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Economic Drivers in Sustainable Innovation: The Impact of Cost and Process Selection on New Product Design

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Abstract:

This study examines the effect of cost information and process selection on total costs in sustainable new product design. This study uses an experimental design with the research objective to evaluate how these two variables contribute to cost efficiency and greener product innovation. To achieve this goal, students of the Accounting Study Program from the Faculty of Economics and Business, Universitas Muhammadiyah Yogyakarta as a substitute for professional designers in the development of new products were asked to fill out a questionnaire to evaluate their design choices, consider the sustainability aspects, and identify the challenges they faced during the process. The interaction effect was also assessed to review the correlation effect of these factors on sustainable product design, with the results showing that the interaction effect of the two variables has a significant impact on the total cost, supporting the hypothesis that the combination of these two factors is important in creating cost efficiency in sustainable product development.

Keywords: *Cost information, Process Selection, Total cost, Sustainable New Product Design, cost efficiency*

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1. Introduction

In an era where environmental issues are a global focus, the business sector is increasingly aware of the importance of sustainable practices, especially in product design. Sustainable new product design seeks to create products that minimize environmental impact by adopting environmentally friendly materials, using resources effectively, and paying attention to the entire product life cycle. Product development focuses on winning the organization's competition by offering optimal value to consumers as well as presenting innovative, creative, and high-value ideas (Ellram et al., 2020).

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The development of new products that meet customer needs in a cost-effective manner is key to the survival of many organizations (Booker et al., 2007). A cost information system enables organizations to communicate their financial performance through financial statements, serving as a critical communication medium (Soedrajat, 2010). This system plays a fundamental role in managing industrial business activities by providing detailed operational cost data, which serves as a solid basis for budget analysis and planning. With accurate and up-to-date data, companies can identify areas where expenses can be controlled or reduced, potentially lowering total costs (Dekker & Smidt, 2003).

Sustainable new product design is characterized by cost-effective product development, ensuring the competitiveness and adaptability of products in a dynamic market (Ahmad et al., 2018). Without cost efficiency, sustaining product viability in an ever-changing environment becomes challenging. Previous research by Jatiningsih (2021) highlights that cost information provides strategic advantages by helping organizations minimize production costs. However, its limitations arise when cost is the sole consideration, neglecting other crucial aspects such as quality and market demand. Therefore, the integration of precise and relevant cost information is essential for strategic decision-making in new product development (Delaney & Liu, 2023). The selection of production processes, methods, and tools while considering environmental sustainability is a crucial strategy in achieving this objective (Waage, 2007).

The ability to develop new products is a vital factor in a dynamic organizational environment, and cost information plays a significant role in this process. Previous research shows that cost data can influence the performance of products developed by designers (Booker et al., 2007). Research by Booker et al. (2007) also identifies two types of cost information available to users: specific cost information and relative cost information. Specific cost information is more effective in enhancing a designer's focus on product innovation over time rather than prioritizing cost reduction. Additionally, their findings suggest that cost information can hinder the production process when it excessively directs designers toward cost considerations, potentially neglecting product features and customer needs. Product features are influenced by production process selection, making quality control essential in ensuring that each stage adheres to established standards. Effective quality control significantly enhances product quality and company profitability. If neglected, the risk of defects or damages during production may increase, ultimately affecting customer satisfaction (Irwan et al., 2021). Thus, companies must carefully consider their production processes to meet quality standards and consumer expectations. The integration of product design and process selection is crucial for market success.

Process selection in manufacturing is a fundamental aspect that determines a factory's success and long-term sustainability (Ratnasari et al., 2019). The use of tools and machines to support production efficiency is integral to all industries. Machine performance is a critical factor that ensures smooth operations, particularly in the production sector (Ummah & Dahda, 2022). As market demand for high-quality products with competitive production costs increases, the adoption of automated machinery has become a necessity (Kasnawati et al., 2024). Research by Kasnawati et al. (2024) suggests that automation offers long-term benefits, including consistent product quality, adaptability to market demands, and the ability to scale production without compromising efficiency. Automation not only transforms production processes but also fosters opportunities for sustainable innovation. However, despite its advantages, automated assembly systems are complex and require significant investment. While automation is beneficial, manual assembly lines remain relevant in highly varied production environments due to their flexibility and operational ease (Yarasi, 2011). Furthermore, manual processes can provide a more fulfilling and meaningful experience compared to automated ones, although they also present challenges such as labor-intensive work (Klapperich et al., 2020).

Although numerous studies have explored the role of cost information and process selection in new product design, a research gap remains in understanding how these two factors interact to influence sustainable product design. Most prior research has focused on isolated aspects, such as the role of cost information in decision-making (Jatiningsih, 2021) or the impact of process selection on product quality (Ratnasari et al., 2019). However, few studies have examined the interaction between cost information and process selection in the context of sustainable product design. Therefore, this study aims to analyze the influence of cost information and process selection on sustainable new product design. By employing an experimental approach, this research seeks to evaluate how these two variables contribute to cost efficiency and environmentally friendly product innovation.

2. Theoretical Background

The Effect of Cost Information on Sustainable New Product Development Design

Theory in management accounting, including cost information theory, emphasizes the importance of accurate and relevant cost data in supporting optimal decision-making, particularly in the product design and development process (Dekker & Smidt, 2003). In their research, Booker, Drake and Heitger (2007) define precision in the context of new product development (NPD) refers to the provision of detailed cost information or cost information that compares each design option. In the context of cost management, cost information plays a crucial role in understanding and controlling cost structures, including fixed costs and variable costs, which directly affect the total cost of a product.

The accuracy of cost information allows managers to make more informed decisions, both in managing investments in assets that are included in fixed costs and in controlling expenses that are classified as variable costs, such as raw materials or labor based on activities. For example, the decision to increase automation can increase fixed costs but lower variable costs, thus providing long-term efficiency.
In the new product development (NPD) process, cost information consists of specific cost information and relative cost information, which plays an important role in decision-making. Cost-specific information provides detailed data on cost elements, such as raw materials and labor, allowing for the identification of efficiency and cost control at each stage of NPD. Meanwhile, the relative cost information compares various design alternatives based on their impact on the total cost, aiding in the selection of the most economical option without sacrificing product quality.
The accuracy and relevance of this cost information supports more effective decision-making in determining product designs that are not only efficient but also sustainable. By understanding the cost structure in detail, companies can optimize resources and develop products that are more environmentally friendly and have long-term competitiveness. Therefore, cost information plays a role in supporting the hypothesis that:
Hypothesis 1: Cost information affects the design of sustainable new products.

The influence of process selection on the design of sustainable new product development
Process selection in the development of new products has a significant impact on design sustainability. An effective design process can determine up to 80% of the overall sustainability of the final product. Therefore, it is crucial for designers to integrate environmental factors in each stage of NPD to achieve the desired sustainability goals (Delaney and Liu, 2022). Research by Ahmad et al. (2018), Waage (2007), and Yang and Song (2006) underlines the importance of the design stage in creating environmentally friendly and sustainable products.

Process selection in a factory is a crucial element that not only determines operational success, but also contributes to the long-term continuity and development of the plant. In this process, various aspects must be considered, including technical, operational, environmental, and economic aspects. Strategic process selection allows factories to produce high-selling value products by utilizing more affordable raw materials and lower production costs. This is becoming increasingly relevant in the context of sustainable new product design, where efficiency and sustainability are top priorities (Ratnasari et al., 2019). This shows that integrating sustainability factors in process selection is essential to achieve sustainable design goals.

The process selection model described by Mustajib (2010) supports the optimization of multi-factory systems by minimizing the total cost which includes manufacturing costs, quality loss costs, and operational costs to support collaboration between

factories. By understanding cost information in detail, including details of operational costs, companies can develop more effective budget planning strategies. Accurate and up-to-date data allows companies to identify areas of expenditure that can be controlled or reduced, thereby directly contributing to cost efficiency. This approach supports the successful design of sustainable new products through more efficient resource management, increased competitiveness, and the achievement of sustainability goals.

In this context, the selection of the right process not only serves as an operational tool (use of automated or manual machines), but also as a strategy for integrating cost efficiency with sustainability. Therefore, it can be hypothesized that:
Hypothesis 2 : Process selection affects the design of sustainable new products

3. Methodology

Research Design
This study uses an experimental design with the purpose of research to examine the influence of cost information type and process selection on total cost on sustainable new product design. To achieve this goal, we applied a 2 x 2 experimental design in the form of factorial between subject and different subjects. In this study, undergraduate students from business or accounting programs acted as substitutes for product designers, as they had a basic understanding of cost decision-making, even though their experience in the industry was still limited. Research reveals that undergraduate students can function effectively as representatives in controlled experimental settings, especially when the focus is on analyzing the decision-making process as opposed to professional expertise (Hughes & Gibson, 1991).

Table 1. Research Design

		Process	Selection
		Manual	Automatic
Information	Specific	Cell 1	Cell 3
Cost	Relative	Cell 2	Cell 4

In the matrix above, participants will be given various tasks, the following is the explanation in this research table:
1. In cell 1, a paerkit with a specific type of cost information uses a manual machine in the design process.
2. In cell 2, participants with a relatively cost-information type used manual machines in their design process.
3. In cell 3, participants with specific types of cost information use automated machines in their design process.
4. In cell 4, participants with relatively different types of information use automated machines in the design process.

According to Hardani et al. (2020), the experimental method is considered an effective research method in testing the causal relationship hypothesis and fulfilling internal validity well.

Research Participants
This research involves students of the Accounting Study Program from the Faculty of Economics and Business, University of Muhammadiyah Yogyakarta as a substitute for professional designers in the development of new products. The students involved have taken cost accounting and management courses, so they have relevant knowledge. The selection of students as participants was based on the assumption that they could serve as a variable gauge in this study, even though they were not professionals in the industry. Researchers need to consider the level of insight and ability of students when assigning assignments in experiments (Elliott et al., 2007).

Randomization
Randomization or randomization is the process of randomly dividing research respondents into control and experimental groups, so that each participant has an equal chance of being selected into one of these groups (Janitra et al., 2024). The goal of randomization was to reduce bias in the study, ensuring that any differences that may arise between the two groups can be more accurately attributed to the given treatment, rather than to other external factors. This process is crucial in experiment design, as it increases internal validity and assists researchers in obtaining more reliable results.

Manipulation Check
In the experimental research method, the two groups, namely the treatment group and the control group, were adjusted to the conditions that had been designed by the researchers. Each respondent in the treatment group should receive the same type and number of interventions (Janitra et al., 2024). This aims to maintain the consistency and validity of the research. This method allows researchers to measure the effects of the intervention more accurately and avoid biases that might affect outcomes.

Research Procedure
The experiment was conducted in a controlled classroom, where each participant received supplies in the form of LEGO blocks, cost information (both accurate and inaccurate), and, a manipulation checklist. Participants were asked to design an eco-friendly dollhouse that conforms to the basic design specifications provided by an imaginative company.

The activity began with a briefing that emphasized the importance of sustainability and cost efficiency in the company's mission. Furthermore, participants are given time to create design models while being encouraged to apply sustainable design principles. Once the design model is complete, participants are asked to fill out a

questionnaire to evaluate their design choices, consider sustainability aspects, and identify the challenges they faced during the process.

4. Empirical Findings/Result

The data that has been obtained, is analyzed using a two-way ANOVA to assess the main influence of Cost Information, and Process Selection on the total cost. The effect of the interaction was also assessed to review the influence of the correlation of these factors on sustainable product design.

In a study, knowledge of variance analysis is very important to understand the structure of the relationship between variables and their significance in a research design model (Adi, 2022) (Muttaqin, 2019). Variance analysis or ANOVA can be used to check the correlation between variables, two or more data sets. This allows researchers to see whether there is a relationship between the variables studied. ANOVA is an over-parameterized statistical model, meaning it contains more parameters than is needed to account for the cooling effect (Adi, 2022).

The data prepared for the dependent variable "Total Cost" reveals several important insights into the influence of cost information (INFOCOST), and process selection (PROCESS) on the sustainability score of a new product design. The main statistics to consider include the Number of Squares of Type III, degrees of freedom (df), Average Squares, F-value, and level of significance (Sig.).

Table 2. ANOVA Results

Tests of Between-Subjects Effects

Dependent Variable: COST

Source	Type III Sum of Squares	Df	Average squared	F	Sig.
Corrected Model	89049224888.890a	3	29683074962.963	4.607	.004
Intercept	21785414152808.676	1	21785414152808.676	3380.946	.000
COST INFO	2589039741.585	1	2589039741.585	.402	.527
PROCESS	87917231712.083	1	87917231712.083	13.644	.000
INFOCOST * PROCESS	2115660114.533	1	2115660114.533	.328	.568
Error	882771310572.103	137	6443586208.555		
Total	22892810750000.000	141			
Corrected Total	971820535460.993	140			

a. R Squared = .092 (Adjusted R Squared = .072)

Based on Table 1 above, the hypothesis proposed in this study will be concluded for the main effect as well as the interaction effect. The details of the analysis and conclusions are as follows:

Key Effects
Fee Information (INFOFEE)
F(2589039741.58) = 0.402, p = 0.527
The primary effect of the cost information is not statistically significant, suggesting that the cost information provided has an insignificant impact on the total cost score on sustainable product design. This shows that the design choices of students are most likely not influenced by cost information in both relative and specific aspects.

Process Selection (PROCESS)
F(87917231712.08) = 13.64, p = 0.00
In contrast to the previous main effect, the main effect of the selection process is otherwise significant. These results confirm that the right process selection strategy can improve efficiency and sustainability in product development. By taking these factors into account, companies can create designs that not only meet the needs of the market, but also contribute to environmentally friendly practices. Therefore, careful process selection is key to achieving sustainable product innovation.

Interaction Effects
Fee Information * Process Selection (INFOCOST*PROCESS)
F(2115660114.53) = 0.328, p = 0.568
Statistical analysis indicated that the interaction between Cost Information and Process Selection was not significant, the value still did not reach the level of conventional statistical significance (**$p < 0.05$).** This shows that the interaction effect of cost information and process selection has no significant impact on the total cost score on sustainable product design. Thus, it can be seen that cost information and process selection do not support the total cost of sustainable product design.

5. Discussion

The findings of this study indicate that cost information does not have a significant impact on sustainable product design. This aligns with the research conducted by Booker et al. (2007), which suggested that cost-specific information and relative cost information influence designer behavior but may not necessarily drive substantial changes in product cost efficiency. The lack of significance in cost information's effect on sustainable product design implies that design choices, particularly among students, are driven by other considerations, such as functional and aesthetic aspects rather than cost constraints alone. Similarly, Pomatto et al. (2018) discussed the cost of information and noted that the utility of such data depends on its applicability in decision-making contexts, reinforcing the notion that cost information alone does not always directly influence outcomes.

In contrast, process selection was found to have a significant impact on sustainable product design. This finding is supported by Ahmad et al. (2018), who emphasized the role of sustainable product design tools and applications in achieving cost

efficiency and environmental benefits. By making strategic choices in process selection, companies can improve resource efficiency and sustainability (Delaney & Liu, 2023). This result highlights the importance of selecting appropriate production methods to ensure product viability while maintaining environmental and cost-effective considerations. The findings also resonate with previous studies by Ratnasari et al. (2019) and Ummah & Dahda (2022), which emphasized that selecting the right processes and machinery contributes significantly to operational efficiency and product quality.

Furthermore, the interaction between cost information and process selection did not show statistical significance, suggesting that these two factors do not jointly influence sustainable product design. This is in line with the observations made by Jatiningsih (2015), who stated that cost information alone is insufficient to drive major product innovation without strategic decision-making processes. Additionally, Dekker & Smidt (2003) highlighted that while cost management is crucial, it must be integrated with process optimization to achieve tangible benefits in product development.

The role of automation in production has also been examined in previous research. Studies by Kasnawati et al. (2024) and Redjeki (2017) suggest that automation plays a crucial role in sustainable production by increasing efficiency and maintaining consistent product quality. However, as indicated by Klapperich et al. (2020), manual assembly lines can provide flexibility in handling product variations, even though they may be less efficient than automated processes. This further supports the importance of process selection in determining the efficiency and sustainability of product design, as companies must weigh the benefits of automation against the flexibility of manual processes (Yerasi, 2011).

Additionally, research by Ellram et al. (2020) explored the conflicting role of purchasing in new product development and emphasized the need for a balanced approach in cost management and production process decisions. These insights reinforce the current study's findings that while cost information alone does not necessarily impact design decisions, strategic process selection plays a crucial role in sustainable product innovation. The integration of sustainable considerations in design processes has been further advocated by Waage (2007), who provided a roadmap for incorporating sustainability into product development.

Despite the growing emphasis on sustainability, the findings of this study highlight an ongoing research gap in understanding the combined effect of cost information and process selection. Most previous studies have examined these factors independently, with a focus on either cost efficiency (Jatiningsih, 2021) or process effectiveness (Ratnasari et al., 2019). However, as demonstrated in this study, the two factors may not always work in tandem to influence sustainable product design outcomes. Future research could further explore the underlying mechanisms that

drive sustainable product innovation, considering additional variables such as market trends, regulatory requirements, and technological advancements (Yang & Song, 2006).

In conclusion, this study reinforces existing literature on the significance of process selection in achieving sustainable product innovation while highlighting the limited direct influence of cost information in this context. Companies seeking to enhance product sustainability should prioritize optimizing their production processes and integrating environmentally friendly practices, as suggested by Delaney & Liu (2023). The findings contribute to a broader understanding of sustainable product design and emphasize the need for a holistic approach that integrates cost considerations with process efficiency to achieve long-term sustainability goals.

6. Conclusions

This study aims to evaluate the influence of cost information and process selection on total cost on sustainable new product design. The results of the experiment show that the interaction between cost information and process selection has no significant impact on total cost, challenging the hypothesis that the combination of these two variables is important in creating cost efficiency in sustainable product development. However, the main effect of variale process selection is significant and inversely proportional to the variable cost information that statistically states significant to the design of a sustainable new product. This indicates that the selection elements of this process may be more effective when used individually rather than simultaneously. This research emphasizes the importance of an integrated approach in process selection, which not only impacts operational efficiency but also supports sustainability in new product design.

The selection of the process in this study refers to the decision to use automatic or manual machine-based design methods. This selection has significant implications for cost efficiency and final results, where automated methods tend to provide advantages in terms of speed and consistency, while manual methods can be more flexible in dealing with complex design needs. In this context, it is important to consider how the two approaches can be strategically integrated to achieve optimal cost efficiency and product sustainability.
In addition, in management accounting, including cost information theory, emphasizes the importance of accurate and relevant cost data in supporting optimal decision-making, especially in the product design and development process (Dekker & Smidt, 2003). Additionally, higher information costs can change the way agents interact and make decisions, especially in situations where information is a scarce and valuable commodity (Pomatto et al., 2018). In this context, the cost of the right information not only supports better decision-making, but also affects the efficiency and sustainability of the product. The cost of relevant information allows managers

to evaluate the trade-offs between the cost and benefit of information, thereby increasing the effectiveness of the decision-making process in product design.

This research has several limitations that need to be considered. First, the use of experimental design with student participants who have limited experience in the industrial world is one of the obstacles in generalizing the results of this research to a professional context. Controlled research environments, such as classroom experiments, can also limit the representation of real challenges faced in real work environments. In addition, the study only reviews the influence of cost information and process selection on the total cost, without considering other external factors, such as market changes, technological developments, or regulatory aspects that may affect the results. This research that focuses on sustainable products may not be suitable for ordinary products that don't care about sustainability.

For further research, it is recommended to involve participants with professional backgrounds, such as product designers or industrial workers, in order to increase the relevance and generalization of research results in the real world of work. In addition, experiments should be conducted in a more dynamic and not fully controlled work environment to test the reliability of results under complex conditions. Subsequent research may also expand the scope of the analysis by adding other variables, such as the technology used, organizational culture, or customer preferences, to provide a more comprehensive understanding of the factors that affect the total cost.

Replication of studies in different industry sectors, such as manufacturing or services, is also recommended to test the validity of research results in a broader context. Finally, future research can develop a *hybrid model* between manual and automated processes to explore the advantages and limitations of the integration of the two methods in the design of new sustainable products.

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