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The Effect of Green Technology Innovation on Financial Performance in Manufacturing Companies Listed on the Indonesia Stock Exchange

Sri Nurdiyanti[1], Susi Sarumpaet[2]
[1,2] Lampung University, Lampung, Indonesia

Email : susi.sarumpaet@gmail.com[1] srin.dyanti25@gmail.com [2]

Abstract*. This study was conducted with the aim of examining the effect of green process innovation variables and green product innovation on the company's financial performance with total asset turnover variables as control variables. The dance used in this selection is the Resource Based View (RBV) theory and stakeholder theory. The population used in the study were manufacturing companies listed on the Indonesia Stock Exchange (IDX) during 2020-2022. Sampling was carried out using purposive sampling technique. The number of samples used in this assessment was 400 samples. The results of this study indicate that green process innovation and green product innovation have a positive and significant effect on corporate financial performance. The results of this study also found that the control variable of total asset turnover is able to control the effect of green process innovation and green product innovation on corporate financial performance.*

Keywords: *Green Technology Innovation, Financial Performance, Manufacturing Performance*

1. INTRODUCTION

The global economy is now growing rapidly, marked by the development of various industrial sectors in recent years. However, the development of the global economy is also followed by the emergence of various problems related to environmental damage. Garbage, waste, and greenhouse gas pollution are factors that cause environmental damage to occur. Indonesia, as a country with a growing industry, is not immune to issues related to the environment. Indonesia is the fifth-ranked country as a contributor to global plastic waste with a waste output generated in 2022 reaching 9.13 million tons of waste. Indonesia is also the fifth largest contributor of plastic waste to the sea with an output of 53,333 tons of plastic waste produced in 2022. Worse still, this waste production has not been accompanied by optimal waste reduction and handling.

In addition to problems regarding environmental pollution due to waste, problems related to greenhouse gas emissions are also issues that need to be taken more seriously. Currently, the level of air pollution, especially in Indonesia's big cities, is quite dangerous for health and threatens people's mobility. Air pollution triggers the warming of the earth's temperature which has an impact on global climate change. Greenhouse gas emissions are caused by human activities. Human activities that contribute the most emissions are industrial activities carried out by companies. Companies as the main actors in economic activities have a major involvement in contributing greenhouse gas emissions. Manufacturing companies are the sector that has the greatest impact on the surrounding environment. Manufacturing companies are companies engaged in processing raw goods into finished goods, which in the processing

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process will certainly have a major impact on the environment. The increasing number of manufacturing companies is one of the causes of the increasing environmental damage that occurs (Pratiwi, 2007). Manufacturing companies as actors who play a major role in environmental damage need to make a solution to prevent further environmental damage. Companies need to make innovations that can help prevent environmental damage if they can improve their financial performance. Therefore, companies need to innovate green technology in their business operations.

Green technology innovation is an action that consists of developing, introducing new ideas, behaviors, products, procedures, and organizational systems that can contribute to reducing environmental impacts (Salvadó et al., 2012). Green technology innovation aims to combine sustainable principles with technological innovation to create environmentally friendly solutions. Green technology innovation is divided into two dimensions, namely the green process innovation dimension and the green product innovation dimension.

Green process innovation focuses on innovations or modifications that include energy efficiency, pollution prevention, waste recycling, and reduced use of hazardous compounds (Salvadó et al., 2012). It involves the development and application of innovative and beneficial technologies to reduce the negative impact on the environment during company operations. Green process innovation plays an important role in improving technological capabilities during the production process by optimizing raw material utilization, minimizing production costs, and producing high-quality products (Soylu & Dumville, 2011).

Green product innovation focuses on developing environmentally friendly product designs. Green product innovation is an effort to increase product recycling, reduce raw materials, and reduce the use of hazardous materials (Lin et al., 2013). Green product innovation aims to create solutions that not only meet consumer needs but can also contribute to the protection and long-term sustainability of the environment.

Both green process innovation and green product innovation have a positive impact on the environment. Previous research conducted by (Xie et al., 2019) and (Wang & Ahmad, 2024) concluded that green process innovation has a positive and significant effect on company financial performance. Companies that innovate green technology in their business operations will have greater market competition opportunities than companies that do not make these efforts. Companies that innovate green technology will be seen as having unique and different resources so that they have superior competencies in market share compared to companies that do not have resources. This allows the company to get a better response from the market, open up new market shares, attract consumer segments that have a tendency towards the

environment, and can strengthen customer loyalty which of course this will have a positive impact on the company. In addition, companies that implement green technology are considered to have met the expectations of stakeholders who have a tendency towards environmental sustainability so that stakeholders will provide full support to the company and this is expected to improve the company's financial performance (Nisa, 2023).

This study was conducted to examine the effect of green technology innovation on financial performance in manufacturing companies in Indonesia. This definition replicates research from Wang & Ahmad, (2024). Through this study, the authors want to test whether green technology innovation can affect the company's financial power when implemented in manufacturing companies in Indonesia.

2. LITERATURE REVIEW

RBV Theory

This theory states that companies will gain a competitive advantage by implementing strategies to exploit and expose their resources, especially related to environmental opportunities (Barney, 1991). The resources in question are tangible resources and intangible resources. Tangible resources include financial reserves and physical resources, while intangible resources include ownership of technology, reputation, culture and human resources (Russo & Fourts, 1997). Green technology innovation is a resource owned by the company in intangible form. Green technology innovation meets the VRIN criteria, namely valuable, rare, inimitable, and non-substitutable. This allows the company to get a good response from market share, be able to attract new market segments, and strengthen customer loyalty. The existence of this positive assessment will result in high market interest in the company and this will have an impact on increasing the company's financial performance.

Stakeholder Theory

Stakeholder theory states that companies must pay attention to and process the interests of a stakeholder that can affect the achievement of a company's goals (Freeman, 2010). Companies must provide benefits to stakeholders by providing information related to company operations (Nisa, 2023). One of the information provided can be information related to environmental management. These efforts will fulfill the expectations of stakeholders who have a tendency towards the environment. They will respond by providing full support for the company's efforts and this is expected to improve the company's financial performance (Nisa, 2023).

Company Financial Performance (ROA)

Financial performance is a parameter used to measure the company's financial health level at a certain period of time (Naz et al., 2016). To find out the financial performance of a company is done by analyzing financial statements. There are several financial statement analyses, one of which is return on assets (ROA). ROA is an accounting expansion used to measure the level of profit obtained through assets. ROA is more often used as a measurement in the green innovation literature because the measurement results show specific actions both in the past and present (Salvadó et al., 2014).

Green Technology Innovation

According to Chen et al. (2006), green technology innovation is software and hardware innovation related to environmentally friendly products or processes. These innovations include technologies in energy efficiency, pollution prevention, waste recycling, environmentally friendly product design, and environmental management in an organization. Green technology innovation is carried out with the aim of combining sustainability principles with technological innovation to create environmentally friendly solutions. Green technology innovation is divided into two dimensions: green process innovation and green product innovation.

Green Process Innovation (GPROC)

Green process innovation is a new or modified process to reduce the impact on the environment (Ziegler & Rennings, 2004). Green process innovation aims to reduce energy consumption during the production process or during the process of converting waste into more valuable goods (Xie et al., 2019). Green process innovation includes efforts to reduce air or water emissions, reduce clean water consumption, increase resource and energy efficiency, and shift the use of fossil energy to renewable energy (Kivimaa & Kautto, 2010). Green process innovation plays an important role in improving technological capabilities during the production process by optimizing the use of raw materials, minimizing production costs, and in producing high quality products (Solyu & Dumville, 2011).

Green Product Innovation (GPROD)

Green product innovation is an innovation or modification of new technology for the purpose of energy efficiency, pollution prevention and waste recycling by making changes and developments to old environmental products. Green product innovation includes increasing the durability or recyclability of products, reducing environmentally friendly raw materials, and reducing hazardous materials (Lin et al., 2013). Green product innovation aims to create

solutions that not only meet consumer needs but can also contribute to the protection and long-term sustainability of the environment.

Total Asset Turnover

Total asset turnover is one of the financial ratios, namely the probability ratio where this secret is used to measure how efficiently the company uses its assets to generate sales. This ratio shows the level of effectiveness of the company in using all its assets to create sales and profits. Total asset turnover is measured by comparing sales to total assets for 1 period (Lucas & Noordewier, 2016).

Research Hypotheses

a) **The Effect of Green Process Innovation on Corporate Financial Performance**

Green process innovation is an environmental process innovation as a new process or process modification that is oriented towards reducing the impact on the environment (Salvador et al., 2012). Green process innovation can create several benefits, including being able to generate energy and raw material efficiency by optimizing the use of resources (Porter & Van Der Linde, 2017). In this way, the company can reduce production costs, increase productivity levels, and will directly affect profit margins and this will increase the company's competitive ability and value (Ar, 2012). This will have a positive impact on improving the company's financial performance.

b) **The Effect of Green Product Innovation on Corporate Financial Performance**

According to Puckett & Smith, poor product design and low environmental standards in developing countries can be a serious problem in the future (Lin et al., 2013). Therefore, many companies are currently integrating green concepts in their product innovation to achieve competitiveness and gain competitive advantage (Reinhardt, 1998), as well as a means for companies to carry out sustainable development and achieve their business targets (Lin et al., 2013). Companies that invest through green product innovation will be able to increase opportunities to avoid violations related to environmental policies and can encourage companies to find new ways to convert waste into products that can provide added value to the company (Wang & Ahmad, 2024).

3. METHODS

Population and Sample

This study uses a sample of manufacturing companies listed on the Indonesia Stock Exchange for the period 2020 to 2022 that meet the sample selection criteria. A total sample of 414 observed data was obtained. However, of the 414 observed data there are 14 data that

experience outliers so they need to be removed. Therefore, the final sample used in this study was 400 observed data.

Operational Research Variables

a) **Company Financial Performance (ROA)**

Financial performance is measured using ROA as used by previous research, namely Xie et al. ROA measurement is done using the formula:

$$ROA = \frac{Net\ Income}{Total\ Assets} \times 100\%$$

b) **Green Process Innovation (GPROC)**

The measurement of green process innovation in this assessment is carried out based on the disclosure items from Xie et al, (2019). There are 5 disclosure items to perform this analysis. The following are the disclosure items of green product innovation according to Xie et al, (2019):

- Reduce resource and energy consumption, and improve resource and energy efficiency
- Using recycled materials in the production process, recycling techniques, and use of environmental technologies
- Conducting environmental campaigns
- Using technologies or tools that can control pollution
- Adopting pollution protection projects and technologies pollution protection projects and technologies

From these disclosure items, a score of 0 to 2 will be given for each disclosure item. A score of 0 is given if the company does not disclose any green process innovation disclosure items; a score of 1 if the company only discloses a casual description of green process innovation; and a score of 2 if the company discloses a description along with details of green process innovation. Then the number of disclosure items obtained is calculated with the following calculation:

$$GPROC = \frac{Number\ of\ Items\ Disclosed}{Total\ Items\ that\ Should\ be\ (10)} \times 100\%$$

c) **Green Product Innovation (GPROD)**

The measurement of green product innovation is carried out using an assessment of several disclosure indicators to determine whether the company has carried out green product innovation in its business operations. The measurement of green product

innovation is based on disclosure items from Xie et al. (2019). There are three disclosure items to conduct this analysis. The following are the atoms of disclosure of green product innovation according to Xie:

- Make changes to product packaging design to avoid pollution and reduction of harmful substances
- Conduct development and create environmentally friendly packaging designs
- Modifying product design to improve efficiency

From these disclosure items, a score of 0 to 2 will be given for each disclosure item. A score of 0 is given if the company does not disclose green innovation disclosure items; a score of 1 if the company only discloses ordinary descriptions related to green product innovation; and a score of 2 if the company discloses descriptions along with details of green product innovation. Then the number of disclosure items obtained is calculated with the following calculation:

$$GPROD = \frac{Number\ of\ Items\ Disclosed}{Total\ Items\ that\ Should\ be\ (6)} \times 100\%$$

d) **Total Asset Turnover (TATO)**

This study uses total asset turnover as a control variable in line with previous research conducted by (Lucas & Noordewier, 2016) and (Xie et al., 2019). The following are measurements to promote total asset turnover:

$$TATO = \frac{Sales}{Total\ Assets}$$

Analysis Technique

The data analysis technique used in this study uses multiple linear regression analysis processed through IBM SPSS Statistics 27 to test the influence between variables in this study. The multiple regression analysis model in this study is as follows:

$$\mathbf{FP}\ \boldsymbol{it} = \boldsymbol{\alpha} + \boldsymbol{\beta_1 GPROCit} + \boldsymbol{\beta_2\ GPRODit} + \boldsymbol{\beta_3 TATOit} + \boldsymbol{\varepsilon}$$

4. RESULTS

Descriptive Statistical Analysis

Tabel 1. Descriptive Statistical Analysis

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
GPROC	400	0,00	1,00	0,3350	0,2245
GPROD	400	0,00	0,67	0,1379	0,1905
TATO	400	0,01	2,465	0,8474	0,4286
ROA	400	-0,140	0,271	0,0295	0,0603
Valid N (listwish)	400				

The results of the descriptive statistical analysis of the green process innovation variable in table 4.1 show an average value of 0.335 with a standard deviation of 0.2245. The minimum value of green process innovation is 0.00 and the maximum value is 1.00. The assessment of the green process innovation variable is based on the number of disclosures contained in the sustainability report or annual report.

The results of descriptive statistical analysis of green product innovation variables in table 4.1 show an average value of 0, 1379 with a standard deviation of 0.1805. The minimum value of the green product innovation variable is 0.00 and the maximum value is 0.67. Green product innovation assessment is based on the number of disclosures made contained in the sustainability report or annual report.

The results of descriptive statistical analysis of the total asset turnover control variable in table 4.1 show an average value of 2.2465 with a standard deviation value of 0.4286. The minimum value of total asset turnover is known to be 0.01 and the maximum value is 2.465. The company with the lowest asset turnover ratio is in the Star Petrochem Tbk company in 2022. While the company with the highest asset turnover rate is at Sentra Food Indonesia Tbk in 2020.

The company's financial performance is measured using the ratio as an assessment indicator. A high ROA ratio indicates that the company has high profits. The high profit is due to the green technology innovation efforts made by the company. Based on the results of descriptive statistical analysis, ROA shows an average value of 0.0295 with a standard deviation of 0.03. The minimum value obtained is -0.140 and the maximum value is 0.271. The company with the lowest ROA level is Lotte Chemical Titan Tbk in 2022, while the company with the highest ROA level is Jamu and Pharmaceutical Industry Sido Tbk in 2022.

Classical Assumption Test

a) **Normality Test**

Normality test is conducted to test whether the variables used have a normal distribution by looking at the residual value (Ghozali, 2018). An equation is said to be free from normality symptoms if it has a Kolmogorov-Smirnov significance value > 0.05.

Tabel 2. Kolmogorov-Smirnov

		Unstandarized Residual
N		414
Normal Parameter[a,b]	Mean	0,0000000
	Std. Deviation	0,08425616
Most Extreme Differences	Absolute	0,115
	Positive	0,105
	Negative	-0,115
Test Statistic		0,115
Asymp. Sig. (2-tailed)[c]		0,000

Based on the results of the normality test in table 4.2, it is known that the Kolmogorov-Smirnov significance value is 0.000 < 0.05. This result indicates that the residual data is not normally distributed. The normality test results which show that the residual values are not normally distributed indicate that there is extreme data in the observation sample so it is necessary to remove outlier data. The detection of outlier data is done by converting the data value into z-score form. After converting the data into z-score form for 414 observed data, 14 data were found as outlier data so they need to be removed from the observation sample. After discarding 14 outlier data, the number of observations in this assessment is 400 data. The results of the normality test on the 400 observed data are as follows:

Tabel 3. Kolmogorov-Smirnov

		Unstandarized Residual
N		400
Normal Parameter[a,b]	Mean	0,0000000
	Std. Deviation	0,05569875
Most Extreme Differences	Absolute	0,45
	Positive	0,34
	Negative	-0,45
Test Statistic		0,45
Asymp. Sig. (2-tailed)[c]		0, 051

Based on the normality test, the disposal of outlier data has been carried out, it is known that the Kolmogorov-Smirnov significance value is 0.051 > 0.05. These results indicate that the residual data in this study are normally distributed.

b) **Multicollinearity Test**

The multicollinearity test is carried out with the aim of seeing whether in the regression model there is a correlation between the independent variables (Ghozali, 2018). A regression model is said to be free from multicollinearity symptoms if it has a tolerance value > 0.10 and a VIF value < 10.

Tabel 4. Multicollinearity Test

Model	Collinearity Statistic	
	Tolerance	VIF
(Constant)		
GPROC	0,816	1,225
GPROD	0,816	1,225
TATO	0,997	1,003

Based on the test results in table 4.4, it is known that the tolerance value and VIF value of all variables of all research variables > 0.10 and < 10. This shows that there are no symptoms of multicollinearity between variables in the regression model.

c) **Heteroskedacity Test**

The heteroskestensity test is carried out with the aim of testing whether there are differences in variance between observations in a regression model. This research was conducted with the Glesjer test to detect the presence or absence of heteroscedasticity in the study. A regression model is said not to experience heteroscedasticity if it has a significance value > 0.05.

Tabel 5. Heteroskedacity Test

Model		Unstandarized Coefficiets		Standarized Coefficients Beta	t	Sig.
		B	Std. Error			
1	(Constant)	0,038	0,005		7,801	0,000
	GPROC	-0,002	0,009	-0,012	-0,201	0,833
	GPROD	0,019	0,010	0,101	1,820	0,070
	TATO	0,002	0,004	0,022	0,448	0,654

Based on the test results in table 4.5, it can be seen that all variables in this study have a significance value > 0.05. This shows that the regression model in this study does not experience symptoms of heteroscedasticity.

d) **Autocorrelation Test**

The relationship autocorrelation test is carried out with the aim of testing whether in a regression model there is a correlation between confounding errors in period t. The regression model can be said to be free from autocorrelation symptoms if it has a Durbin-Watson value located between the dU and 4-dU values.

Tabel 6. Autocorrelation Test

Model	R	R Square	Ajusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0,383[a]	0,147	0,140	0,055909	2,024

Based on the results of the autocorrelation test in table 4.6, it shows that the Durbin-Watson value is 2.024. When compared with the table value using 5% significance with the number of samples (n) = 400 and the number of variables (k) = 3, the results obtained are dU = 1.84596 and 4-dU = 2.15404. The Durbin-Watson value lies between the dU and 4-dU values, namely 1.84596 < 2.024 < 2.15404, indicating that there are no autocorrelation symptoms in the regression model.

Coefficient of Determination

Tabel 7. Coefficient of Determination

Model	R	R Square	Ajusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0,383[a]	0,147	0,140	0,055909	2,024

The coefficient of determination (Ajusted R Square) obtained is 0.140, which means that the green process innovation variable and green product innovation as well as the total asset turnover control variable can explain the dependent variable ROA by 14%.

F Test

Tabel 8. F Test

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0,213	3	0,071	22,691	0,000 [b]
	Residual	1,238	396	0,003		
	Total	1,461	399			

Based on the results in table 4.8, the statistical F test shows 22.691 with a significance level of 0.000. The significance value which is smaller than 0.05 indicates that all variables in this study together (simultaneously) affect the company's financial performance.

Research Results

Based on the results of testing the effect of green process innovation on the company's financial performance, it is found that the t-count value on the green process innovation variable shows a positive value of 2.772, the significance value of 0.023 is smaller than 0.05. So it can be concluded that the first hypothesis (H1) in this study is accepted, namely green product innovation has a positive and significant effect on the company's financial performance.

Green process innovation can help companies to reduce operational costs through efficient use of energy and waste reduction. This energy efficiency is done by making savings on the use of energy resources by utilizing existing renewable resources. This way the company can minimize the use of electricity and fuel costs. This will help companies reduce production costs, increase productivity levels, and will directly affect the company's profit margins which will have an impact on increasing the company's competitive ability and financial performance (Ar, 2012). The results of this study are in line with stakeholder theory where according to this theory green product innovation can meet the needs of customers who are increasingly concerned about the environment. In addition, green product innovation can attract investors who are interested in sustainable and socially responsible companies, increasing the company's access to capital and financial support. RBV theory also explains that the company's unique and different green product innovations can provide a competitive advantage by meeting the demands of consumers who care about the environment. This innovative product is difficult to imitate by competitors, so it can be a rare and valuable resource for the company. And this will increase interest in the company's products which in turn will improve the company's financial performance.

Based on the results of testing the effect of green product innovation on the company's financial performance, it is found that the t-count value on the green process innovation variable shows a positive value of 3.851, the significance value of 0.000 is smaller than 0.05. So it can be concluded that the second hypothesis (H2) in this study is accepted, namely green product innovation has a positive and significant effect on the company's financial performance. The results of this study are in line with RBV theory and stakeholder theory. RBV theory explains that unique and different green product innovations owned by companies can provide a competitive advantage by meeting the demands of consumers who care about the environment. This innovative product is difficult for competitors to imitate, so it can be a rare and valuable resource for the company. And this will increase interest in the company's products which will ultimately improve the company's financial performance. Stakeholder theory explains that green product innovation can meet the needs of customers who are increasingly concerned about the environment. In addition, green product innovation can attract investors who are interested in sustainable and socially responsible companies, increasing the company's access to capital and financial support.

Based on the results in the study, it is known that the total asset turnover variable has a t-count value of 5.805 with a significance value of 0.000 (smaller than 0.05) which is proven to have a significant and positive effect on the company's financial performance. These results

indicate that total asset turnover has a positive and significant effect on the company's financial performance. This shows that the greater the level of total asset turnover of a company will improve the company's financial performance as measured by ROA.

5. CONCLUSION

This study was conducted with the aim of testing and providing empirical evidence related to the influence of the independent variables of green process innovation and green product innovation on the dependent variable of corporate financial performance. The results of this study prove that green process innovation and green product innovation have a positive and significant effect on the company's financial performance. Companies that carry out green process innovation and green product innovation will be seen as having unique and different resources by stakeholders. Companies that make this innovation are considered to have higher competitiveness compared to other companies. In addition, companies that carry out green process innovation and green product innovation will also meet the expectations of stakeholders who are concerned about the environment. This will result in higher market interest in the company, the company can attract new consumer segments, and can strengthen customer loyalty. The positive response will then have an impact on increasing the company's revenue and profitability.

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