



The Effect of Green Innovation on Firm Value at Different Life Cycle: The Role of Sustainable Growth and Debt Financing Cost

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Abstract

Purpose: This study investigates the impact of green innovation on firm value at different stages of the life cycle of energy sector companies in Indonesia. It also examines the moderating effects of sustainable growth and debt financing costs.

Methodology: The study utilizes panel data from 61 companies during the period from 2017 to 2022 to analyze the impact of green innovation on firm value and the moderating roles of sustainable growth and debt financing costs.

Finding: The findings show that green innovation significantly increases firm value. However, the study finds that there is no significant moderating role of sustainable growth and debt financing costs on the impact of green innovation on firm value. Additionally, the influence of green innovation on firm value varies across life cycle stages. It positively affects firm value during the growth and decline stages, while the impact is not significant at the mature stage.

Implication: These findings enhance our understanding of the importance of green innovation for improving the value of firms in the energy sector throughout their life cycles.

Originality: This study provides a novel contribution by exploring the impact of green innovation on firm value in Indonesia's energy sector and assessing the moderating roles of sustainable growth and debt financing costs.

Keywords: Company's Life Cycle, Energy Firm, Firm Value, Green Innovation

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1. Introduction

The Earth Summit in Rio de Janeiro in 1992 and the Rio+20 Summit in 2012 were important international meetings addressing environmental issues and sustainable development. The Rio Earth Summit aimed to raise global awareness about environmental problems and seek solutions to the challenges faced by countries worldwide. The 1992 Earth Summit resulted in Agenda 21, which guided countries in managing the environment and promoting sustainable development. The 2012 Earth Summit, on the other hand, introduced the concept of the Green Economy as a solution for sustainable development. Both conferences demonstrated international commitment to addressing environmental and sustainable development issues, and the concepts generated from these conferences have provided a foundation for governments, businesses, and society to manage the environment and natural resources sustainably. A green economy has become one of Indonesia's strategies to promote economic growth, enhance social welfare, and preserve environmental quality (Kemenko Perekonomian Republik Indonesia, 2022).

Companies primarily aim to maximize shareholder value (Ross et al., 2019). If the company's value is high, the market or investors will have faith in the current performance of the company and also in its promising prospects (Agustia et al., 2019). This perspective has evolved with the stakeholder theory, which states that a company's goals should focus on creating value for shareholders and all stakeholders (Freeman, 1984). To create value for all stakeholders, companies need to enhance their performance in various aspects, including financial performance, social performance, and environmental performance. Companies that can improve their performance in all these aspects are expected to be more stable and sustainable in the future (Slaper & Hall, 2011).

Integrating environmental and sustainable practices into a company's competitive strategy has become an important and pressing issue due to increasing environmental pressures, society, and politics (Zhang et al., 2019). Companies are incorporating green innovation into their business strategies to address these mounting pressures to mitigate environmental risks. Green innovation significantly contributes to sustainable company growth by enhancing its competitive advantage, performance, and reputation (Agustia et al., 2019), thereby increasing its value. This aligns with Porter's concept that by implementing environmental initiatives, companies can reduce production costs, improve economic efficiency, and achieve a competitive advantage (Porter, 1991). However, green innovation requires substantial investment, especially in technology and infrastructure. Therefore, the question arises: Can green innovation promote growth while maintaining its environmental benefits?

Green innovation creates mutually beneficial relationships between companies and the environment. It is a core element that drives company development and growth. The higher the implementation of green innovation, the greater the firms' sustainable growth can be achieved (Qiao et al., 2021). By continuously and efficiently focusing on market-oriented innovation, companies can improve their productivity and drive sustainable growth (Vanderpal, 2015), as well as increasing profitability and enhancing competitiveness (Qiao et al., 2021). Thus, companies that grow sustainably can invest in green innovation, ultimately positively impacting their value.

Porter hypothesized that appropriate policy pressures can drive companies to adopt green innovation, leading to cost savings, improved productivity, and better competitive advantages (Porter & Van Der Linde, 1995). Furthermore, when companies generate sufficient profits, they can meet operational needs with internal funds, reduce dependence on external debt, and lower financing costs. Thus, green innovation can serve as a positive signal to creditors, enabling companies to obtain lower external financing costs and ultimately increase their value (Shi et al., 2022). Conversely, when companies heavily pollute the environment without mitigating environmental risks, it can be perceived that they are unwilling to make environmental changes. As a result, these companies face higher risks of legal proceedings and government fines, which reduce their value and may result in higher restrictions on debt financing by creditors (Shi et al., 2022). Therefore, companies with lower debt financing costs are more likely to engage in green innovation, which can ultimately enhance their value.

Energy companies that rely on long-term investments tend to face greater regulatory and environmental risks in the future as the consequences of climate change increase over time. In particular, the energy sector is highly impacted by climate change and fossil fuel regulations, posing a threat to the industry (Apergis et al., 2022). With their large-scale projects and significant fossil fuel reserves, energy companies risk losing market value due to renewable technology innovations and increasing climate policies by governments (van der Ploeg & Rezai, 2019). So, the energy sector in Indonesia faces significant challenges regarding the negative environmental impacts and climate change resulting from conventional practices. To address these issues, energy companies in Indonesia must transition towards green innovation and renewable energy. However, there is still a literature gap regarding the impact of green innovation on the value of energy companies in Indonesia. Therefore, examining the influence of green innovation on the value of energy companies in Indonesia will provide a better understanding of its benefits, including cost savings, improved company image, and competitiveness in a competitive global market. By

analyzing innovative practices and new technologies in the sustainable energy industry, this research will provide insights into how energy companies in Indonesia can leverage the potential of green innovation to enhance their value.

Moreover, findings of this research will serve as a basis for strategic decision-making and policies that can accelerate the transition toward a more sustainable energy system in Indonesia. Existing regulations in Indonesia, such as Law No. 30 of 2007 on Energy and Government Regulation No. 79 of 2014 on the National Energy Policy, have provided a legal framework and general principles for developing renewable energy in Indonesia. Additionally, policies and initiatives such as the Indonesia Energy Transition Outlook (IEO), Just Energy Transition Partnership (JETP), and Indonesia Green Investment Fund (IGIF) support the transition to renewable energy.

This contributes to the literature in twofold. First, it gives understanding the influence of green innovation on the value of energy companies at different stages of their lifecycle in Indonesia. By recognizing the benefits of green innovation, such as cost savings, improved company image, and competitiveness in the global market, energy companies in Indonesia can develop effective green innovation strategies. Second, findings of this research will also serve as a foundation for strategic decision-making and policies that can accelerate the transition to renewable energy. By reducing the negative impact of the energy sector on the environment, improving operational efficiency, and strengthening companies' positions in an increasingly environmentally conscious global market, this research will play a role in achieving sustainability goals in Indonesia's energy sector.

2. Literature Review

2.1. Green Innovation

In the past, investing in environmental activities was considered unnecessary. However, strict environmental regulations and popular environmental experts have changed companies' rules and competition patterns (Sezen & Çankaya, 2013). In the current green economy and digitalization era, inefficient products and business processes that cause environmental damage will be replaced by products and processes that utilize environmentally friendly technologies (Caracuel & Ortiz-de-Mandojana, 2013). Urgent environmental issues are expanding opportunities for companies to engage in green innovation to create or enhance business value while improving operational efficiency and corporate reputation (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013).

Kemp & Arundel (1998) define green innovation as the development, adoption, or exploitation of new products, production processes, services, or business methods by an organization to reduce environmental risks such as pollution, waste, and other negative impacts from the use of natural resources such as raw materials and energy, compared to existing alternatives. Green innovation provides various benefits to both companies and the environment. Regarding business, green innovation can enhance competitiveness and the competitive advantage of organizations, improve efficiency and productivity, and create added value for stakeholders (Porter & Van Der Linde, 1995). Additionally, green innovation can help organizations meet increasingly stringent environmental regulations and standards and reduce reputation and legal risks (Porter & Van Der Linde, 1995).

Previous research on the effect of green innovation on firm value has tended to be inconsistent. Some studies have shown that green innovation has a positive influence on firm value because it can enhance operational efficiency, reduce costs, and meet established environmental standards (Agustia et al., 2019; Ar, 2012; Dai & Xue, 2022; Zhang et al., 2019). Furthermore, the concept of environmental concern can provide better value for companies. The influence of green innovation on firm value becomes more significant with an extended investment time horizon, meaning that green innovation can be considered a long-term rather than a short-term strategy (Rezende et al., 2019). However, some other studies have shown that green innovation does not significantly influence firm value (Caracuel & Ortiz-de-Mandojana, 2013; Sezen & Çankaya, 2013). This could be due to

limited available data, analytical methods, or industry contexts. Green innovation can positively influence firm value if done correctly and in the proper context (Ar, 2012).

2.2. Stakeholder Theory

The stakeholder theory concept explains that a company's responsibility extends to shareholders and other parties with a stake in the company. Stakeholder theory is crucial in companies' current and future strategic decision-making. Companies that prioritize stakeholder interests tend to succeed in attaining strategic and financial goals (Parmar et al., 2010). The contribution of stakeholder theory to sustainability lies in the addition of a business argument that the best economic interest of corporations occurs when relationships with external parties strengthen (Freeman, 1984).

2.3. Signaling Theory

Signaling theory states that companies can use specific signals to communicate important information to stakeholders (Spence, 1973). Disclosing information about implemented green innovation initiatives, environmental achievements, certifications obtained, or collaborations with strategic partners can serve as effective signals (Aguilera et al., 2007). Using these signals, companies strive to build a positive reputation among stakeholders and gain their support and trust. Investors can also view green innovation as an indicator that a company has a long-term commitment to sustainability and the potential to generate long-term value (Margolis & Walsh, 2003). Using green innovation signals can also influence the market's perception of a company and enhance the company's reputation in terms of social and environmental responsibility.

2.4. Cash Flow Theory

The cash flow theory states that the value of a stock is the present value of future net cash flows. Positive net cash flows represent cash payments by the company to shareholders, while negative net cash flows represent cash payments by shareholders to the company (Sharafeddine, 2015). In each period, net cash flows from operations are available for debt and equity payments, capital expenditures, and dividend payments. Debt or equity financing can augment operational cash flows in each period. Debt financing creates obligations to pay cash in future periods, thus reducing the available cash flow for capital expenditures and dividend distributions in those periods. In contrast, equity financing reduces the proportional share of total cash flow available for dividends and reinvestment (Walter, 1963). In cash flow theory, a concept related to company cash flow management is known as Free Cash Flow (FCF). This concept implies that companies with high levels of free cash flow also have a greater risk of wasteful practices. This occurs because managers in companies with high free cash flow have more flexibility in managing company resources without strict constraints and may use the funds for personal interests or unprofitable projects, which can harm shareholders (Jensen, 1986).

2.5. Life Cycle Theory

The life cycle theory of the firm proposes that a company undergoes a series of predictable development stages in which the company's resources, capabilities, strategies, structure, and functions will change significantly (Miller & Friesen, 1984). Companies tend to follow predictable life cycle patterns, and each stage has different characteristics and requires different strategies to face emerging challenges (Rothaermel, 2021). Dickinson (2011) suggests periodic measurement of life cycle stages based on the company's cash flow model. The cash flow model has two main advantages compared to traditional life cycle models. First, it reflects all financial information of the company rather than a single attribute measurement related to the company (such as company age, sales growth, scale, strategy, and flexibility). Second, it is periodic and shows the actual state of the business cycle. Therefore, the cash flow model proxy is a better way to measure the various stages of the company life cycle.

Table 1. Categories of the Company Life Cycle

Life cycle	Net Cash Flow from Operating Activities	Net Cash Flow from Investment Activities	Net Cash Flow from Financing Activities
Introduction	-	-	+
Growth	+	-	+
Mature	+	-	-
Decline	-	+	+ / -
Decline	-	-	-
Decline	+	+	+
Decline	+	+	-

Source: Data Processed (2024)

2.6. Hypothesis development

Effect of green innovation on firm value

Green innovation shares the same concept as conventional innovation, aiming to enhance productivity and cost efficiency and open new market opportunities. Green innovation adds value by improving a company's economic performance, reducing negative environmental impacts, and creating competitive advantages (Agustia et al., 2019). Companies can improve their performance through green innovation by recycling reusable items, recycling waste before disposal, reducing hazardous materials to ensure product quality and create a positive impression on society, and utilizing efficient raw materials and energy (Ramus, 2002). Companies that practice green innovation tend to gain long-term benefits by reducing regulatory risks and operational costs, ultimately enhancing firm value (Xie et al., 2022). The stakeholder theory states that companies should consider the interests of all stakeholders, including financial, social, and environmental interests, in value creation. To achieve this, companies must improve their performance and ensure long-term sustainability. High productivity and regular innovation can help companies achieve and maintain firm value while considering environmental performance as a crucial aspect of corporate decision-making. Thus, the hypothesis is as follows.

H1: Green innovation has a positive influence on firm value.

Sustainable growth moderates the influence of green innovation on firm value

Sustainable growth is a process that restores the necessary balance for the organization's and society's long-term well-being. Sustainability is based on the triple-bottom-line performance (economic, social, and environmental). Therefore, to maintain sustainability, companies must operate in a way that ensures long-term economic performance while avoiding socially or environmentally detrimental short-term behavior (Büyükbacı, 2012). Green innovation can enhance a company's competitive advantage and improve its production efficiency (Porter, 1985), enhancing its capacity for sustainable growth (Büyükbacı, 2012). High sustainable growth indicates sustainable and stable long-term company growth. This means the company can consistently increase its revenue, profit, and firm value yearly (Büyükbacı, 2012). In the long run, high sustainable growth reflects the company's ability to create value for stakeholders, including shareholders, employees, customers, and society. Green innovation is crucial for a company's sustainable growth (Suki et al., 2023). Research by Qiao et al. (2021) states that the higher the level of green innovation conducted by a company, the better the sustainable growth that can be achieved. Therefore, companies that experience sustainable growth will be able to allocate resources for investment in green innovation, which, in turn, has a positive impact on firm value. Therefore, we hypothesized that:

H2: Sustainable growth has a moderating effect on the influence of green innovation on firm value.

Debt financing cost moderates the influence of green innovation on firm value

When a company engages in green innovation, it sends a positive signal to stakeholders that it is willing to make environmental changes, enhancing its social image and increasing investor confidence (Ramus, 2002). As a result, stakeholders are willing to provide financial support to the company at lower costs (Cheng et al., 2013). Creditors will feel more

confident lending to the company because they understand that it pays attention to environmental issues and has policies and strategies to reduce its negative environmental impact (Li & Chen, 2023). Porter's hypothesis states that appropriate policy pressure can drive companies to engage in green innovation, leading to cost savings, increased productivity, and better competitive advantages (Porter & Van Der Linde, 1995)). Furthermore, when a company generates sufficient profits, it can finance green innovation internally, thereby reducing reliance on external debt and lowering its financing costs, ultimately increasing firm value (Shi et al., 2022). Research by Shi et al. (2022) indicates that a company's disclosure of green innovation significantly reduces its debt financing cost. Additionally, research by (Dai & Xue, 2022) also shows that debt financing cost moderates the influence of green innovation on firm value. The hypothesis is as follows.

H3: Debt financing cost has a moderating effect on the influence of green innovation on firm value.

The influence of green innovation on firm value may vary at different stages of the company's life cycle

Companies generally follow predictable patterns of life cycle development over time, which can be categorized as introduction, growth, maturity, and decline stages (Rothaermel, 2021). Companies may face different challenges and make different choices in different life cycle stages, subsequently impacting the firm (Dai & Xue, 2022). This includes the decision to engage in green innovation, which the company's specific conditions can influence in each life cycle stage. In order to attain competitive advantage, companies often engage in various activities such as innovation, marketing, and mass production (Porter, 1985). The stage of the company's life cycle affects its decisions regarding investment in innovation. In the introduction and growth stages, companies invest more in riskier innovations to gain strategic advantages. During the growth stage, there may be differing opinions on investment in innovation, but companies often make initial investments to gain a competitive edge. As companies mature, they may reduce their investment in innovative activities, although there is an argument that mature companies still invest in innovation. In the decline stage, companies may increase their investment in innovation to improve and regain market share (Shahzad et al., 2022). Therefore, the hypothesis is as follows.

H4: There is different influence of green innovation on firm value at each stage of the company's life cycle.

3. Methodology

This research utilized secondary data from energy sector companies listed at the Indonesia Stock Exchange (IDX) from 2017 to 2022. The study included data from 61 energy sector companies that met the sample criteria, resulting in 262 observations.

Table 2. Descriptive Statistics

Variable	Minimum	Maximum	Mean	Std. Deviation
FV	0,5495	2,1930	1,1095	0,4996
GI	0,0000	0,6667	0,2150	0,2493
SG	-0,1355	0,3581	0,0733	0,1389
DFC	0,0153	0,1243	0,0643	0,0348
SIZE	26,9584	31,3769	29,0138	1,4083
ROA	-0,0804	0,1606	0,0347	0,0720
DER	0,0615	2,1740	0,7922	0,6996
Growth	-0,2947	0,5319	0,0639	0,2527
Interest Rate	0,0350	0,0600	0,0452	0,0086

Source: Data Processed (2024)

Table 2 presents the statistic descriptive of the variables used in this study. It shows that firm value, measured by Tobin's Q, has an average of 1.1095 with a value range between 0.5495 and 2.193. The average value of Tobin's Q variable is 1.1095, indicating that the market values of the majority of energy sector companies exceed their book asset values.

Companies with high Q ratios generally have good growth potential and profitability because they have attractive investment opportunities or strong competitive advantages (Ross et al., 2019). The average value of the green innovation variable is 0.2105, with a range between 0 and 0.6667, indicating that some energy sector companies in Indonesia have adopted green practices. However, there is still room for improvement to achieve higher levels of innovation in the overall energy sector. The standard deviation of green innovation is 0.2493, reflecting variation in the level of adoption among companies. Among the 61 sampled energy companies, 22 consistently implemented green innovation from 2017 to 2022, 13 were inconsistent but had prior implementation, and 26 did not adopt green innovation.

The sustainable growth variable averages 0.0733, ranging from -0.1355 to 0.3581. Negative values indicate unsustainable growth or long-term declines for some observed companies. The standard deviation of sustainable growth is 0.1389, reflecting the diversity in company performance. Similarly, the debt financing cost variable averages 0.0643, ranging from 0.0153 to 0.1243, with a standard deviation of 0.0348. The average financing cost for the observed companies is 6.5%. However, some have lower costs (1.53%), like Akbar Indomakmur Stimec Tbk in 2019, while others have higher costs (12.43%), like PT Borneo Olah Sarana Sukses Tbk. in 2018. These differences can be attributed to factors such as company risk profiles, levels of debt, or different financing policies in each company (Shi et al., 2022).

This study will use the panel data regression model to test the hypotheses. The specific models that can be employed for this purpose include:

1. Regression model to test H₁

$$FV_{it} = \beta_0 + \beta_1 GI_{it} + Control_{it} + \varepsilon_{it} \dots\dots\dots (1)$$
2. Regression model to test H₂

$$FV_{it} = \beta_0 + \beta_1 GI_{it} + \beta_2 SG_{it} + \beta_3 GI_{it} \times SG_{it} + Control_{it} + \varepsilon_{it} \dots\dots\dots (2)$$
3. Regression model to test H₃

$$FV_{it} = \beta_0 + \beta_1 GI_{it} + \beta_2 DFC_{it} + \beta_3 GI_{it} \times DFC_{it} + Control_{it} + \varepsilon_{it} \dots\dots\dots (3)$$
4. Regression model to test H₄

$$FV_{it} = \beta_0 + \beta_1 GI_{it} + Control_{it} + \varepsilon_{it} \dots\dots\dots (4)$$

This model is applied to observe data according to the life cycle of companies, and the results are compared.

The variables and their definition is presented in table 3.

Table 3. Definitions of Variables

No	Variable	Definition
1	FV	Firm value is measured using Tobin's Q ratio, namely the total market value of equity and liabilities divided by the book value of total assets.
2	GI	Green innovation is measured by analyzing company annual reports with three indicators: green production processes, green products, and recyclable components. Then the content analysis results will be quantified in terms of ratio.
3	SG	Sustainable growth = (ROE x Retained Ratio)/(1 - ROE x Retained Ratio)
4	DFC	Debt financing cost = interest expenses / (long term debt + short term debt)
5	SIZE	The firm's size: the natural logarithm of the firm's total assets
6	ROA	Return on assets: the firm's net profit, divided by its total assets
7	DER	Debt to equity ratio: debt divided equity
8	Growth	The growth ability of the firm: the growth of total revenue in the current period, divided by the total revenue of the previous period
9	Interest Rate	The BI-7 Day Reverse Repo Rate is the interest rate used, which implements the reference interest rate issued by Bank Indonesia.
10	Pandemic Covid-19	The dummy method will be used as a code during the Covid-19 pandemic and before the Covid-19 pandemic. The number 1 indicates the period of the covid-19 pandemic, namely for the 2020 and 2021 periods. The number 0 indicates the period before the covid-19 pandemic, namely the 2017-2019 period.
11	Life Cycle	The specific definition of the enterprise life cycle, as shown in Table 1

Source: Researcher Development (2024)

4. Results and Discussion

Table 4 displays the regression results for empirical models 1, 2, and 3. In model 1, column 1, the analysis reveals that green innovation significantly and positively impacts firm value at a 1% significance level. The coefficient indicates that for each unit increase in green innovation (assuming other variables remain constant), the firm value will increase by 0.3379, confirming Hypothesis 1. However, columns 2 and 3 indicate that neither sustainable growth nor debt financing cost moderates the effect of green innovation on firm value. Thus, Hypotheses 2 and 3 are rejected.

Table 4. Regression Results of Research Models 1, 2, and 3

FV	Model 1	Model 2	Model 3
GI	0,3379*** (0,005)	0,3254** (0,011)	0,3597* (0,058)
SG		0,1953 (0,289)	
GIxSG		0,1925 (0,691)	
DFC			-0,4725 (0,505)
GIxDFC			-0,3196 (0,889)
SIZE	-0,0358** (0,045)	-0,0421* (0,076)	-0,0365** (0,038)
ROA	0,9387** (0,012)	0,8719** (0,020)	0,9032** (0,016)
DER	0,0645 (0,117)	0,0778* (0,063)	0,0581 (0,165)
Growth	0,01211 (0,855)	0,0080 (0,906)	0,0160 (0,809)
InterestRate	-1,4030 (0,597)	-1,0502 (0,692)	-1,2129 (0,649)
Pandemi	-0,0420 (0,391)	-0,0534 (0,281)	-0,0399 (0,419)
_cons	0,9718* (0,073)	1,1208** (0,011)	1,01988* (0,054)
Prob. (F-Stat)	0,0157	0,0175	0,0358
R square	0,1461	0,1691	0,1549

Source: Data Processed (2024)

Effect of green innovation on firm value

Based on the statistical results, green innovation has a significant positive influence on the firm value of the energy sector companies in Indonesia. This means that the more companies adopt green innovation, the higher their firm value will be. This means that green innovation practices, whether in the form of environmentally responsible production processes such as the use of clean technology and energy efficiency, products that support the transition to clean and sustainable energy, or effective recycling practices in waste or byproduct processing, will increase the value of energy companies in Indonesia.

Several examples of green innovation implementation in the energy sector companies in Indonesia are PT Adaro Energy Tbk., which adopts environmentally friendly technologies such as circulating fluidized bed (CFB) and ultra-supercritical (USC) boilers that offer higher efficiency and reduce environmental impacts from emissions. This power plant project became the first and largest in Southeast Asia to implement such technologies (Adaro, 2017). PT Bayan Resources Tbk. produces various types of environmentally friendly coal, such as eco-coal (sub-bituminous) and bituminous coal, both of which have low sulfur and ash content (Bayan, 2021). PT AKR Corporindo Tbk. also implements green innovation by developing new water treatment and wastewater treatment facilities to recycle a significant

portion of waste and natural water to produce fresh water for industrial water needs (AKR, 2019).

Several studies, such as Dai & Xue (2022), Agustia, Sawarjuwono, & Dianawati (2019), Chen & Ma (2021), Ar (2012), and Zhang, Rong, & Ji (2019), have also found that green innovation has a significant impact on firm value. Green innovation can enhance a company's reputation, competitiveness, and environmental performance, increasing firm value (Ar, 2012). These research findings are also consistent with Porter's hypothesis (1985), which states that green innovation can enhance a company's competitive advantage and production efficiency, thereby increasing firm value. In addition, stakeholder theory indicates that when a company adds value to all stakeholders, not just shareholders, it increases trust and firm value.

Green innovation practices, such as using renewable energy or energy efficiency, can reduce a company's operational costs. This can increase the company's net cash flow and generate added value for shareholders. Moreover, implementing green innovation can help companies effectively manage cash flow. Green innovation can reduce the risk of waste and inefficient use of funds. By allocating resources appropriately, companies can generate higher free cash flow. This can increase firm value and provide long-term benefits to shareholders. Companies use green innovation to signal stakeholders about their sustainability and social responsibility commitment. By conveying credible information through financial reports and concrete actions, companies can build trust and confidence in the company's long-term value. This can enhance market perceptions and evaluations of the company, ultimately increasing firm value.

The role of sustainable growth in moderating the effect of green innovation on firm value

Based on the result, sustainable growth does not significantly moderate the impact of green innovation on firm value, with a positive coefficient. The positive coefficient indicates that higher levels of sustainable growth strengthen the positive influence of green innovation on firm value. In other words, increasing sustainable growth will enhance the positive impact of green innovation on firm value. Companies that engage in green innovation tend to prioritize sustainable growth and strive to provide benefits to the company, the environment, and the surrounding community, despite the challenges involved in implementing green innovation, such as operational changes, including the selection of more sustainable raw materials, energy-efficient production processes, or the adoption of new technologies (Qiao et al., 2021).

Sustainable growth can affect firm value by enhancing the company's reputation and gaining trust from stakeholders, making the company more attractive to investors and assisting the company in the long term (Büyükbacı, 2012). These research findings align with stakeholder theory, emphasizing the importance of sustainable business practices that provide long-term benefits to all involved parties. Companies incorporating sustainable growth into their business strategies can deliver sustainable value to shareholders, employees, customers, and the environment. Thus, the green innovation implemented by companies can yield long-term benefits for all parties involved, ultimately enhancing firm value. These findings are also consistent with cash flow theory, where stable, sustainable growth ensures smooth cash flow, mitigate risks associated with green innovation, allocates cash flow wisely, and avoids waste and inefficient use.

The role of debt financing costs in moderating the effect of green innovation on firm value

Companies that engage in such innovation typically require high costs as they need to invest in more environmentally friendly technologies. In this regard, companies can choose to finance green innovation through either debt financing or equity financing. However, equity financing costs are usually higher than debt financing costs because shareholders bear higher risks and expect higher returns to compensate for those risks. In contrast, debt financing can provide tax benefits as interest payments can be deducted as company expenses (Ross et al., 2019).

Based on the result, debt financing cost does not significantly moderate the influence of green innovation on firm value. However, the negative coefficient of 0.3196 suggests that lower debt financing costs will enhance the impact of green innovation on firm value. Green innovation by companies provides positive information about environmental performance to the public, effectively reducing information asymmetry between creditors and the company, helping creditors understand the company's environment, reducing environmental debt-related risks, and thus lowering debt financing costs (Li & Chen, 2023). Among external funding sources, debt financing is the most significant, but due to the long innovation cycle, creditors are usually reluctant to provide debt financing for cost-saving innovations (Yao et al., 2022). High debt financing costs can reduce the available cash flow for investing in green innovation. This can affect the company's ability to widely implement green innovation practices and achieve the expected long-term benefits. Thus, companies must consider debt financing carefully when planning and implementing green innovation.

Additionally, based on the observational data used in this research, the average Debt to Equity ratio (DER) is 0.7891. DER is an indicator that measures the proportion of a company's financing using debt compared to equity. The average DER value indicates that the companies in the observational data tend to have relatively lower levels of debt financing than equity financing. Although the cost of debt financing does not significantly moderate the impact of green innovation on firm value, the appropriate utilization of debt financing can play a vital role in the company's prospects (Li & Chen, 2023).

Table 5 exhibits results from model estimation. The theory of the company life cycle states that different stages of business development occur due to changes in strategy, structure, decision-making methods, and the organizational situation of the company over time (Miller & Friesen, 1984). Based on table 5 shows that the impact of green innovation on firm value differs at each stage. The research results in Table 5 indicate that in the observational data, green innovation has a significant positive influence on firm value in the growth and decline stages, with coefficients of 0.8771 and 0.6948, respectively. In the mature stage, green innovation does not show a significant effect but a negative coefficient of 0.2367. These findings are consistent with previous research conducted by Dai & Xue (2022), which states that companies in the growth and decline stages may experience a more significant impact of green innovation on firm value than companies in the mature stage.

Table 5. Regression Results in the Growth, Mature, and Decline Stages

FV	Model 1	Model 2	Model 3
GI	0,8771*** (0,000)	-0,2367 (0,303)	0,6948*** (0,000)
SIZE	-0,1018** (0,034)	-0,0656 (0,650)	-0,1095** (0,030)
ROA	2,3738*** (0,000)	0,0656 (0,920)	0,2021 (0,740)
DER	0,1546** (0,020)	0,0985 (0,295)	0,0482 (0,452)
Growth	-0,1680 (0,169)	0,0824 (0,464)	-0,0575 (0,550)
InterestRate	-0,6799 (0,833)	-2,5441 (0,542)	-2,0048 (0,662)
Pandemi	-0,0194 (0,793)	-0,0314 (0,706)	-0,0452 (0,572)
_cons	2,5462* (0,064)	2,0783 (0,621)	3,1041** (0,033)
Prob. (F-Stat)	0,0000	0,8433	0,0066
R square	0,0975	0,0535	0,0925
N	56	152	54

Source: Data Processed (2024)

In the growth stage, companies face challenges in green innovation, such as long implementation times, complex implementation, and high costs (Shahzad et al., 2022).

However, companies in the growth stage are motivated to gain a competitive advantage and quickly dominate the market by developing new technologies and products (Miller & Friesen, 1984). Regarding cash flow and external financing needs, companies in the growth stage typically make large-scale investments and have relatively tight cash flows, thus requiring substantial external funding to obtain the necessary cash flow for rapid growth (Dickinson, 2011). Green innovation can enhance a company's ability to obtain external funding (Dai & Xue, 2022). Green innovation can meet the needs of companies in the growth stage to rapidly develop technology and expand the market while reducing the funding constraints faced by the company. Implementing green innovation in the production process, using technology to reduce energy and water consumption, and minimizing pollution and waste by using more efficient materials, can positively increase firm value.

In the mature stage, in terms of growth capability, these companies have already established a confident market presence for a while and have a relatively stable customer base (Rothaermel, 2021). Companies in the mature stage also demonstrate higher profitability than others in the company life cycle. However, they also experience a decline in growth compared to companies in the growth stage (Rothaermel, 2021). In terms of cash flow and external financing needs, compared to companies in the growth stage, companies in the mature stage have more stable cash flows, resulting in relatively fewer funding constraints and lower external financing demands (Dickinson, 2011). Companies in the mature stage have already developed on a relatively large scale. They are experiencing relatively stable growth, so the benefits of expanding the market and reducing funding constraints brought by green innovation do not significantly affect companies in the mature stage (Dai & Xue, 2022). If implementing green innovation results in high costs without significant benefits, it can affect the company's financial performance and reduce firm value (Sezen & Çankaya, 2013). Therefore, the potential for companies in the mature stage to increase firm value through green innovation is relatively tiny.

Companies in the decline stage typically focus on cost efficiency as their growth capability gradually diminishes, and they start losing their competitive advantage, resulting in declining profit margins (Rothaermel, 2021). In terms of cash flow and external financing needs, companies in the decline stage face significant funding constraints and tremendous pressure on loans and debt repayment, resulting in relatively tight cash flows and increased external financing needs (Dickinson, 2011). Through green innovation, companies can enhance production efficiency and reduce operational costs (Chen et al., 2006), which aligns with the needs of companies in the mature stage. Companies can also use green innovation to help address and derive benefits from declining situations, such as finding new opportunities through green innovation to create products that cater to a changing market, improve operational efficiency, and as an effort to improve the declining or negative image of the company (Dai & Xue, 2022). Implementing green innovation in the company's production process and producing environmentally friendly products using more efficient and sustainable materials can potentially increase firm value in the decline stage. On the other hand, implementing waste recycling green innovation may potentially decrease firm value in the decline stage.

Green innovation can benefit companies at specific stages in the company life cycle. Although the benefits of green innovation in increasing firm value take time to be realized by companies, companies still need to develop green innovation to maintain business growth and sustain firm value in the future (Büyükbacı, 2012).

5. Conclusion

This research concludes that green innovation has a positive and significant influence on firm value in the energy sector in Indonesia. Companies that adopt green innovation practices, such as environmentally friendly production processes, eco-friendly products, and effective recycling practices, can enhance firm value. Sustainable growth was found to have no significant moderating effect on the relationship between green innovation and firm value, except in the case of waste recycling. However, sustainable growth can still

provide long-term benefits to all stakeholders by enhancing the company's reputation and strengthening the positive influence of green innovation on firm value. Although debt financing cost was not found to moderate the influence of green innovation on firm value, lower debt financing costs can enhance the value of companies implementing green innovation. Green innovation provides the public with positive information about the company's environmental performance, reduces information asymmetry between creditors and the company, and helps mitigate environmental debt-related risks, thereby reducing debt financing costs.

Furthermore, the influence of green innovation on firm value differs depending on the stage of the company's life cycle. In the growth stage, green innovation has a significant favorable influence on firm value because companies at this stage are motivated to gain a competitive advantage, develop new technologies and products, and overcome the limitations of external funding required for rapid growth. However, the benefits of green innovation tend to be limited in the mature stage as companies already have a stable market share and slower growth rates, resulting in green innovation having no significant influence on firm value. In the decline stage, green innovation can significantly influence firm value through cost efficiency improvements and efforts to improve the company's negative image. However, the influence of green innovation in waste recycling in the decline stage may have a non-significant negative influence on firm value. The adverse effects of green innovation on firm value can occur when the implementation of green innovation results in high costs without significant benefits, which can affect the company's financial performance. Therefore, companies need to continually develop and adopt relevant green innovation practices to sustain growth and enhance firm value in the future.

Further research could extend the time horizon, include a sample beyond the energy sector in Indonesia, incorporate variables related to government regulations to understand changes in the influence of green innovation on firm value across the company's life cycle, consider the role of indenture in the analysis, and utilize firm value measurements from a company's fundamental perspective. This would provide a more comprehensive and accurate insight into the influence of green innovation on firm value at each stage of the company's life cycle.

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