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Does Innovation Efficiency Matter to Firm Performance the Moderating Role of Environmental Uncertainty?

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Abstract:

We examine the relationship between innovation efficiency and firm performance, as well as the moderating role of environmental uncertainty in the relationship. Competitive globalization pressures, dynamic changes in customer demand, and rapid technological advances make it difficult for firms to achieve and maintain their competitive advantage. We argue that when environmental uncertainty increases, innovation is needed to maintain the firm's competitive advantage, by making it efficient in its implementation. We tested manufacturing companies listed on the Indonesia Stock Exchange year 2013-2019 with a total number 564 observations. We find that a innovation efficiency improves firm performance, and environmental uncertainty can encourage firms to be more efficient in innovating to improve their performance. This study contributes to a greater understanding of the relationship between innovation efficiency and firm performance in the situation of dynamic environmental uncertainty from the perspective of contingency theory. The evidence shows that environmental uncertainty, as a contingency problem, is an opportunity for firms to improve their performance, by being more active in carrying out innovation projects. When environmental uncertainty increases, policymakers within the firm must ensure that the innovation projects carried out can run efficiently, thus providing great benefits for improving firm performance.

Keywords: Innovation efficiency, environmental uncertainty, firm performance

1. Introduction

The manufacturing industry has played a significant role in Indonesia's economic development since the era of the New Order. After that, the government increasingly realized that development and innovation were very important in the manufacturing industry. The government emphasized that innovation is the driven force of economic growth and is a key factor to catch up with developed countries. The government then established a research and innovation agency to support the program. The existence of the research and innovation agency is expected to stimulate stakeholders to create or develop products and processes that can compete in an increasingly competitive environment. Moreover, the government encouraged firms to further enlarge their innovation programs so they can produce products that can compete in the global market. Innovative firms tend to be more flexible and more adaptable to the business environment, thus taking advantage of opportunities better than competitors. Without continuous development and innovation, constraints within internal and external conditions will destroy the balance between the market supply and demand (Kafetzopoulos et al., 2019).

Innovation drives new ideas, risk-taking, and new business approaches (Tsai & Yang, 2014). Innovation encourages firms to produce quality products or services at low costs, improvise products with new attributes, and produce products that are different (Atalay et al., 2013; Ruiz-Moreno et al., 2016). Innovation creates more efficient process mechanisms and creates new sources or raw materials (Gunday et al., 2011; Vyas, 2009). In addition, innovation creates new market niches and forms of industry (Vyas, 2009). In the Oslo Manual, innovation is defined as the implementation of new or significantly improved products (goods or services), new processes, marketing techniques, or new organizational methods in the business practices, workplace, organizations, or external relations (OECD/Eurostat, 2005). Therefore, firms that cannot innovate have an impact on the abandonment of the firm's products, a decline in the production cycle, and the loss of the firm's position in the market environment (Evangelista & Vezzani, 2010).

Several types of research confirmed the positive impact of innovation on firm performance. Innovation is the main factor that affects the performance, long-term viability, and sustainability of the organization (Zapata-Cantu et al., 2016). Yin & Sheng (2019) stated that innovation is aimed at improving the firm's performance in the long term. Evangelista

&Vezzani, (2010) and Crowley (2017) showed that to survive and compete in global and market niches, firms must adopt innovation into their strategies, not only concerning their products but also their processes. Product and process innovation is the firm's effort to find a better market position for improving firm performance (Atalay et al., 2013; Kafetzopoulos & Psomas, 2015). Product innovation creates a competitive advantage in the market through new products that are better than competitors so it helps companies to create market share and increase sales (Atalay et al., 2013; Evangelista & Vezzani, 2010). New products and services resulting from the innovation process generate new market share and the ability to create prices to increase firm profitability (Hoonsopon & Ruenrom, 2012; Sudaryati & Amelia, 2015). However, several studies that focus on the relationship between innovation and firm performance have not provided conclusive results (Camisón & Villar-López, 2014). Product innovation does not directly affect the firm's performance. Firms must have the capacity to develop market share related to new products that are produced (Gunday et al., 2011). In addition, the process innovation carried out by the firm has an impact on increasing the firm's costs. New technologies to support the innovation process incur large costs, thereby reducing the firm performance (Tavassoli & Karlsson, 2015). There is a lack of appropriate models to track the impact of various types of innovation on firm performance overtimes, so future research is recommended to validate the findings of previous studies and present an integrative research framework that simultaneously covers the influence of innovation and firm performance (Haned et al., 2014).

The existence of a literature gap in the field of innovation encourages researchers to study innovation in an integrative way. This paper attempts to examine innovation efficiency as an integrative framework for innovation. Efficiency is an important concept in innovation because investing in innovation is not an activity that firm management wants (Hollanders & Esser, 2007). Innovation is based on how to create a quality product by optimizing all available resources so that efficiency can be increased by the firm. Innovation efficiency reduces unnecessary burdens as an effort to defend themselves in a competitive environment, so innovations do not have a significant impact on the decline in firm performance (Hollanders & Esser, 2007). Management's ability to calculate the efficiency of innovation appropriately provides the benefits to meet consumer preferences without placing an excessive burden on firm resources. Innovation efficiency is defined as the firm's ability to translate innovation inputs into innovation outputs (Hollanders & Esser, 2007). Although innovation is not a linear process of converting innovation inputs into innovation outputs, studying how the resources used as innovation inputs produce optimal outputs provide a basic explanation of the concept of innovation efficiency (Hollanders & Esser, 2007).

Some researchers empirically test the efficiency of innovation with different input and output choices. Revilla et al. (2003) estimated the efficiency of innovation by considering the firm's revenue, the number of employees, and R&D expenses as inputs, while total revenue, new hires, and patents as innovation outputs. Guan et al. (2006) considered R&D, learning, manufacturing, marketing, and organization as inputs to innovation and market share, sales growth, export rates, profit growth, productivity, and new product rates as outputs of what he defined as technological innovation capability. They concluded that only 16% of firms are technically efficient. Innovation efficiency is the optimal combination of R&D employment as input while patents as innovation output (Broekel, 2012). Broekel (2012) concluded that the intensity of regional and inter-regional collaboration that is close to the industry average characterizes the innovation efficient areas. On the other hand, areas with very high or low intensity of collaboration, as well as the imbalances between regions and inter-regional are more often found among regions with innovation efficiency. Claudio et al. (2013) used R&D capital stock and high-skilled staff as inputs as well as the number of the new products and patents as outputs of technological efficiency. They observed that the efficiency varies depending on the size of the firm and the knowledge level of the firm.

The effectiveness of innovation as a competitive strategy is influenced by the environmental context in which the firm operates and competes (Kafetzopoulos et al., 2019). Some researchers considered the dynamics of the modern business environment to influence the relationship between innovation and firm performance (Kafetzopoulos et al., 2019; Tsai & Yang, 2014; Turulja & Bajgoric, 2019). This encouraged researchers to examine the moderating role of environmental uncertainty on the relationship between innovation efficiency and firm performance. Environmental uncertainty is characterized by increasingly fierce global competition, dynamic changes in customer demand, and rapid technological advances which creates difficulties for the firms to achieve and maintain their competitive advantage (M. Wang & Fang, 2012). Firms with high innovation capabilities cope with environmental uncertainty by exploiting market demand that changes rapidly (Tsai & Yang, 2014), considering the risks posed, innovation efficiency needs to be carried out so there will be no interference with short-term firm performance. Rapid environmental changes make current products and services obsolete, so firms must continue to introduce new products and services to improve enterprise competitiveness (Turulja & Bajgoric, 2019). The products and services should last longer against the changing environmental conditions so that the benefits of these products and services can improve the firm performance. Firm management must find proper information so that efficiency can be done when creating these new products and services. Environmental uncertainty encourages management to be more active in finding sources of information related to market conditions and competitors to reach efficiency in the run of innovations programs.

We identify two gaps in the literature examining the relationship between innovation and firm performance. First, there is no comprehensive confirmation regarding the form of efficiency in innovation activities that can improve the firm performance. Second, a study examines the moderating role of environmental uncertainty in the relationship between innovation efficiency and firm performance. Therefore, our main objective is to examine whether environmental uncertainty has a moderating role in the relationship between innovation efficiency and firm performance.

2. Literature Review

2.1. Contingency Theory, Innovation Efficiency, and Environmental Uncertainty

The contingency approach to management accounting is based on the premise that no universal accounting system applies equally to all organizations in all circumstances (Otley, 1980). This indicates that no accounting system can answer all problems within different situations. Dynamic changes in the external environment create contingency problems for the firms. Therefore, an active management effort is needed to solve the contingency problems arising from changes in the external environment. The firm's management efforts in solving an arisen contingency problem help the firm to store the needs to answer these contingency problems.

Rapid technological advances, changes in consumer preferences, and fluctuations in product supply and demand of materials are contingency problems faced by firms at all times. These conditions create environmental uncertainty that can disrupt the firm's sustainability (Chan et al., 2016). This condition indicates that environmental uncertainty is a contingency problem that creates difficulty for firm management to predict the firm's sustainability in the future due to changes in the external environment. Changes in the external environment encourage management to be more active in creating internal and external contingency factors to respond to the environmental changes (Tsai & Yang, 2014). Therefore, innovation is a management step to deal with contingency problems arising from a highly competitive market (Kafetzopoulos et al., 2019).

Innovation is a form of the firm's ability to implement new ideas in business processes. The firm's ability to implement new ideas requires research and development that is based on the perspective of consumers and internal resources (Tavassoli & Karlsson, 2015). The existence of research and development of new ideas resulted in an increased investment issued by firms to finance innovation. Therefore, it takes efficiency in the implementation of innovation. The efficiency of innovation results in investments made by the firm that is not considered as a burden to the firm's internal resources, so that the firm can carry out operational activities well during the innovation process.

2.2. Innovation Efficiency and Firm Performance

Competitive globalization pressures, dynamic changes in customer preferences, and rapid technological advances create difficulties for companies to achieve and maintain their competitive advantage. Therefore, to gain a competitive advantage and survive in a competitive environment, firms must intensify their innovation activities as the main source to maintain their position in global competition. Firms must adopt innovation in their strategy to survive in global competition (Crowley, 2017; Evangelista & Vezzani, 2010). Innovative firms tend to be more flexible and more adaptable to the business environment, thereby increasing opportunities better than competitors (Becheikh et al., 2006). The firm's innovation activities create opportunities to gain a better market position, more efficient process mechanisms, thus having an impact on improving firm performance. In the modern era, investing in innovation projects help firms to improve their short-term performance and produce cumulative impacts in the long term.

However, innovation needs a large amount of money and carries a high risk because uncertainty revolves around the entire innovation process (Chatterjee & Bhattacharjee, 2020). Differences in demand for resources and adaptability to markets, changes in technology and knowledge, and uncertainty of innovation will affect the distribution and use of operational costs so that firms do not have a sense of security to carry out innovation projects. The uncertainty of innovation projects makes managers reluctant to innovate to maintain the firm's short-term performance growth (Xu & Zhu, 2010). This jeopardizes the prospects for the firm's sustainability in the future since a highly competitive environment requires firms to be more innovative in developing their products and production processes. Therefore, innovation must consider efficiency factors to reduce the excessive burden on the use of firm resources. Innovation efficiency has an important role in an increasingly complex business environment, where innovation efficiency can reduce unnecessary burdens to defend itself in a competitive environment so the innovations made have a significant impact on improving firm performance (Claudio et al., 2013).

The optimal combination of using innovation inputs to produce greater output when innovation efficiency is carried out provides opportunities for firms to develop or create new products according to consumer preferences with the use of lower operating expenses. Innovation efficiency makes the innovation projects carried out have greater benefits compared to the cost incurred. New products resulting from innovation projects can create new market niches, making the firm a market leader that helps to determine prices for these new products (Sudaryati & Amelia, 2015). This causes the firm's revenue to increase because of the rising in market share and the ability to shape prices. This has an impact on increasing firm performance when innovation efficiency is carried out. Moreover, innovation efficiency provides an option for firms to invest in technologies that have a longer life cycle for improving production processes. The amount of costs incurred for investment projects in technology has an impact on declining firm performance (Tavassoli & Karlsson, 2015). Therefore, innovation efficiency encourages firms to consider the use of technology that can provide higher economic benefits so that the firm's performance can improve. This shows that innovation efficiency is a form of strategy to improve firm performance while remaining actively involved in the competitive environment (Claudio et al., 2013). Therefore, this research formulates the hypothesis that:

- *H1: Innovation efficiency has a positive impact on firm performance*

2.3. The Moderating Role of Environmental Uncertainty on the Impact of Innovation Efficiency on Firm Performance

Environmental uncertainty has an impact on changes in the firm's innovation activities. Tsai & Yang (2014) showed that innovation has a different impact on firm performance due to the impact of market changes and the intensity of competition. According to Atuahene-Gima et al. (2006), market turbulence positively affects the causal relationship

between innovation strategy and firm performance. Successful firms tend to develop innovative strategies to meet customer demands and capture market niches for new products when environmental uncertainty increases (Atuahene-Gima et al., 2006). Hult et al. (2004) also stated that a high level of market uncertainty leads firms to adopt greater innovations and perform better. Thus, innovation should be a top priority not only for improving the firm's performance but also for increasing its chances of surviving in a period of continuous turbulence and great uncertainty (Dervitsiotis, 2012). Firms have a greater need to maintain and innovate to operate in markets when environmental uncertainty increases. Firms are faced with changes in customer preferences regarding products or services as well as the opportunities offered by these changes, trying to create innovative ideas that will produce new products that are in line with customer preferences to make the improvement of firm's performance stable (Kafetzopoulos et al., 2019; Turulja & Bajgoric, 2019).

Environmental uncertainty poses a great risk to firms. This affects the innovation activities of firms because it is difficult for managers to integrate innovation issues in their strategic decisions when environmental uncertainty increases (Tsai & Yang, 2014). Innovation has a high risk that increases when environmental uncertainty becomes more dynamic. When environmental uncertainty increases, efficiency is needed to minimize the risks posed by innovation projects. Innovation efficiency provides space for managers to maintain firm finances and minimize the risks caused by considering the optimal combination of innovation inputs and outputs. Innovation efficiency encourages firms to be more active in innovation projects when environmental uncertainty increases without disrupting the firm's short-term performance. When environmental uncertainty increases, firms actively seek information related to competitors' strengths and customer preferences. This encourages firms to intensively conduct research and development (R&D) to create new products that are superior to competitors and able to meet customer preferences (Sudaryati & Amelia, 2015). Innovation efficiency directs firm managers to efficiently spend cash when conducting R&D so the innovation output is in line with market needs and is ahead of competitors (K. Wang et al., 2019). When environmental uncertainty is increasingly dynamic, the firm's innovation efficiency is increasingly being improved to minimize the risks posed that cause an impact on maintaining firm performance. Moreover, environmental uncertainty causes technology to change rapidly causing technology to become full of uncertainty. Innovation efficiency directs firm managers to choose the use of new technologies that provide great benefits for increasing production cycles, developing new products and creating new processes. This results in environmental uncertainty encouraging firms to efficiently allocate technology investment expenditures so that the dynamic environmental uncertainty encourages managers to be more efficient in spending cash and has an impact on improving firm performance. Therefore, this study hypothesizes that:

- H2: Environmental uncertainty strengthens the impact of innovation efficiency on firm performance

3. Methodology

3.1. Sample and Data Collection

The population of this study is the manufacturing firms listed on the Indonesia Stock Exchange for seven years from 2013-2019. We analyze R&D expenses, machine purchases and repairs, and information technology purchases to identify each firm's innovation efficiency. All research data was collected manually from the firm's financial statements and annual reports. The final sample consists of registered manufacturing firms with 564 observations, omitting certain observations due to incomplete data (particularly regarding innovation efficiency). The sample includes manufacturing firms from various industrial sectors such as the cement industry, electronics, pharmaceuticals, metals, food and beverages, cigarettes, textiles, household appliances, plastics, wood and paper industries, cables, and cosmetic industries.

The sample selection of manufacturing firms in Indonesia is because manufacturing has a large market share with a competitive environment. This shows that manufacturing firms in Indonesia are required to carry out innovation projects to survive in a competitive environment. Furthermore, the selection of research samples from 2013-2019 is because the year 2013 is the initial year of global competition planning for firms in Indonesia, especially to face the Asean Economic Community (AEC) which will take place in 2020. This shows that the research period used to show how prepared the manufacturing industry in Indonesia to face the global competition, especially the AEC, by being actively involved in innovation projects and emphasizing efficiency in these projects.

3.2. Research Design and Measurements

Multiple linear regression estimation and moderated regression were used to test the hypothesis. This model was adopted and modified from the previous model used by Claudio et al. (2013); Gao & Chou (2015); Kafetzopoulos et al. (2019); Turulja & Bajgoric (2019). The empirical model is described below:

$$ROA = \beta_0 + \beta_1 EFF + \beta_2 DAR + \beta_3 SIZE + \beta_4 AGE + \beta_5 RISK + \bar{\epsilon} \dots\dots\dots (1)$$

$$ROA = \beta_0 + \beta_1 EFF + \beta_2 EU + \beta_3 DAR + \beta_4 SIZE + \beta_5 AGE + \beta_6 RISK + \bar{\epsilon} \dots\dots\dots (2)$$

$$ROA = \beta_0 + \beta_1 EFF + \beta_2 EU + \beta_3 EFF*EU + \beta_4 SIZE + \beta_3 DAR + \beta_4 AGE + \beta_5 RISK + \bar{\epsilon} \dots\dots\dots (3)$$

Where ROA is the firm's performance, measured as the proportion of net income to total assets. Measurement of firm performance that is directly related to innovation is difficult to determine (Calvo-Mora et al., 2015). This condition is caused by the complexity that occurs in the implementation of innovation resulting in many components of the firm's performance involved. This study used financial performance as a measurement of the economic results received by the organization in doing innovation. EFF is the variable to measure innovation efficiency. Innovation efficiency provides a basic explanation of how the use of resources as innovation inputs provides optimal results (Hollanders & Esser, 2007).

Innovation efficiency is obtained by operationalizing innovation inputs and outputs on non-parametric mathematical methods called Data Envelopment Analysis (DEA). In estimating the innovation efficiency, 3 inputs are used: research and development costs, machine purchases and repairs, and information technology purchases (Broekel, 2012; Claudio et al., 2013; OECD. et al., 2005; Revilla et al., 2003) and an output which is sales (Guan et al., 2006). The EU is a variable to measure environmental uncertainty. This study reviews the environmental uncertainties that arise from a market perspective. Market uncertainty indicates changes in the composition of market niches and their preferences (M. Wang & Fang, 2012). Environmental uncertainty is estimated using the coefficient of variation in sales for five years (Huang et al., 2017).

In addition, we use control variables to provide more comprehensive research results. Four control variables are used, namely firm size (SIZE), capital structure (DAR), firm age (AGE), and firm risk (RISK). Firm size is measured by the natural logarithm of total assets (Claudio et al., 2013). Capital structure is measured using the proportion of total debt to total assets (AlQadasi & Abidin, 2018). Firm age is measured by the length of time the firm operates in a competitive environment from the beginning of its establishment to the year of research observation (Claudio et al., 2013). Firm risk is measured by the proportion of the total receivables and inventories divided by total assets (AlQadasi & Abidin, 2018).

4. Results

4.1. Descriptive Analysis

Table 1 shows the results of the innovation efficiency analysis of manufacturing firms listed on the Indonesia Stock Exchange from 2013-2019. The firm is declared efficient in doing innovation if it has a score of 1 for the results in DEA analysis. Table 1 shows that the innovation efficiency is still low in manufacturing firms listed on the Indonesia Stock Exchange. This indicates that the manufacturing firms sampled have not been able to optimize their resources for innovation activities. Moreover, manufacturing firms in Indonesia do not yet have the orientation to carry out intensive R&D as a firm strategy in facing an increasingly competitive environment. Firms still feel 'comfortable' with their products and processes so they do not have the desire to develop.

| Year | Number of Firms | Number of Efficient Firms | Percentage (%) |
|------|-----------------|---------------------------|----------------|
| 2013 | 78 | 2 | 2,56 |
| 2014 | 85 | 2 | 2,35 |
| 2015 | 79 | 2 | 2,53 |
| 2016 | 69 | 2 | 2,90 |
| 2017 | 77 | 3 | 3,90 |
| 2018 | 92 | 3 | 3,26 |
| 2019 | 84 | 3 | 3,57 |

Table 1: Innovation efficiency of manufacturing companies' period 2013 – 2019

Table 2 shows the descriptive analysis for 564 observational data of manufacturing firms. The results show that the average firm performance (ROA) is 0.0388, indicating the ability of manufacturing firms listed on the Indonesia Stock Exchange to improve their performance is still low. The minimum value is -0.1761, indicating that some firms still experience substantial losses during the observation period. The results show that the maximum value of the firm performance is 0.4468, indicating that there are firms that can obtain very high net income during the observation period.

Furthermore, this table also shows a descriptive analysis for innovation efficiency and environmental uncertainty. The results show that the average innovation efficiency (EFF) is 0.0204, indicating that the ability of manufacturing firms listed on the Indonesia Stock Exchange is still very low. Firms are not able to manage resources efficiently when carrying out innovation projects. The minimum value is 0.0000, indicating that there are firms that are still not able to efficiently carry out innovation projects. The results show that the maximum value of innovation efficiency is 1.00, indicating that there are firms that can carry innovation projects efficiently.

In addition, the results of the study show that the average environmental uncertainty (EU) is 0.1879, indicating that the sampled firms can reduce environmental uncertainty so their sales volatility is not high. The minimum value of environmental uncertainty is 0.0179, indicating that there are firms that can control environmental uncertainty so their sales volatility is very low. The results show that the maximum value of environmental uncertainty is 1.3968, indicating that there are firms that are very vulnerable when environmental uncertainty increases, where firm sales are very volatile when environmental uncertainty is dynamic. Other results related to the control variable are shown in Table 2.

| | Min | Max | Mean | Std. Dev. |
|------|---------|---------|---------|-----------|
| ROA | -.1761 | .4468 | .0389 | .0673 |
| EFF | .0000 | 1.0000 | .0204 | .0968 |
| EU | .0179 | 1.3968 | .1879 | .1530 |
| DAR | .0005 | 1.7874 | .4723 | .2288 |
| SIZE | 18.8937 | 33.4945 | 28.6551 | 1.6661 |
| AGE | 7 | 102 | 39.12 | 14.753 |
| RISK | .0049 | 3.8043 | .3991 | 0.3042 |

Table 2: Descriptive Analysis

Table 3 shows a weak positive correlation between innovation efficiency (EFF) and firm size (SIZE) with the value of 0.085 ($p < 0.05$), firm age (AGE) is 0.208 ($p < 0.01$), and firm risk (RISK) is 0.034 ($p > 0.10$). Meanwhile, innovation efficiency has a negative correlation with environmental uncertainty (EU) with the value of -0.033 ($p > 0.10$), and capital structure (DAR) is -0.043 ($p > 0.10$). In addition, the results of the analysis also show that there is no multicollinearity problem between independent variables because the Pearson correlation value does not exceed 0.80. According to Gujarati et al., (2004), multicollinearity is most likely to occur if the correlation coefficient is above 0.80. The results show that there is no multicollinearity because the correlations between the independent variables are all below the value of 0.8. Thus, the results of the Pearson correlation confirm that there is no multicollinearity problem.

| | EFF | EU | DAR | SIZE | AGE | RISK |
|------|---------|----------|-------|---------|------|------|
| EFF | 1 | | | | | |
| EU | -.033 | 1 | | | | |
| DAR | -.043 | .102** | 1 | | | |
| SIZE | .085* | -.144*** | .057 | 1 | | |
| AGE | .208*** | -.167*** | -.065 | .145*** | 1 | |
| RISK | .034 | -.060 | .055 | -.058 | .040 | 1 |

Table 3: Pearson Correlation Analysis

Note: ***Significance Level $P < 0.01$, **Significance Level $P < 0.05$, *Significance Level $P < 0.10$

4.2. Regression Analysis

Table 4 shows the results of multiple linear regression for the relationship between innovation efficiency and firm performance. In addition, Table 4 also shows the results of the moderated regression for the relationship between the interaction of innovation efficiency and environmental uncertainty with firm performance. The table shows that Adjusted R^2 has a value ranging between 0.244-0.253 and the value of F-statistics ranges between 26.83-35.94 (significant at the level of p -value < 0.01). These values indicate that the model is quite suitable to explain about 24.4%-25.3% changes in the tested relationship.

| Variable | Model 1 | Model 2 | Model 3 | | | |
|----------------|---------|---------|---------|---------|---------|---------|
| | β | Sig. | β | Sig. | β | Sig. |
| Constant | -.114 | .008*** | -.111 | .013** | -.104 | .019** |
| EFF | .191 | .000*** | .191 | .000*** | .093 | .045** |
| EU | - | - | -.006 | .705 | -.017 | .328 |
| EFF*EU | - | - | - | - | .693 | .011** |
| DAR | -.096 | .000*** | -.095 | .000*** | -.097 | .000*** |
| SIZE | .006 | .000*** | .006 | .000*** | .006 | .000*** |
| AGE | .000 | .007*** | .000 | .009*** | .000 | .032** |
| RISK | .007 | .390 | .007 | .406 | .006 | .449 |
| Adjusted R^2 | 24.4% | 23.6% | 24.3% | | | |
| F-Statistic | 35.942 | 29.929 | 26.833 | | | |
| N | 564 | 564 | 564 | | | |

Table 4: Regression Results

Note: ***Significance Level $P < 0.01$, **Significance Level $P < 0.05$, *Significance Level $P < 0.10$

Table 4, Model 1 shows that there is a significant positive relationship between innovation efficiency (EFF) and firm performance. The coefficient value is 0.191 (t-stat. = 2.279) and significant at the level of p -value < 0.01 to support hypothesis H1. The findings show that innovation efficiency improves firm performance among manufacturing firms listed on the Indonesia Stock Exchange. This finding is in line with the theory that innovation efficiency results in the efficient cash spending of the firm when carrying out innovation projects. Innovation efficiency directs firm managers to use innovation inputs optimally so they can provide greater output. This results in the firm performance being stable in the short-term and experiencing significant growth in the long term. This shows that an innovation efficiency is a form of strategy that firms can develop to improve their performance (short-term or long-term) and maintain their sustainability. These findings are in line with (Gao & Chou (2015) also Claudio et al. (2013) which stated that an innovation efficiency is a form of strategy to improve firm performance by remaining actively involved in the competitive environment, and there are several spaces that firm can develop to improve its innovation efficiency.

Separated analysis results for the interaction of innovation efficiency and environmental uncertainty (EFF*EU) with firm performance are shown in Table 4, Model 3. Model 3 shows the interaction coefficient of innovation efficiency and environmental uncertainty is positive and related to firm performance where the coefficient is 0.693 (t-stat = 2.546), significant at the level of p -value < 0.05 . These findings are in line with contingency theory to support hypothesis H2. This shows that an increasingly dynamic environment encourages firms to be more efficient in allocating the cash spend to finance innovation projects. Environmental uncertainty and innovation have their respective risks so firms must do innovation efficiency to maintain their position in the competitive environment. Environmental uncertainty provides a gap

for firms to innovate actively to obtain new market niches so the innovation efficiency carried out by the firms when environmental uncertainty increases provide an opportunity for firms to improve their performance.

5. Discussion and Conclusion

The dynamic business environment encourages firms to adapt to the environment and increase innovation to survive in a highly competitive environment (Chen et al., 2010; Kafetzopoulos et al., 2019; Tsai & Yang, 2013; Turulja & Bajgoric, 2019). Considering the risk factors of environmental uncertainty and innovation, carrying out an innovation efficiency project is required. Innovation efficiency has an important role in a highly complex business environment where innovation efficiency can reduce unnecessary burdens to defend itself in a competitive environment. In line with the contingency theory, innovation efficiency must be increased to respond to the ongoing environmental changes so the firm can maintain its position in the competitive environment. Therefore, efforts to further improve innovation efficiency when environmental increases provide opportunities for firms to expand market niches and improve their performance (Claudio et al., 2013).

Thus, this study aims to investigate the relationship between innovation efficiency and firm performance. Innovation efficiency is the optimal combination of innovation inputs and outputs. This study describes the optimization of innovation inputs (R&D, machine purchases and repairs, and IT purchases) capable of producing greater output (sales). We illustrate that in the modern era, firms must actively innovate considering the risks posed, efficiency is needed in its implementation. These results support hypothesis H1 and are consistent with the research of Gao & Chou (2015) also Claudio et al. (2013) that innovation efficiency is a form of strategy that firms can implement to improve their performance. We conclude that innovation efficiency provides an opportunity to be more active in innovation projects to improve their market position, thus helping firms to improve their performance.

This study also aims to investigate the moderating role of environmental uncertainty in the relationship between innovation efficiency and firm performance. Uncertainty in a business environment, especially market uncertainty, affects the innovation activities of the firms. Firms will find it highly difficult to innovate when changes occur rapidly. Therefore, firms must be selective in innovating to meet these customer preferences. We illustrate that innovation efficiency will be further enhanced by firm management when environmental uncertainty occurs. This efficiency is carried out to minimize the risks of innovation projects and the existing environmental uncertainty. In addition, we illustrate that firms continue to carry out their innovation projects when environmental uncertainty increases while considering efficiency in their implementation. These results support hypothesis H2 and are consistent with the research of Kafetzopoulos et al. (2019) also Turulja & Bajgoric (2019) stated that when changes in customer preferences regarding products or services occur rapidly, the firm tries to create innovative ideas to produce new products that are in line with customer preferences so the firm's performance can increase. We conclude that environmental uncertainty creates new opportunities for firms that dare to innovate, thereby opening up opportunities to gain new market niches. Environmental uncertainty encourages firm management to be efficient when carrying out innovation projects without interfering with the firm's cash. This shows that environmental uncertainty encourages firms to be more efficient in carrying out innovation projects to increase firm performance.

These findings contribute to theory and knowledge by providing empirical evidence that firms that can perform efficiencies in carrying out innovation projects will obtain improved performance. In addition, when environmental uncertainty increases, firms are increasingly active in carrying out efficient innovation projects to acquire new market niches, thereby providing benefits for their performance improvement. Therefore, the firm strives to continue to carry out innovation projects in a competitive environment because it provides benefits for improving performance while considering efficiency in its implementation.

This study has several limitations. First, we limit innovation outputs to R&D expenses, machine purchases and repairs, and information technology purchases. In addition, the innovation output used is limited to sales. These limit our conclusion because there is a possibility that the innovation project has been carried out by the firm without charging the innovation project on the innovation output accounts. Second, we limit environmental uncertainty to only market uncertainty. This limits our conclusion because there is a possibility that technological changes and increased competitive pressures can create environmental uncertainty. Therefore, further investigations are needed in future studies to consider the use of more comprehensive inputs and outputs to measure innovation efficiency, as well as using technological uncertainty and increased competition pressure to measure environmental uncertainty.

6. References

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