
RESEARCH AND DEVELOPMENT INTENSITY, FIRM PERFORMANCE,
AND GREEN PRODUCT INNOVATION

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Abstract. This study was conducted to determine the effect of research and development intensity (RNDI) on firm performance (FP) with green product innovation (GPI) as an intervening variable. Companies which are always innovative with market developments will get two benefits. First, achieving competitive advantage. Second, obtaining economic benefits, therefore it will increase firm performance. This study uses 170 company observations from listed companies in Indonesia Stock Exchange at 2013-2017 as sample of research. The samples were chosen by purposive sampling method and were analyzed by path analysis method using STATA software. The result shows that RNDI has an effect on FP, RNDI has an effect on GPI, and GPI has an effect on FP. They indicate that GPI can mediate the effect of RNDI on FP in partial.

Keywords: R&D intensity, green product innovation, firm performance

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JEL Classifications: Q01, L25, O30.

1. Introduction

Rapid global economic growth makes environmental problems as a key and the main focus of sustainable economic development (e.g. Stjepanović et al., 2017; Tvaronavičienė, 2018; Lavrinenko et al., 2019; Fatoki, 2019; Masood et al., 2019; Kormishkina et al., 2019; Chehabeddine, Tvaronavičienė, 2020; Vigliarolo, 2020; Energy Transformation towards Sustainability, 2020). To overcome these environmental problems, the United Nations launched Sustainable Development Goals (SDGs) number 9, namely industry, innovation and infrastructure which are important points in the development of sustainable industries, encouraging innovation and strengthening infrastructure. The Indonesian government on 2014 also passed Law number 3 of 2014 concerning industry which specifically regulates green industry (articles 77-83). One company that has a high innovation culture is PT Petrokimia Gresik which is the largest fertilizer producer in Indonesia. Innovation has led PT Petrokimia to be more effective and efficient. In 2016, the realization of savings from innovation activities amounted to Rp 278.8 billion.

Regarding environmental concerns, several companies have implemented green innovation in their industry and have been proven to have a good impact on the environment and the company itself. Huang, et al. (2016) defines green product innovation as a new product or improvement from previous products that reduces the impact of various environmental problems that arise in the product life cycle. Green product innovation is one of the applications of legitimacy theory. This study found that green product innovation has a positive influence on company performance. Companies with green product innovation will increase customer value and

legitimacy from the community, thereby gaining new markets that will increase sales. These results support previous research, namely Ar (2012); Cai and Li (2018); Chan, et al. (2016); Gluch et al. (2009); Palmer and Truong (2017). In contrast, this study does not agree with Dangelico et al. (2013) who found that green product innovation had no significant effect on company performance. Green product innovation requires a long time so that the impact is felt by the company.

Green innovation as one of the important points in SDGs, usually begins with research and development (R&D) activities. The results of a survey of 1,320 companies in Indonesia conducted by the World Bank in 2015 found that only 1.9% of Indonesian companies issued funds for research and development. This amount is far behind when compared to neighboring countries and developing countries too, Malaysia, which is equal to 10.5% of companies. While this research found that companies that actively undertake R&D activities will find it easier to develop products by paying attention to environmental problems that arise. These results are in line with the study of De Medeiros, et al. (2014), Huang, et al. (2016), and Tumelero, et al. (2019) who managed to find a positive effect of the intensity of R&D on green product innovation. These results also support the RBV theory that a company's internal capabilities such as R&D will encourage the creation of competitive advantages, one of which is green product innovation.

In addition to having an impact on green product innovation, the intensity of R&D also has a positive influence on company performance. The study found an increase in funding for R&D resulted in an increase in the company's ability to conduct development and research to create new products that are in line with the demands of the community or improve existing processes. This will make the company's sales increase and there will be savings on the improved process. It also fulfills the interests of stakeholders so that the company can survive in the market and is always adaptive. This study supports the research of da Silva et al. (2015); Gu (2016); Jaisinghani (2016); Mulero Mendigorri, et al. (2016) which revealed the intensity of R&D has a positive effect on company performance. In contrast, this study does not agree with Tahat, et al. (2018) who did not find any influence from these variables.

Theoretically, this research contributes to the literature through several aspects. First, this study expands research on innovation by using green product innovation. Second, conducting research related to the mediating role of the green product innovation variable in the relationship of R&D intensity and company performance that has not been studied before. This study shows that green product innovation can partially mediate these two variables Third, based on the R&D theory, this study looks at its impact on company performance in the coming year.

2. Literature Review

2.1. Legitimacy Theory

According to O'Donovan (2002), company must ensure that its operations have been running smoothly continuously and in accordance with existing norms in society. In the legitimacy theory, the company will focus on the community and its environment and will voluntarily report its activities (Deegan, 2004). The differences that occur between business actions and people's expectations (legitimacy gap) can cause problems for companies (Sethi, 1977). There are two ways for companies to gain legitimacy (Dowling & Pfeffer, 1975). First, there is a compatibility between the company's operational activities and the value system prevailing in the community. Second, companies need to express social value in their activity reports. Green product innovation is one way for companies to gain legitimacy from the public.

2.2. Stakeholder Theory

Freeman (2010) states that stakeholder theory is defined as an individual or group of people who can influence or can be influenced by a business business. Based on this theory, a company must pay attention to the interests of stakeholders because the company does not operate alone (Ghozali & Chariri, 2007; Cardoso et al., 2018).

The intensity of research and development is expected to reflect companies that are always developing and strive for going concern. Likewise in green product innovation, stakeholders do not need to worry because the innovations made by the company do not pay attention to the environment.

2.3. Resource Based View (RBV) Theory

Resource-based view (RBV) theory is a theory used to understand how companies achieve sustainable competitive advantage through the company's resources. RBV theory focuses on the concept of corporate attributes that are difficult to replicate so as to produce superior performance and competitive advantage (Barney, 1991). Company resources must have the following criteria in order to achieve competitive advantage and sustainable performance, including valuable, scarce, imperfectly imitated, and unsubstituted (Barney, 1991).

2.4. Effect of Research and Development Intensity on Company Performance

Companies usually carry out R&D activities to improve product quality and adjust to the changing market needs. The purpose of the company in order to meet the interests of stakeholders so that the company can survive and compete. This is in line with the application of stakeholder theory. However, the costs incurred for R&D activities in companies cannot be classified as small. According to Sougiannis (1994), it takes about seven years for expenses for R&D activities to produce returns of up to 200 percent.

Even so the costs incurred by the company to conduct R&D will not be in vain. Companies that carry out R&D activities will get two benefits, namely to improve their innovation capability and absorptive capacity (Dai and Yu, 2013). Through this increase in absorptive capacity, the intensity of R&D can improve company performance (da Silva, et al., 2015; Gu, 2016; Jaisinghani, 2016; Mulero Mendigorri, et al., 2016). Based on this hypothesis proposed in this study as follows:

H1. The intensity of research and development influences company performance

2.5. Effect of Research and Development Intensity on Green Product Innovation

Horbach (2008), in his study of the determinants of environmental innovation, stated that organizations that want to succeed in developing new environmentally friendly products must invest in tools and methods that can support this goal. Huang, et al. (2016) suggest managers evaluate the type and amount of investment in R&D needed to develop green product innovation. Block (2012) argues that investment in R&D can affect a company's ability to develop new products and create and adopt innovative technologies that can increase its competitive advantage. This is consistent with the theory of resource-based view, which states that internal resources owned by companies such as R&D activities can increase competitive advantage in companies, one of which is green product innovation. Several studies have found that when research and development is higher, the better also the impact on green product innovation (De Medeiros, et al., 2014; Huang, et al., 2016; Tumelelo, et al., 2019). Thus, the hypothesis proposed in this study is as follows:

H2. The intensity of research and development has an effect on green product innovation.

2.6. Effect of Green Product Innovation on Company Performance

Green product innovation is defined as product development by reducing negative impacts and risks caused to the environment (Lin, et al., 2013). Guoyou et al. (2013) consider environmentally friendly innovation as an instrument to improve the company's environmental management process, and related to various changes that occur that result in a reduction in environmental burden. Companies that implement green product innovation are expected to minimize the resources used and prevent waste in the product disposal phase. In addition, green product innovation has an impact on competitive advantage and corporate image (Kam-Sing Wong, 2012). The existence of good environmental performance, high efficiency, and competitive advantage will encourage in-

vestors to invest (Agustia et al., 2019) Including environmental problems in the company's business activities is one way to add value to customers (Hansmann and Claudia, 2001). This is in line with the application of the theory of legitimacy that the products produced do not interfere with the community or are environmentally friendly. Research Ar (2012); Cai and Li (2018); Chan, et al. (2016); Gluch et al. (2009); Palmer and Truong (2017); Singh, et al. (2016) has also proven that green product innovation has a good impact on the company's business. Based on this, the hypothesis proposed in this study is as follows:

H3. Green product innovation influences company performance.

2.7. Effect of Research and Development Intensity on Company Performance with Green Product Innovation as Intervening Variables

Based on stakeholder theory, a company must be able to fulfill all stakeholder interests. One of the stakeholders' interests is to want the company to remain going concern. R&D activities are the company's efforts to stay afloat and compete by continuing to innovate. Although the costs incurred for these activities are usually high, R&D activities have a positive impact on company performance (da Silva, et al., 2015; Gu, 2016; Jaisinghani, 2016; Mulero Mendigorri, et al., 2016).

R & D activities can also support the existence of green product innovation in companies (De Medeiros, et al., 2014; Huang, et al., 2016; Tumelero, et al., 2019). Investment in R&D can influence companies in developing new products. This is in line with the RBV theory which relies on internal resources. Green product innovation is also one application of the theory of legitimacy, which states that companies must act in accordance with norms and rules in society. In this case the company considers the environmental impact received by the community. The existence of environmentally friendly innovations can also increase public confidence in consuming company products that will have an impact on the performance of the company itself (Ar, 2012; Cai & Li, 2018; Chan, et al., 2016; Singh, et al., 2016). Based on the description above, the research hypothesis proposed is as follows:

H4. The intensity of research and development influences company performance through green product innovation.

3. Research Methodology

3.1. Research Design

This study uses quantitative approach which use 170 companies listed in Indonesian Stock Exchange 2013-2017 as a sample. Moreover, this study also use path analysis and Sobel-test for hypotheses testing. Following are the linear regression equation:

$$FP_{i,t+1} = \alpha + \beta_1 RNDI_{i,t} + e \tag{1}$$

$$GPI_{i,t} = \alpha + \beta_1 RNDI_{i,t} + e \tag{2}$$

$$FP_{i,t+1} = \alpha + \beta_1 GPI_{i,t} + e \tag{3}$$

$$FP_{i,t+1} = \alpha + \beta_1 RNDI_{i,t} + \beta_2 GPI_{i,t} + e \tag{4}$$

Notes:

- FP : Firm performance
- RNDI : Research and development intensity
- GPI : Green product innovation
- α : Constanta
- β : Coefficient
- e : Error

3.2. Definition of Operational Variables

3.2.1. Intensity of Research and Development

The intensity of R&D is all expenditures that companies use to create new products or processes, or improve existing products, or discover new knowledge that will be useful in the future (Kieso, 2014). The ratio of the R&D intensity used is the burden of R&D divided by sales (Jaisinghani, 2016; Vithessonthi & Racela, 2016).

3.2.2. Green Product Innovation

Green product innovation is a diverse process that has three key environmental focuses, namely raw materials, energy, and pollution (Dangelico & Pujari, 2010). To find a company implementing green product innovation, there are ten indicators used to measure it. These indicators include: substitution of raw materials that cause pollution, substitution of hazardous raw materials, designs that focus on reducing resource consumption at the production stage, designs that focus on reducing waste generated at the production stage, designs that focus on product improvement and decomposition, design which focuses on increasing product use, designs that focus on increasing product recycling, product life cycle analysis to improve product design, expanding the scope of the market for environmentally friendly products, and improving manufacturing technologies for environmentally friendly products. Based on these indicators, the total disclosed divided by the number of indicators is 10 (Huang, et al., 2016).

3.2.3. Company Performance

The company's performance is the result of the company's operational activities in utilizing available resources. This study uses a financial perspective to measure company performance. According to the Indonesian Institute of Accountants (2009: 4), company performance can be measured by analyzing and evaluating the company's financial statements. Return on assets (ROA) size to be used is the ratio of net income to assets (Jaisinghani, 2016). This study uses a one-year gap, to calculate company performance due to the nature of the independent variables.

4. Result and Discussion

4.1. Results

Table 1. Results of Regression Analysis (Robust)

	Model 1	Model 2	Model 3	Model 4
	FP	GPI	FP	FP
RNDI	3.259*** (6.52)	3.136*** (5.99)		2.973*** (5.90)
GPI			0.153*** (3.44)	0.091** (2.36)
_cons	0.057*** (7.99)	0.340*** (23.90)	0.019 (1.14)	0.026 (1.54)
r2	0.232	0.066	0.077	0.257
N	170	170	170	170

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1 which is contain of the regression analysis result shows that all hypotheses have significant value less than 0,005 therefore all hypotheses are accepted.

Based on the path analysis in Figure 1, green product innovation mediates the relationship between R&D intensity and company performance partially. This is because the intensity of R & D and green product innovation influences company performance, as well as the intensity of R & D influences green product innovation. In accordance with the theory of Baron and Kenny (1986) which states that partial mediation occurs when the independent variable is able to influence the dependent variable without going through the intervening variable (path c'). The direct effect of the model (line c') is 0.439 while the indirect effect (line a x b) is 0.042. This is also supported by the sobel test (Table 2) which yields a significance of less than 0.05 (p-value 0.032). Based on these results, the H4 which states that the intensity of research and development affect the company's performance through green product innovation is accepted.

Table 2. Sobel Test

	Input	Test Statistic	Std. Error	P-value
a	3,136	2.1481	0,1329	0,0317
b	0,091			
Sa	0,524			
Sb	0,039			

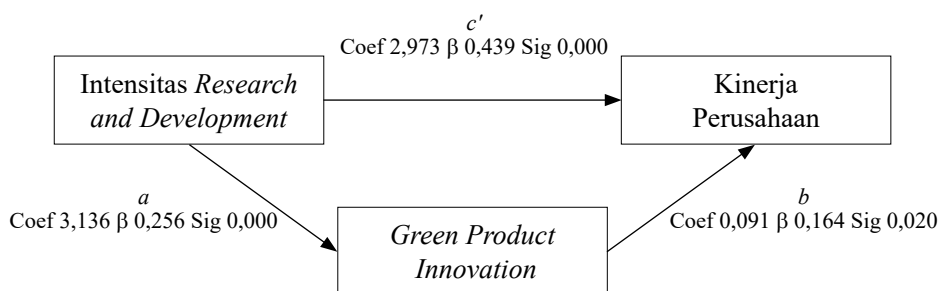


Figure 1. Path Analysis

4.2. Discussion

4.2.1. Effect of Research and Development Intensity on Company Performance

Based on the results of statistical analysis, this study found that the intensity of research and development had a positive and significant effect on company performance. This can be seen from the test results that show a significance value of 0,000 smaller than the significance level that has been determined that is 5%.

R&D activities in a company are also known as high-risk and risky activities. Therefore, this activity requires special attention from the company. Managers should view R&D as an investment and not as a burden. That is because R&D generally provides benefits not in the same year, but in the following year. This is in accordance with one of the characteristics of research and development activities that takes a long time starting from the formulation of ideas to the manufacture of products. When companies can use funds for R&D effectively and efficiently, it will benefit the company. Increased investment in R&D results in an increase in the company's ability to carry out development and research to create new products that are in accordance with the demands of the community or improve existing processes. This will make the company increase its sales and can reduce expenses due to savings on improved processes. When there is an increase in sales and savings, the company will get higher profits and better company performance. This study supports the research of da Silva, et al. (2015); Gu (2016); Jaisinghani (2016); Mulero Mendigorri, et al. (2016) which states that the intensity of R & D has a positive effect on company performance. In contrast, this study does not agree with the research of Tahat, et al. (2018) which revealed that there was no influence on these variables.

4.2.2. Effect of Research and Development Intensity on Green Product Innovation

Based on the results of statistical analysis, this study found that the intensity of research and development had a positive and significant effect on green product innovation. This can be seen from the test results which show that the significance value of 0.001 is smaller than the significance level that has been determined that is 5%.

Research and development activities are closely related to the innovations produced. Companies that actively carry out research and development activities will find it easier to develop products. The company will also pay attention to problems arising from product innovation as well as environmental sustainability. Product innovation in companies that have a goal of sustainable development and attention to environmental sustainability is called green product innovation. In accordance with the theory of resource-based view, companies that have internal resources in this case are research and development activities with rare, unique, non-replicable and unsubstituted characteristics, which will support the creation of competitive advantage. Green product innovation is a form of excellence owned by companies and not owned by competitors. However, the nature of research and development activities that spend time, the results are uncertain and risky require special attention from the company. Companies must always evaluate the types of R&D activities and the amount of R&D costs needed to develop green product innovation. Companies that succeed in doing this will be easier to develop green product innovation.

Thus, this study supports the research of De Medeiros, et al. (2014); Huang, et al. (2016); Tumelero, et al. (2019) which revealed that the intensity of research and development had a positive effect on green product innovation.

4.2.3. Effect of Green Product Innovation on Company Performance

Based on the results of statistical analysis, this study found that green product innovation had a positive and significant effect on company performance. This can be seen from the test results that show that the significance value of 0,000 is greater than the significance level that has been determined that is 5%.

The issue of environmental sustainability is currently one of the focuses of the company, including in terms of innovation. The existence of green product innovation can be a company advantage in a competitive environment. Including environmental issues in the company's business activities is one way to add value to customers. These results are in accordance with studies from Hansmann and Claudia (2001). In addition, based on the theory of legitimacy, green product innovation can also make companies gain legitimacy from the public. This is because green product innovation is evidence that companies innovate according to existing norms in society, and pay attention to environmental sustainability in their business.

As a result of increasing customer value and legitimacy from the public, companies with green product innovation will gain a new market. This new market is very profitable. The company will get more customers and of course increase sales of the product. Increased sales cause profits to increase. Based on profitability ratios, an increase in profit can be interpreted as an increase in company performance. In addition, green product innovation will encourage efficient use of raw materials and be more energy efficient so that the costs incurred go down. Green product innovation will also lead companies to find new ways to turn waste into products that can be sold and increase revenue.

This study supports the research of Ar (2012); Cai and Li (2018); Chan, et al. (2016); Gluch et al. (2009); Palmer and Truong (2017); Singh, et al. (2016) which states that the existence of green product innovation has a positive effect on company performance. In contrast, this study does not agree with the research of Dangelico et al. (2013) which revealed that green product innovation had no significant effect on company performance.

4.2.4. Effect of Research and Development Intensity on Company Performance with Green Product Innovation as Intervening Variables

The results based on the path analysis show that there is an indirect influence by green product innovation on the relationship between research and development intensity and company performance.

Companies that actively carry out research and development activities will become more productive. Increased investment in research and development has resulted in an increase in the company's ability to conduct research and development to create new products that are in accordance with the demands of the community or improve existing processes. This makes an increase in sales and savings that lead to increased company performance. This result is supported by stakeholder theory that research and development can meet the interests of stakeholders in order to remain going concern.

In addition, research and development activities are closely related to the green product innovation that is produced. Companies that spend more on research and development will have the ability to pay greater attention to the environment. As a result, it is easier for companies to produce product innovations that are beneficial to society and friendly to the environment. This result is supported by resource based view theory that companies with internal resources such as research and development will support the creation of competitive advantages in this case is green product innovation.

In addition, green product innovation that involves environmental elements in innovation results in increased customer value and legitimacy from the community. This result is in accordance with the theory of legitimacy. Through green product innovation, the company will gain more market share and increase sales so that the company's performance also increases. This is also offset by the efficiency of raw materials and energy which makes cost reduction.

Based on the explanation above, it can be seen that green product innovation can mediate the relationship that occurs between the intensity of research and development on company performance.

Conclusions

Based on the results of the analysis and discussion described previously, it can be concluded as follows:

1. The intensity of research and development has a positive effect on company performance. This is because investment in research and development results in an increase in the company's ability to conduct development and research to create new products or improve existing processes so that there is an increase in sales and savings resulting in increased company performance.
2. The intensity of research and development has a positive effect on green product innovation. Companies that actively conduct R&D activities will find it easier to develop products by taking into account environmental problems that arise.
3. Green product innovation has a positive effect on company performance. Companies with green product innovation will increase customer value and legitimacy from the public, thereby gaining new markets. The new market will make sales increase, followed by profits and company performance. This is supported by a decrease in costs due to the efficiency of raw materials and energy.
4. Green product innovation is proven to mediate the relationship between research and development intensity on company performance. This is because the greater intensity of R & D makes it easier for companies to involve environmental elements in green product innovation so as to increase market share and result in increased company performance.

The limitation in this study is that not many companies care about and report on the intensity of research and development. This is evidenced by the World Bank survey that in 2015 only 1.9% of companies in Indonesia issued funds for R&D. In addition, this study uses annual report data for green product innovation variables so that the perspective is from external parties. Based on the conclusions and limitations of this study, the advice

given by researchers is that researchers can then use primary data sources such as questionnaires for green product innovation variables so that the information obtained is more complete.

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