



# The Influence of Management Control Systems and Operational Performance on Environmentally Friendly Innovation in Production Waste Management (Case Study PT. Timuraya Tunggal Karawang)

Nadira Najwa Alia<sup>1</sup>, Yanti<sup>2</sup>, Ade Trisyanto<sup>3</sup>

<sup>1,2,3</sup>Accounting, Faculty of Economics and Business, Buana Perjuangan University Karawang

**ABSTRACT:** The issue of environmental pollution due to industrial *waste* is a serious challenge for the manufacturing sector in Indonesia, including PT Timuraya Tunggal which faces problems in managing production waste, especially *sulfamic acid* (SA) *waste*. Although the company has implemented environmentally friendly practices such as *waste* reduction and green technology, its implementation has not been running optimally. The main focus of this research is to analyze the influence of management control system and operational performance on environmentally friendly innovation in production *waste* management. This research was conducted using a quantitative approach, utilizing primary data collected through distributing questionnaires to 100 employees who are directly involved in *waste* management. Data processing was carried out through the application of the *Partial Least Square* (PLS) method analyzed through *SmartPLS* version 4.0 software. The results of the analysis show that the management control system and operational performance have a significant effect on green innovation. This finding confirms the importance of integrating management control systems and improving operational performance as strategies to support efficiency and sustainability in managing company production *waste*.

**KEYWORDS:** Green Innovation, Management Control System, Operational Performance, Production Waste, Sustainability.

## INTRODUCTION

The manufacturing industry in Indonesia continues to grow rapidly and contributes significantly to the national economy. However, this development also raises environmental challenges, such as material recycling, waste reduction and the application of green technologies that are increasingly applied by global companies to support operational sustainability (Simpson et al., 2021). As happened at PT Timuraya Tunggal, the problem faced by the company is the management of production waste especially sulfamic acid (SA) waste which has the potential to cause environmental pollution if not managed properly. Although the company has adopted several environmentally friendly practices, such as waste reduction and the use of green technology (Smith et al., 2020). However, the application of these innovations still needs to be improved, because it will have an impact on operational efficiency (Zhang et al., 2021). This needs to be supported by a management control system in environmentally friendly waste management. However, the integration between this system and environmentally friendly practices still needs to be improved (Chen et al., 2021). Furthermore, the obstacle faced is the application of cost innovation and productivity improvement, which is also an obstacle that is environmentally friendly without sacrificing production efficiency (Harrison et al., 2021). In addition, increasingly stringent government regulations regarding sustainability and waste management and increasing consumer awareness of environmental issues trigger pressure for companies to implement more environmentally friendly waste management systems (Martin et al., 2020).

A management control system is a procedure designed to ensure the efficient achievement of company objectives including inventory management. A sustainable company is one that is economically viable, beneficial to society and environmentally responsible (Helena et al., 2024). The management control system serves to reduce discrepancies between recorded inventory data and physical stock and improve supervision of the use of raw materials which in turn reduces waste and improves operational performance (Zhang et al., 2022). Operational performance involves managing the optimal utilization of resources in order to achieve company goals such as making environmentally friendly innovations that can increase productivity and reduce costs including the use of green technology with the aim of increasing efficiency (Tjiptono, F. 2020). In addition, an effective management control system has the potential to reduce waste while encouraging increased operational efficiency (Suharto, S. 2022). In waste management, environmentally friendly innovation production focuses on the use of methods and technologies that reduce adverse effects on the



environment such as waste reduction and more efficient resource utilization. Companies that implement green innovation not only contribute to reducing the impact on the environment but can also increase the competitiveness and profitability of the company (Porter et al., 2023). The application of green technology in waste management can increase operational efficiency, reduce costs and improve the company's reputation in the eyes of consumers who are increasingly concerned about environmental issues. These technologies enable waste processing and reutilization, which brings economic benefits while strengthening the company's competitiveness.

Previous research with the title "Environmental Innovation Practices And Operational Performance: The Joint Effects Of Management Accounting And Control Systems And Environmental Training" (Santos et al., 2023) from the results of the analysis, it is concluded that the implementation of a management control system integrated with environmental training can improve environmental innovation practices and company operational performance. The management control system not only acts as a monitoring tool but as an instrument that has significance in directing sustainable organizational behavior. While the study obtained by (Ismail Badollahi et al., 2022) entitled "The Effect of Management Control System on Managerial Performance in Regional Drinking Water Companies (PDAM)", the results showed that the management control system through strategic planning, budgeting and information-based evaluation contributed positively to the effectiveness of managerial decision making. The results of research conducted by (Sarkis et al., 2020) with the title "Green Supply Chain Management: A Review And Bibliometric Analysis" the results of his research state that there is a relationship between the adoption of green supply chain management (GSCM) and improved operational performance. However, this research has not specifically explored how the integration of an effective management control system can support environmentally friendly innovations, especially in the management of material inventories in various industries. In fact, this kind of integration has the potential to be the main key for companies to not only focus on improving operational efficiency but also provide significant added value in long-term sustainability efforts. Then research from (Awan et al., 2022) with the title "Green Supply Chain Management Practices Impact On Operational Performance With The Mediation Of Technological Innovation" the results of his research show that green supply chain management (GSCM) and technological innovation act as mediation in strengthening the influence of environmentally friendly practices on operational performance. Then research from (Teoh et al., 2023) entitled "The Impact Of Green Supply Chain Practices Toward Operational Performances Among SMEs In Penang, Malaysia" the results of his research show that the application of green supply chain management practices such as environmentally friendly product design and reverse logistics, has a significant effect on improving the efficiency and effectiveness of operational performance in small and medium enterprises (SMEs). Then research from (Yang et al., 2020) entitled "Management Control Systems and Environmental Innovation in SMEs: Evidence from Developing Countries" the results of his research found that the role of the management control system in managing environmentally friendly raw materials in the small and medium industrial sector (SMI) is still limited. This has an impact on low operational performance such as production process efficiency and waste reduction, so that integration of management control systems with environmental innovation is needed to support the sustainability and competitiveness of small and medium industries (SMIs). This emphasizes the need to develop a management control system that is integrated with environmentally friendly innovations, in order to support business sustainability and improve the competitiveness of SMEs in the face of global market pressures that are increasingly concerned about environmental issues.

Research that has a relationship with the influence of the management control system and operational performance on environmentally friendly innovation in production waste management still has significant limitations that require further research. A company has the responsibility to manage production waste in an environmentally friendly way to support sustainability and minimize negative impacts on society and the surrounding environment. If the company does not implement an effective management control system and operational performance towards environmentally friendly innovation in production waste management, the risk of environmental damage and company reputation can increase. Based on very limited previous research that discusses the influence of the management control system and operational performance on environmentally friendly innovation in production waste management, it is interested to be studied as an aspect of novelty. Therefore, this research formulates the following research questions:

RQ1 = How does the management control system affect the efficiency of environmentally friendly environmentally friendly production waste management at PT Timuraya Tunggal?

RQ2 = How does operational performance affect the implementation of environmentally friendly innovation in production waste management at PT Timuraya Tunggal?

## LITERATURE REVIEW

### Contingency Theory

Contingency theory explains that there is no one managerial approach that is universally applicable to all organizations, because the effectiveness of a system depends largely on the extent to which the system is aligned with the internal and external conditions of the organization (Jeffrey et al., 2024). In this case, the management control system must be adjusted to the dynamics of the business environment faced by the company, such as the level of complexity of the production process, regulatory pressure, environmental risks, and technological capabilities owned (Desvanni et al., 2025). When companies face environmental challenges such as the management of hazardous production waste (e.g. sulfamic acid), the management control system implemented needs to be able to adapt to these characteristics and risks to remain effective (Chen et al., 2022). Operational performance results from the organization's ability to adjust business processes and resource management to environmental conditions. The suitability between operational strategies and external environmental conditions encourages the achievement of efficiency and effectiveness of work processes in the manufacturing industry (Hasibuan et al., 2022). In other words, contingency theory emphasizes that there is no one form of operational structure that is ideal for all situations. Operational effectiveness depends on the fit between the operational strategy and the environmental factors at hand.

Meanwhile, green innovation also cannot be separated from the principle of contingency, the adoption of green technology, the redesign of production processes and waste management requires a system that is aligned with the internal capabilities and external pressures of the company. Companies that adapt environmental control systems to external characteristics such as regulatory pressure or consumer expectations of sustainability and are better able to produce effective green innovations (Pratiwi et al., 2023). Therefore, contingency theory explains that the success of green innovation as a sustainability strategy is largely determined by the extent to which organizational structures, systems and resources are adapted to the characteristics of the challenges faced. Thus, the relationship between the management control system, green innovation and operational performance is highly dependent on the suitability of the system to the situation and conditions faced by the company. In the manufacturing industry in Indonesia, especially in companies such as PT Timuraya Tunggal, the integration of management control systems with environmentally friendly innovative practices is needed to respond to regulatory pressures, efficiency demands, and the expectations of increasingly environmentally conscious consumers. By using the Contingency theory approach as a theoretical basis. There is a match between the control system, environmental innovation and operational performance as an effort to achieve a sustainable company.

### Management Control System

The management control system is a tool used to supervise and control operational activities within the company with the aim of achieving efficiency and effectiveness in achieving organizational goals. The management control system functions to provide oversight of decisions made by management to ensure that the company moves in a direction that is in accordance with the strategic objectives that have been set (Anthony et al., 2020). The implemented management control system plays an important role in managing production waste, especially sulfamic acid (SA) waste, which can have a negative impact on the environment. A good management control system can encourage innovation in resource management, including in reducing environmental impacts through environmentally friendly technology (Simons, R. 2022) The challenge faced by the company lies in trying to balance between reducing negative impacts on the environment through environmentally friendly waste management, while maintaining operational efficiency in the production process. Therefore, the implementation of an effective management control system plays a role in helping the company to integrate environmentally friendly innovations in its product waste management system, as well as ensuring that the control measures taken do not sacrifice the company's performance and productivity, but rather support sustainability and the reduction of negative impacts on the environment.

### Operational Performance

Operational performance is a measure of the efficiency and effectiveness of a company in managing its internal processes to achieve predetermined goals, including the management of time, cost and quality (Sugiarto et al., 2021). In the manufacturing industry, good operational performance includes achieving production goals by minimizing waste, and improving the quality of products and services (Haryanto et al., 2022). The assessment of operational performance involves not only the results achieved, but also the company's ability to make continuous improvements in every aspect of production to increase competitiveness and profitability (Zulfi et al., 2023). With increasing demands to pay attention to corporate sustainability, companies are expected to not

only focus on operational efficiency, but also on the use of environmentally friendly technology and innovation to reduce negative environmental impacts without sacrificing operational performance (Sari et al., 2022). For example, PT Timuraya Tunggal can utilize its improved operational performance to support the implementation of environmentally friendly innovations in production waste management (Rahmawati et al., 2023).

### Green Innovation

Green innovation is the application of technology, products or processes that aim to minimize negative impacts on the environment, including the reduction of pollution and increased efficiency in resource utilization. This innovation is not only focused on environmental sustainability, but also to improve the operational efficiency and competitive advantage of the company (Porter et al., 2023). Green innovation in the production industry involves the development of technologies that can manage waste more efficiently and more environmentally friendly without compromising the company's operational (Guclu et al., 2023). In addition, this kind of innovation can strengthen the company's competitive position, reduce costs and improve the company's image in the eyes of the public (Hojnik et al., 2021). In this case, PT Timuraya Tunggal can integrate environmentally friendly innovations in its management control system to manage sulfamic acid (SA) waste, so as to reduce environmental impacts without sacrificing the company's operational efficiency.

### FRAMEWORK OF THOUGHT AND HYPOTHESIS

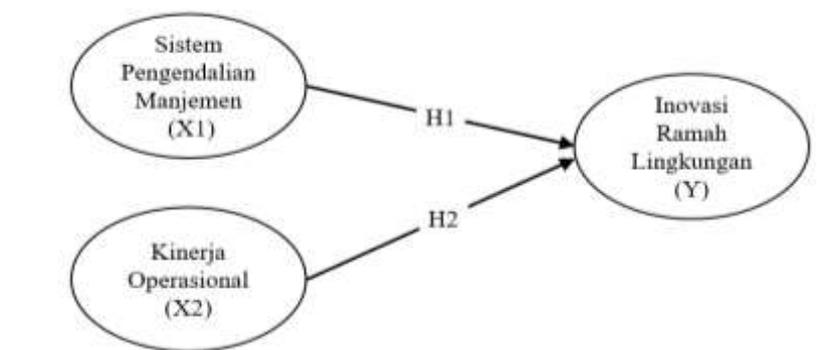


Figure 1. Framework of thought

Source: Author, 2025

### Effective Management Control System Significantly Affects Environmentally Friendly Innovation in Production Waste Management at PT.Timuraya Tunggal Karawang

A management control system integrated with environmentally friendly innovations can strengthen the effectiveness of production waste management. Good management control can optimize the use of resources in production activities and reduce the risk of environmental pollution (Sunarti et al., 2023). The implementation of strict control over production waste can encourage operational efficiency of up to 30%, while improving the company's reputation in the eyes of stakeholders (Wijaya et al., 2021). The correlation between the implementation of management control systems and operational efficiency is very important, especially in efforts to manage production waste. As an illustration, the better the implementation of this system, the greater the company's ability to reduce waste significantly. This condition not only contributes to improving production efficiency, but also strengthens the positive impact on the implementation of corporate social responsibility (CSR) (Raharjo et al., 2023). Research results from (Sunarti et al., 2023; Wijaya et al., 2021; Raharjo et al., 2023) Therefore, the management control system is very important to encourage company efforts to implement environmentally friendly innovations which ultimately lead to better and sustainable production waste management. This research aims to further examine how an effective management control system can be optimized in other industrial sectors to support sustainability and more efficient waste management. Based on the explanation above, the following hypothesis can be formulated:

**H1 = Effective management control system Significantly Affects Environmentally Friendly Innovation in Production Waste Management at PT.Timuraya Tunggal Karawang**



**Superior Operational Performance Has a Significant Effect on Environmentally Friendly Innovation in Production Waste Management at PT.Timuraya Tunggal Karawang**

Good operational performance can have a major influence on the development of environmentally friendly innovations in production waste management. Increased operational efficiency allows companies to identify and handle waste more effectively, and opens up opportunities for the development of environmentally friendly technologies (Setiawan et al., 2021). With optimal performance, companies can reduce waste and increase the use of resources and energy more efficiently (Sari et al., 2021). Companies with good operational performance are better able to innovate in waste management, including the implementation of more environmentally friendly waste reduction solutions. Therefore, effective operational performance can be a key driver for more efficient and sustainable environmentally friendly innovations in production waste management. Based on the explanation above, the following hypothesis can be formulated:

**H2 = Superior operational performance has a significant effect on environmentally friendly innovation in production waste management at PT Timuraya Tunggal Karawang.**

**RESEARCH METHOD**

This study uses quantitative methods by utilizing primary data collected through questionnaires using a Likert scale of 1-5. PT Timuraya Tunggal became the research population used in this study by involving PT Timuraya Tunggal employees who were responsible for managing sulfamic acid (SA) waste, the sample consisted of 100 employees, who were selected through purposive sampling method. The variables used in this study include the management control system (X1), Operational Performance (X2) and Environmentally Friendly Innovation (Y). Data analysis is carried out through three stages, namely outer model analysis, inner model analysis, and hypothesis testing. Data processing in this study used SmartPLS software version 4.0.

**RESULTS AND DISCUSSION**

**Research Results**

**Variable Description**

X1 : Management control system

**Table 1. Variable Description - Management Control System**

|      | Mean  | Median | Min   | Max   | Standard deviation | Excess kurtosis | Skewness |
|------|-------|--------|-------|-------|--------------------|-----------------|----------|
| X1.1 | 4.030 | 4.000  | 3.000 | 5.000 | 0.591              | -0.087          | -0.007   |
| X1.2 | 3.960 | 4.000  | 3.000 | 5.000 | 0.706              | -0.983          | 0.057    |
| X1.3 | 4.080 | 4.000  | 3.000 | 5.000 | 0.673              | -0.783          | -0.098   |
| X1.4 | 3.910 | 4.000  | 3.000 | 5.000 | 0.680              | -0.824          | 0.115    |
| X1.5 | 3.990 | 4.000  | 3.000 | 5.000 | 0.671              | -0.755          | 0.012    |
| X1.6 | 4.050 | 4.000  | 3.000 | 5.000 | 0.684              | -0.845          | -0.064   |
| X1.7 | 3.920 | 4.000  | 3.000 | 5.000 | 0.627              | -0.448          | 0.062    |
| X1.8 | 3.980 | 4.000  | 3.000 | 5.000 | 0.693              | -0.900          | 0.027    |
| X1.9 | 3.980 | 4.000  | 3.000 | 5.000 | 0.678              | -0.805          | 0.025    |

Source: Author, 2025

Table 1 presents that in the management control system variable, the highest average value is found in indicator X1.3, namely "The implemented management control is able to reduce waste generated in the production process", with an average of 4.080 and a standard deviation of 0.673. Conversely, the lowest mean value is found in indicator X1.4, namely "The existing management control system supports the company's efforts to reduce negative impacts on the environment", with an average of 3.910 and a standard deviation of 0.680. Overall, these results indicate that all indicators on the management control system variable have a relatively high average value trend.

X2 : Operational Performance

Table 2. Variable Description - Operational Performance

|       | Mean  | Median | Min   | Max   | Standard deviation | Excess kurtosis | Skewness |
|-------|-------|--------|-------|-------|--------------------|-----------------|----------|
| X2.1  | 4.030 | 4.000  | 3.000 | 5.000 | 0.699              | -0.943          | -0.042   |
| X2.2  | 4.080 | 4.000  | 3.000 | 5.000 | 0.673              | -0.783          | -0.098   |
| X2.3  | 3.960 | 4.000  | 3.000 | 5.000 | 0.582              | 0.001           | 0.003    |
| X2.4  | 4.000 | 4.000  | 3.000 | 5.000 | 0.648              | -0.589          | 0.000    |
| X2.5  | 3.990 | 4.000  | 3.000 | 5.000 | 0.656              | -0.647          | 0.010    |
| X2.6  | 3.980 | 4.000  | 3.000 | 5.000 | 0.648              | -0.587          | 0.019    |
| X2.7  | 4.040 | 4.000  | 3.000 | 5.000 | 0.734              | -1.138          | -0.063   |
| X2.8  | 3.990 | 4.000  | 3.000 | 5.000 | 0.656              | -0.647          | 0.010    |
| X2.9  | 3.980 | 4.000  | 3.000 | 5.000 | 0.632              | -0.462          | 0.016    |
| X2.10 | 3.980 | 4.000  | 3.000 | 5.000 | 0.693              | -0.900          | 0.027    |

Source: Author, 2025

Based on the data in Table 2, the operational performance variable obtained the highest average value in indicator X2.2, namely "The company uses operational performance indicators to monitor the effectiveness of production waste management", with an average of 4.080 and a standard deviation of 0.673. In contrast, the lowest mean value is found in indicator X2.3, namely "Improved operational performance contributes to the reduction of waste in the production process", with a mean of 3.960 and a standard deviation of 0.582. In general, this finding indicates that all indicators on the operational performance variable have a tendency to have relatively high mean values.

Outer Model Evaluation (Measurement Model)

Convergent Validity Test

Loading Factor Value

Convergent validity aims to ensure that each indicator on a variable has a high value and shows a positive correlation. An indicator is declared valid if its loading factor value exceeds 0.70. However, a loading factor value between 0.50 to 0.60 is still acceptable for preliminary studies as an adequate validity reference.

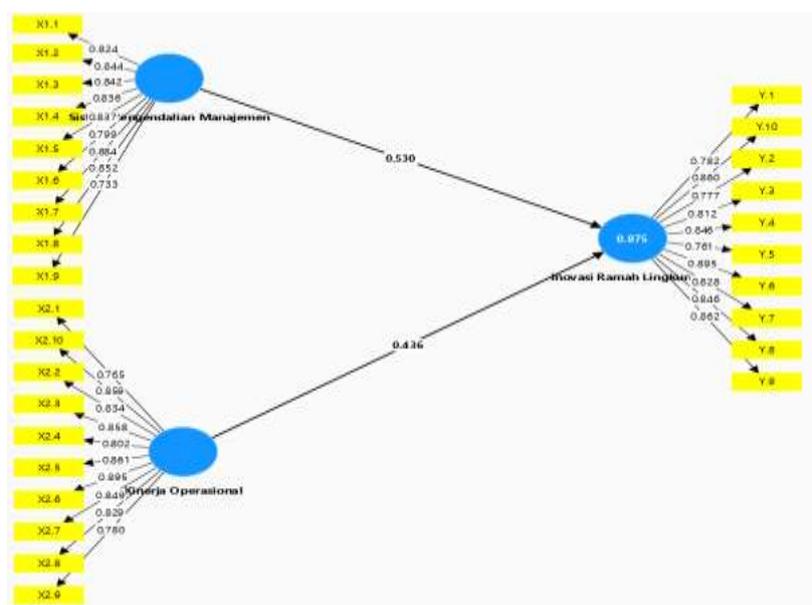


Figure 2. PLS Model - Algorithm After Convergent Validity Test

Source: Author, 2025



Given that the correlation value of all research variable indicators is above 0.70, the test results in Figure 2 show that all indicators meet the credibility criteria.

**Average Variance Extraced (AVE)**

Each construct value is tested for validity using the Average Variance Extracted (AVE) test. The AVE value is calculated from the average squared factor loading of indicators in a construct. The AVE value must be more than 0.50 for the construct to be considered convergently valid. If the AVE is below 0.05, it indicates that the convergent validity of the construct is lacking. All evidence clearly shows that the latent variables included in this study have accurately represented the indicators (Yuliawan, 2021).

**Table 3. Average Variance Extraced (AVE)**

|                               | Average variance extracted (AVE) |
|-------------------------------|----------------------------------|
| Inovasi Ramah Lingkungan      | 0.686                            |
| Kinerja Operasional           | 0.696                            |
| Sistem Pengendalian Manajemen | 0.687                            |

Source: Author, 2025

AVE values for Management Control System (0.687 > 0.50), Operational Performance (0.696 > 0.50) and Green Innovation (0.686 > 0.50). Based on the test data presented in Table 3, each construct shows adequate convergent validity. Therefore, all AVE values of each construct are in accordance with the specified standards.

**Reliability Test using Composite Reability and Cronbach's Alpha**

The Composite Reliability and Cronbach's Alpha tests are used to evaluate the internal consistency of research instruments. A construct is declared reliable if the Cronbach's Alpha and Composite Reliability values both exceed 0.70.

**Table 4. Composite Reability and Cronbach's Alpha**

|                               | Cronbach's alpha | Composite reliability (rho_a) |
|-------------------------------|------------------|-------------------------------|
| Inovasi Ramah Lingkungan      | 0.949            | 0.950                         |
| Kinerja Operasional           | 0.951            | 0.953                         |
| Sistem Pengendalian Manajemen | 0.943            | 0.943                         |

Source: Author, 2025

The results of the reliability test using the Cronbach's Alpha and Composite Reliability methods shown in Table 4 show the suitability for these constructs. This is evident in the management control system with a Cronbach's alpha value of 0.943 (> 0.70), operational performance with a value of 0.951 (> 0.70), and the green innovation construct with a value of 0.949 (> 0.70). In addition, the value of the Management Control System (Cronbach's Alpha value: 0.943 > 0.70), Operational Performance (Cronbach's Alpha value: 0.951 > 0.70) and Environmentally Friendly Innovation construct (Cronbach's Alpha value: 0.949 > 0.70). The Management Control System has a value higher than 0.70 on Composite Reliability, Operational Performance has a value higher than 0.70 on Composite Reliability and Environmentally Friendly Innovation has a value higher than 0.70 on Composite Reliability. Thus, it can be concluded that all construct indicators have met the reliability criteria, so they can be trusted and relied upon in measuring the variables of this study.

**Inner Model Evaluation (Structural Model)**

**R Square Test**

The R-Square test is used to measure the extent to which independent latent variables affect dependent latent variables. Therefore, the evaluation of this test is carried out by assessing the amount of contribution of the independent variables in explaining the variability of the dependent variable. The research model is categorized as good, moderate or weak based on R<sup>2</sup> values of 0.70, 0.50, and 0.25, respectively.



**Table 5. R Square Test**

|                          | R-square | R-square |
|--------------------------|----------|----------|
| Inovasi Ramah Lingkungan | 0.875    | 0.872    |

Source: Author, 2025

Table 5 shows that the R-Square value of the variable disclosure of Production Waste Management is 0.875, meaning that this variable can contribute to the variable management control system and environmentally friendly innovation by 87.5%, while the remaining explanation is given from other variables.

**Hypothesis Test**

**Table 6. Path Coefficient**

|   | Original sample (O) | Sample mean (M) | Standard deviation (STDEV) | T statistics ( O/STDEV ) | P values |
|---|---------------------|-----------------|----------------------------|--------------------------|----------|
| Kinerja Operasional -> Inovasi Ramah Lingkungan           | 0.436               | 0.472           | 0.191                      | 2280                     | 0.023    |
| Sistem Pengendalian Manajemen -> Inovasi Ramah Lingkungan | 0.530               | 0.495           | 0.190                      | 2784                     | 0.005    |

Source: Author, 2025

Table 6 is a research finding that illustrates the results of hypothesis testing, with the following explanation:

1. Based on the analysis of the relationship between the Management Control System and Green Innovation, (*original sample* value of 0.530, *T-statistic* value of 2.784 and *p-value* of 0.005 <0.05). These results indicate that the Management Control System has a significant influence on Green Innovation.
2. Furthermore, the results of the analysis of the relationship between Operational Performance and Green Innovation, (*original sample* value of 0.436 *T-statistic* value of 2.280 and *p-value* of 0.015 <0.05). Thus, it can be concluded that Operational Performance also has a significant effect on Green Innovation.

**DISCUSSION**

**Effective Management Control System Significantly Affects Environmentally Friendly Innovation in Production Waste Management at PT.Timuraya Tunggal Karawang**

The results of hypothesis testing show that the implementation of the management control system has a significant effect on environmentally friendly innovation in the management of PT.Timuraya Tunggal's production waste. This relationship is statistically proven from the positive path coefficient value and is supported by significant p-values and indicates that the relationship between the management control system and green innovation that occurs is not the result of chance, but reflects a strong empirical relationship (Sunarti et al., 2023; Wijaya et al., 2021).). This means that the implementation of an effective management control system at PT Timuraya Tunggal contributes significantly to the company's success in implementing green innovation practices that are integrated with the production process. This is also reinforced by the high coefficient of determination (R square) value which shows that most of the variation in green innovation can be explained by the independent variables in this model, namely the management control system and operational performance. Therefore, the management control system not only functions as a monitoring tool, but has also become a strategic instrument that supports the implementation of environmentally friendly innovations and encourages long-term sustainability of production waste management (Sunarti et al., 2023; Wijaya et al., 2021; Raharjo et al., 2023).

The results of this study are related to contingency theory which shows that the effectiveness of the management system is highly dependent on its suitability to the internal and external conditions of the organization (Jeffry et al., 2024). In this case, referring to contingency theory that each company has different characteristics, risks and challenges, so that control strategies, systems or methods cannot be applied uniformly (Desvanni et al., 2025). Thus, an effective management control system can improve operational efficiency towards environmentally friendly innovation in production waste management. This system allows companies to control, monitor and evaluate the production process in a more structured manner so as to reduce waste and improve resource utilization (Sunarti et al., 2023). In addition, the implementation of an optimal control system helps in managing production waste more

efficiently, reducing excessive use of raw materials, and increasing production effectiveness (Wijaya et al., 2021). However, in its implementation there are still challenges such as indiscipline in the application of SOPs, lack of employee awareness and limited technology in waste management, which can hinder the optimization of operational efficiency (Raharjo et al., 2023). However, an effective management control system not only focuses on improving operational efficiency, but also helps companies reduce the environmental impact of production waste (Huo et al., 2022). Thus, strengthening the management control system in green innovation is proven to be able to improve financial performance and increase operational efficiency through cost reduction, product quality improvement, and support from stakeholders (Yanti et al., 2023).

### **Superior operational performance has a significant effect on environmentally friendly innovation in production waste management at PT.Timuraya Tunggal Karawang**

The results of hypothesis testing show that superior operational performance has a significant effect on environmentally friendly innovation in production waste management at PT.Timuraya Tunggal Karawang. This relationship is statistically proven through a positive path coefficient value and a significant p-value so that it can be ascertained that the relationship is not the result of chance, but rather reflects a strong empirical relationship (Setiawan et al., 2021; Sari et al., 2022). This means that the higher the operational performance achieved by the company, the greater its ability to identify innovation opportunities, integrate environmentally friendly technology, and optimize production processes in a sustainable manner. This is also supported by the high coefficient of determination (R square) value, which shows that the operational performance variables and the management control system are simultaneously able to make a substantial contribution to the variation in green innovation.

The results of this study support the view of contingency theory which asserts that there is no one managerial approach that is universally applicable, because organizational strategies must be adjusted to internal conditions such as structure, resources, work culture, external conditions such as regulation, competition and environmental demands. This adjustment ensures that the operational strategy is aligned with the context at hand so that it can produce optimal and sustainable operational performance (Fradito et al., 2025). With optimal process management, PT Timuraya Tunggal is able to minimize waste, optimize resource utilization, and reduce production costs without sacrificing product quality (Humaira et al., 2021). This research reinforces contingency theory which suggests that the success of an operational strategy is highly dependent on its suitability to the internal and external conditions of the organization (Fradito et al., 2025). Each company has different complexities, risks and environmental challenges, so that improving operational performance must be tailored to the characteristics and demands faced. In addition, achieving this efficiency also encourages cost savings and optimization of resource use, which has a positive impact on waste reduction and environmental value creation (Salim et al., 2021). However, the implementation of these innovations still faces obstacles such as high initial investment costs, lack of employee awareness of the importance of green innovation, and limited infrastructure in modern waste management that can hinder the effectiveness of its implementation (Raharjo et al., 2023; Florencio et al., 2023). Nevertheless, with management commitment and reliable information system support the integration between operational efficiency and environmental innovation can be realized, which ultimately strengthens the competitive advantage and corporate image in the eyes of the public and stakeholders (Nursyabani et al., 2023).

### **CONCLUSION**

The results of this study indicate that the implementation of an effective management control system has a significant effect in encouraging environmentally friendly innovation in the production waste management process at PT Timuraya Tunggal. The system enables the company to manage the production process in a more structured manner, reduce waste, and improve operational efficiency and compliance with sustainable environmental practices. In addition, superior operational performance also plays a significant role in driving the implementation of green innovations. Work process efficiency, resource optimization and waste control support the integration of green technologies without compromising productivity. Despite obstacles such as technological limitations and employee awareness, management commitment and a strong control system can strengthen the company's position in the face of regulatory pressure and increasingly environmentally conscious market expectations. Thus, both management control system variables and operational performance simultaneously contribute positively to the success of green innovations that support business sustainability.



## IMPLICATIONS

Future research is expected to add other variables such as green technology adoption, top management commitment to sustainability, environmentally oriented work culture, and production process innovation, which could potentially strengthen the relationship between operational performance. Environmentally friendly innovation management control system. In addition, on the external aspect, the variables of regulatory pressure, market demands and partnerships with green suppliers are also important to examine further. The addition of these research variables is expected to increase the completeness of the analysis of the factors that determine the effectiveness of the company's sustainability strategy, especially in production waste management.

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