 2 types of cost information, namely the specific type and the relative type (Booker et al., 2007).

The measurement of the second variable, namely energy efficiency, is based on the first and second-level categories. The first level is categorized as products that have high energy efficiency, while the second level is categorized as products that have low energy efficiency. High-efficiency products contribute to the reduction of carbon emissions, thereby creating environmentally friendly products (Hossain, 2018). Meanwhile, products that have low efficiency tend to increase greenhouse gas emissions and exacerbate climate change (Zainuddin et al., 2017).

Measurement of product development variables that can affect environmental friendliness can be done by paying attention to two main aspects, namely the total cost and intensity of the plastic content contained in the product. The total cost is seen from the total amount of materials used to design the dollhouse in the experimental task. Total cost reductions that focus on raw material and energy efficiency can improve product sustainability (Hassan & Li, 2020). On the other hand, the intensity of the plastic content contained in the product is an important variable to measure environmental impact. Plastic is difficult to decompose and is harmful to the ecosystem, which can increase the environmental impact of these products. Therefore, efforts to reduce the use of plastics through material innovation or substitution with environmentally friendly materials can reduce the carbon footprint of products and improve overall environmental friendliness (Kumar et al., 2021).

This experimental research provides several sets of instruments in the form of worksheets and random research objects to participants through distribution carried out by researchers. Participants are combined in a room with the freedom to choose their seats according to their wishes so that participants will get worksheets that are different from each other. The purpose of randomization or freedom in choosing the instrument used is to ensure equality in the grouping of participants so that the results obtained are reliable and reflect the actual situation. In addition, it can increase the internal validity of the study by equalizing the chances between participants and controls to receive certain treatments.

Checking manipulation is carried out by asking participants several questions to ensure that the research conducted will be well understood. The question aims to verify whether the participant truly understands the experimental treatment given, such as the information, instructions, and context provided during the treatment. The results of the manipulation check showed that 141 participants met the criteria for data processing, with 100% of them successfully passing the manipulation check, so that the internal validity of the study could be maintained.

RESULTS AND DISCUSSION

Hypothetical Statistics

Table 1. Descriptive Statistics The Interaction between Cost Information Types and Energy Efficiency Dependent Variable: New Product Development Design

	Energy Efficiency		Total
	Height (1)	**Low (0)**	

Cost Information Type	Specific	Mean: 366361.1111 SD: 84990.45025 N: 18	Mean: 362884.6154 SD: 71046.68472 N: 13	Mean: 364903.2258 SD: 78200.64145 N: 31
	Relative	Mean: 406918.3673 SD: 86329.81494 N: 49	Mean: 399090.1639 SD: 81100.06721 N: 61	Mean: 402577.2727 SD: 83173.00380 N: 110
	Total	Mean: 396022.3881 SD: 87228.99299 N: 67	Mean: 392729.7297 SD: 80175.50053 N: 74	SD: 394294.3262 SD: 83316.11641 N: 141

Source: Output SPSS

Based on table 1, the average design of new environmentally friendly product development in each experimental design group. Based on the Descriptive Statistical Test, the average design of new product development in the type of cost information for participants who received energy efficiency had the highest mean value of 406918.3673 with a standard definition of 86329.81494 and the total data of 49 (N), this shows that a high mean value means that the product design is not environmentally friendly because it has a fairly high plastic content. The lowest mean value is 362884.6154 with a standard definition of 71046.68472 and a total of 13 (N). This shows that a low mean value means that the design of the product can be interpreted as environmentally friendly because it has a fairly low plastic content.

Of the 141 participants, the design of environmentally friendly products in specific and relative cost information types with and relative participation in energy efficiency and not energy efficiency resulted in an average of 364903.2258 and 402577.2727 and 396022.3881 and 392729.7297.

Homogenity Test

Table 2. Descriptive Statistics
The Interaction between Cost Information Types and Energy Efficiency
Dependent Variable: COST

F	df1	df2	Sig.
0.170	3	137	0.916

Source: Output SPSS

Based on the analysis of the Homogeneity Test, the results of cost as a dependent variable obtained a significant value of 0.916 because it was greater than 0.05. Therefore, it can be said to be a homogeneous significant.

Hypothesis Test

Table 3. Analysis of Variance Test
The Interaction between Cost Information Types and Energy Efficiency
Dependent Variable: COST

Source	Type III Sum of Squars	df	Mean Square	F	Sig.
Corrected Model		3	12027376064	1.761	0.158
Intercept		1	11.392E+13	2038.546	0.000
EFFENERGY		1	34809309435	5.096	0.026
COST INFO		1	754938815.4	0.111	0.0740
EFFENERGY* COST INFO		1	111869879.0	0.016	0.898
Error		137	6830207352		
Total		141			
Corrected Total		140			

Source: Output SPSS

Hypothesis analysis was carried out through Analysis of Variance (ANOVA) with a significance level of 0.05. Based on the information contained in table 3, the type of cost information shows a significant value of 0.074, which is greater than 0.05. It can be interpreted that there is no direct influence on environmentally friendly design in the development of new products. Likewise, the significance value for energy efficiency is 0.026, which is smaller than 0.05, indicating a direct influence on eco-friendly design in the development of new products. However, the significance value for the interaction between cost information type and energy efficiency was 0.898, which was greater than 0.05, indicating that there was no effect of the interaction between the two variables on the development of new environmentally friendly products.

The Effect of Cost Information on the Development of New Environmentally Friendly Products

Variance analysis (ANOVA) shows that the cost information type does not have a significant influence on the development of new environmentally friendly products with a significant value of ANOVA of 0.074, which is greater than 0.05. Therefore, the hypothesis (H1) that states that the type of cost information has a significant effect on the development of new environmentally friendly products is rejected. This was influenced by participants who did not know in depth about the background of environmentally friendly products, as well as the lack of influence of cost information on decision-making, which was reinforced by research ZAFIRAH (2024). According to a study conducted by (Hasan, 2024) It found that internal factors such as product quality have a significant influence on decision-making, while cost information is not always a major consideration. In addition, research (Husniar et al., 2023) It also shows that one of the external factors in the form of market competition may play a greater role in the decision to innovate. Thus, it indicates that although cost information is important, internal factors such as product innovation and quality and external factors of market competition can be more dominant in influencing decision-making in the development of new environmentally friendly products.

The Effect of Energy Efficiency on the Development of New Environmentally Friendly Products

Energy efficiency has a very significant role in the development of new environmentally friendly products. Based on the results of the ANOVA test, a significance value of 0.026, which is less than 0.05, indicates that low energy efficiency can reduce costs and support environmentally friendly raw materials that have little plastic content. Therefore, the hypothesis (H2) that energy efficiency has a significant effect on the development of new environmentally friendly products is acceptable. This is supported by research conducted by Ijomah, M. A., Gilbert, P., & Evans, S. (2007), by paying attention to raw materials that are easier to recycle or reuse to reduce waste and resource management costs. Energy efficiency in the development of new environmentally friendly products can also increase the competitiveness of companies because environmentally friendly products will tend to be more cost-effective and increase interest in people's purchasing power (Kamra et al., 2024). A sustainable design concept emphasizes the integration of energy efficiency principles and the importance of essential strategies to achieve a balance between environmental sustainability and economic benefits. Thus, the higher the energy efficiency set, the greater its contribution in supporting the development of new products.

CONCLUSION

This study examines the influence of cost information type and energy efficiency on new product development. Experiments reveal that this type of cost information cannot interact with energy efficiency in determining new products in a more environmentally friendly direction. The reason can be concluded with various reinforcements. First, there is no significant influence on the type of cost information on the development of environmentally friendly products. Second, the specific cost information type has a fairly low average value, which shows that designers produce sustainable products that are environmentally friendly because they have a fairly low plastic content. Third, there is a significant relationship between energy efficiency and sustainable product development. This indicates that energy efficiency determines product sustainability more than cost information because the role of sustainable energy efficiency optimization is the main factor in increasing the competitiveness of environmentally friendly products.

Although cost information is not one of the main factors in the development of new products, energy efficiency has an important role in supporting environmentally friendly sustainability. With the implications of

energy efficiency for a designer or company, it can be used to add insight and a means of decision-making for product design that is conceptualized with the role of energy efficiency to improve environmental work by reducing plastic waste contained in products, improving product quality in terms of competitiveness and raw materials from the beginning of production until environmentally friendly products are ready to be marketed.

The research conducted still has limitations that need to be considered. These limitations include the industrial sectors analyzed. In addition, market dynamics and technological developments that continue to change have not been fully taken into account in the research model used. In the next study, it is recommended to expand the scope of the industry studied so that the results are easier to apply in various sectors. In addition, long-term analysis can be carried out to understand how cost and energy efficiency information affects future decision-making. Further research can also explore the relationship between new technology trends and sustainability strategies in the development of a product.

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