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The Influence of Environmental Cost and Carbon Productivity on Profitability: The Mediating Role of Green Innovation

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ABSTRACT

This study aims to examine the influence of environmental cost and carbon productivity on company profitability, with green innovation as a mediating variable. The sample comprises 54 firm-year observations from 18 basic industry sector companies listed on the Indonesia Stock Exchange (IDX) for the 2022–2024 period. Data were analyzed using Partial Least Squares-Structural Equation Modeling (PLS-SEM). The results show that green innovation does not mediate the effect of environmental cost or carbon productivity on profitability. However, environmental cost has a significant direct effect on profitability (negative direction), while carbon productivity has no significant effect. In addition, green innovation itself exerts a significant positive influence on profitability. These findings suggest that environmental investment directly impacts firm profits and green innovation can enhance profitability, whereas improving carbon productivity alone has not yet produced a tangible financial impact. Practically, this study provides insights for basic industry sector in formulating sustainability strategies that balance environmental cost, carbon productivity, and green innovation to optimize profitability.

INTRODUCTION

Global climate change caused by increased carbon dioxide (CO_2) emissions has become a serious threat to economic, social, and environmental sustainability. This condition is caused by the continued dominance of fossil-based energy in the global energy system, resulting in negative externalities in the form of global warming (Senna & de Araujo Moxotó, 2025). Zhong et al. (2025) revealed that Indonesia is the largest contributor to carbon emissions in Southeast Asia, which is projected to grow 375% by 2060. This condition confirms that without strong intervention, the rate of emissions growth in Indonesia will be difficult to control.

As a concrete step in addressing this situation, the government issued Law No. 7 of 2021 concerning Harmonized of Tax Regulations (UU HPP), which introduces carbon tax as an economic instrument to control carbon emissions. Empirically, carbon tax policies have proven effective in reducing carbon emissions and improving energy efficiency in various countries (Chai et al., 2025; Kundu et al., 2025; X. Wang & Qiu, 2025). This effectiveness is a strong foundation when applied to high-emission sectors, such as the manufacturing industry (Ahmed et al., 2025; Wen et al., 2025). Climateworks Centre (2025) shows that the manufacturing sector contributes around 28% of total national emissions, with the basic industry sub-sector being one of them. The high contribution of these emissions indicates that production activities in this sector are still highly dependent on fossil fuels.

This reliance has led to an increase in production intensity, which generates large amounts of emissions and waste, resulting in companies having to bear increasingly high environmental cost (X. Wang & Qiu, 2025). Environmental cost includes the economic consequences arising from greenhouse gas emissions and pollution waste that require recovery, control, and compliance with environmental regulations (Arnold-Keifer et al., 2025). Aliamutu et al. (2023) found that increased environmental spending has a positive effect on company financial performance with the right management support. However, these findings differ from the study by Azizah & Cahyaningtyas, (2023), which shows that environmental cost actually reduce profitability.These findings highlight the need for other environmental metrics that emphasize efficiency rather than just cost burdens, one of which is carbon productivity. According to research by Geldres-Weiss et al. (2025), carbon productivity is defined as the ratio of a company's revenue to its CO_2 emissions. The higher the carbon productivity, the greater the economic value generated per unit of emissions. Companies with high carbon productivity tend to be more efficient in their use of energy and reduce energy costs per unit of output, thereby reducing operating costs without sacrificing output (Oltulular, 2025). A leaner cost structure not only increases profitability but also promotes carbon efficiency as the key to green innovation.

Siregar et al. (2024) define green innovation as efforts to produce goods, services, and technologies with very low environmental impact or even those that improve the environment. A study in China found that green innovation significantly reduces corporate carbon emissions (Xie & Wang, 2024). Green innovation is not only beneficial to the environment but can also increase long-term profitability. Although green innovation sometimes requires initial investment, Batool et al. (2025) shows that companies with strong liquidity are able to absorb these costs and obtain long-term benefits. Therefore, adopting green innovation can improve operational efficiency and regulatory compliance, thereby improving financial performance.

Previous literatures have focused on separate analyses of environmental cost and carbon productivity on profitability mediated by green innovation. Meanwhile, studies examining all four aspects simultaneously are still limited. For example, Ju & Jin (2024) found that green innovation improves carbon performance, but did not directly test profitability. Meanwhile, studies in Indonesia, such as Febriani & Darmawati (2025), found that carbon productivity and environmental cost have a positive effect on financial performance. However, these studies did not consider green innovation as a mediating mechanism.

From a stakeholder theory perspective, companies are expected to not only pursue financial profits, but also respond to stakeholder pressures and expectations. Porles-Ochoa & Guevara (2024) assert that clean energy innovation can mediate the relationship between carbon efficiency and financial performance, indicating that companies' responses to environmental issues can simultaneously improve their economic performance. Therefore, this study seeks to fill this gap by simultaneously testing the influence of environmental cost and carbon productivity on profitability through the mediation of green innovation in the context of basic sector industry companies in Indonesia. In addition, this study is expected to make a real contribution to the practice of corporate sustainability strategies in Indonesia, particularly in promoting carbon efficiency and increasing sustainable profitability.

LITERATURE REVIEW

Stakeholder Theory

Freeman & Verlag (2004) believe that the sustainability and long-term success of a company greatly depends on its ability to respond to the expectations of various parties such as the government, consumers, investors, and non-governmental organizations. In the context of environmental sustainability, pressure from these stakeholders is the main driver for companies to implement environmentally friendly business practices. This pressure will encourage companies to fulfill their social and environmental responsibilities to stakeholders who demand more ethical business practices.

Singh et al. (2021) found that stakeholder pressure encourages increased environmentally-based innovation. In Indonesia, Widyantoro et al. (2025) proved that stakeholder pressure encourages green innovation and has an indirect impact on company financial performance. These findings confirm that the impact of stakeholder pressure on performance is highly dependent on the industry context, investor perceptions, and how companies execute their social responsibilities and environmental innovations. Additionally, Cerciello et al. (2023) revealed that green practices and environmental performance have not significantly contributed to profitability, indicating that the impact of stakeholder responses is not always direct and can be mediated by other factors, such as cost structure or managerial strategies.

Profitability

Profitability indicates a company's ability to generate profits from the management of its resources. In addition, profitability is also an important indicator for assessing the financial health of a company. High profitability is also viewed positively because it can increase competitive advantage in the market (Saidi et al., 2025). In accounting and finance research, a company's financial profitability is most often proxied by Return on Assets (ROA) (Fatimah et al., 2021; Hertina Dede et al., 2023). This ratio measures how efficiently a company's assets are used to generate profits (Safina & Gunawan, 2025).

The use of ROA as a measure of profitability is very common in studies examining the relationship between sustainability practices and financial performance. Yuniarti et al. (2022), for example, used ROA to measure financial performance when testing the mediating role of financial performance. Astuti & Ahmar (2025) also used ROA as a profitability indicator and found that ROA strengthens the relationship between green factors and company value. Research by Yan et al. (2022) found that carbon performance and technological innovation have a positive effect on financial performance, as measured using ROA.

The research by Akuma et al. (2025) found that environmental commitment and stakeholder engagement are significantly positively correlated with company profitability. However, several studies note the potential trade-off that short-term and large investments in environmentally friendly activities can reduce initial profits (Batool et al., 2025). However, in the long term, companies that consistently implement sustainable practices tend to achieve better financial performance as stakeholder support increases. Based on this, this study views profitability as an important outcome that is influenced by a company's environmental strategy.

Green Innovation Mediates the Relationship Between Environmental Cost and Profitability

Richards (1997) explains the concept of environmental cost, which include costs of prevention, detection, remediation, and treatment of waste resulting from corporate activities. Environmental costs tend to show a pattern of cost behavior over time. They’re usually grouped into control costs (prevention and monitoring/detection) and failure costs (internal and external failures). In the early stages, companies may spend more on prevention and monitoring because

they need to improve systems and make investments. Over time, these investments help reduce waste and environmental incidents, leading to lower failure costs and, ultimately, lower total environmental costs. A study by Solovida et al. (2025) shows that identifying, tracking, and allocating environmental cost can improve a company's eco-efficiency. Research by Al-Mawali (2021) on environmental cost accounting found that good environmental cost accounting has an impact on environmental performance and financial performance.

Historically, environmental expenditures have often been viewed as an additional burden that reduces profits (Kotango et al., 2024; Nurhalija et al., 2025). However, stakeholder theory provides a different perspective. Under stakeholder theory, a commitment to environmental cost actually strengthens stakeholder support, thereby increasing profitability. If environmental cost is focused on preventive measures and efficiency, companies can gain stakeholder trust. A study by Ma & Peng (2025) found that environmental cost plays a role in increasing environmentally friendly innovation. From a stakeholder perspective, green innovation is a positive signal that a company is serious about managing its environmental impact. J. Wang & Yao (2025) even proved that environmental protection spending sends a positive signal to external parties, thereby improving company performance.

Environmental cost investments encourage environmentally friendly innovations, and these innovations then result in cost efficiencies that can contribute to company profits. In other words, companies that spend on environmental cost strategically can reap financial benefits if green innovations are successfully implemented.

H_1: Green innovation mediates the effect of environmental cost on profitability.

Green Innovation Mediates the Relationship Between Carbon Productivity and Profitability

Mckinsey (2008) defines carbon productivity as the amount of economic output generated per ton of CO_2e emissions. Mckinsey (2008) also asserts that in order to achieve global emission reduction targets while maintaining economic growth, the world must drastically increase carbon productivity.

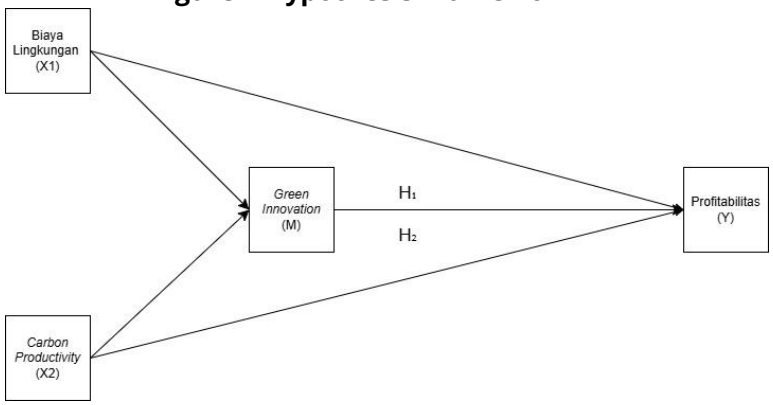
At the sector and country levels, carbon productivity is measured by economic output per unit of carbon emissions. A study by Liu & Oka (2024) breaks down carbon productivity into a “true carbon productivity” component and other zero-sum components. At the company level, this concept is adapted as the ratio between a company's revenue and its total greenhouse gas emissions (Bagchi et al., 2022). Research by Ghose et al. (2023) shows that carbon productivity has a positive effect on corporate financial performance. A study by J. Wang et al. (2021) also shows that increased carbon efficiency is positively related to financial performance.

According to stakeholder theory, companies that proactively reduce their carbon footprint will be viewed positively by stakeholders. Research by Chai et al. (2023) supports this view by stating that environmental performance can be a tool to enhance a company's reputation and competitive advantage, thereby increasing stakeholder support for the company's business activities. With high carbon productivity, companies demonstrate that they are responding positively to stakeholder demands.

Ju & Jin (2024) explain that companies can save energy and reduce emissions through green innovation, thereby increasing carbon efficiency and improving corporate carbon performance. In other words, efforts to increase carbon productivity almost always involve the application of innovative, environmentally friendly technologies or processes. It is this innovation that then enables companies to reduce emissions without sacrificing output, often while improving operational efficiency. Several cross-country studies support this mediating role. Li et al. (2024) found that green financing increases carbon productivity through the mediation of green innovation, both in terms of the quantity and quality of innovation.

H_2: Green Innovation mediates the effect of carbon productivity on profitability.

Figure 1 Hypothesis Framework



Source: Data Processed, 2025

METHODS

The data collection took place through a documentation of annual reports and/or sustainability reports of companies in the basic industry sector during 2022-2024. This study used purposive sampling, a type of non-probability sampling in which participants are deliberately selected based on criteria that have been set in advance (Juliani & Fachruzzaman, 2024). The sample frame was developed from 101 listed companies that published reports during that period, then selected purposively based on the following criteria:

Table 1. Population and Sample

Description	Total
Basic industry companies listed on the IDX that publish annual and/or sustainability reports during the 2022-2024 period	101
Basic industry companies that do not have data for environmental cost and/or total GHG emissions	(56)
Basic industry companies that record environmental cost in currencies other than Rupiah	(9)
Basic industry companies that were delisted or suspended during the 2022-2024 period	(9)
Basic industry companies that suffered operational losses during the 2022-2024 period	(9)
TOTAL RESEARCH SAMPLE	18
OBSERVATION PERIOD	3
TOTAL OBSERVATION DATA	54

Source: Data Processed, 2025

Table 2. Operational Variable

Variable	Measurement	Source
Environmental Cost (EC)	$EC = \frac{\sum \text{Environmental Cost}}{\text{Net Income}}$	(Heryanti & Harahap, 2025)
Carbon Productivity (CP)	$CP = \frac{\text{Revenue}}{\text{GHG EMISSION}}$	(Jung et al., 2021)

Green Innovation (GI)	$GI = \frac{(\sum GPRODI + \sum GPROSI)}{4}$	(Agustia et al., 2019)
Profitability (ROA)	$ROA = \frac{Net\ Profit}{Total\ Asset}$	(Yu et al., 2025)

Source: Data Processed, 2025

Data Model Analysis

The data used are secondary data from basic industry companies obtained from annual reports and sustainability reports for the 2022-2024 period. The analysis was done using Partial Least Squares-Structural Equation Modeling (PLS-SEM) with SmartPLS, as suggested by (Hair et al., 2019) when the model is predictive, the sample size is relatively small, and mediation variables are involved. The analysis began with descriptive statistics to describe the distribution of each research variable. Next, an outermodel test was conducted using outer loading values, Average Variance Extracted (AVE), as well as composite reliability and Cronbach's alpha. After the measurement model met the validity and reliability criteria, a structural model (inner model) test was conducted. Hypothesis testing was performed using the bootstrapping procedure in SmartPLS. Hypotheses were accepted if the t-statistic value was > 1.96 and the p-value was < 0.05 at a 5% significance level. Based on this procedure, the research results could be measured and tested systematically.

RESULTS

Descriptive Statistical Analysis

Table 3. Statistic Descriptive

Variable	Mean	Median	Min	Max	Std. Deviation
Environmental Cost (EC)	0.052	0.025	0,001	0.544	0.084
Carbon Productivity (CP)	63,024,605.637	16,645,546.830	208,683.021	656,657,847.800	144,159,285.654
Green Innovation (GI)	0.769	0.750	0.250	1.000	0.203
ROA	5.265	4.130	0.100	15.130	4.047

Source: Data Processed, 2025

Table 3 shows that the average Environmental Cost is 0.052 with a minimum value of 0.001 and a maximum value of 0.544, meaning that expenditures related to environmental activities in the sample companies are still relatively low and varied. Carbon Productivity has an average of 63,024,605.637 with a standard deviation of 144,159,285.654, which is quite large, indicating a wide difference in the ability of companies to generate economic output in relation to carbon emissions. Green Innovation has an average of 0.769 with a range of 0.250-1.000, indicating that most companies have implemented green innovation at a medium to high level. Meanwhile, ROA has an average of 5.265%, reflecting a moderate level of profitability with considerable variation between companies.

Outer Loading

Table 4. Outer Loading Test

Variable	Environmental Cost	Carbon Productivity	Green Innovation	Profitabily
Environmental Cost (EC)	1.000			
Carbon Productivity (CP)		1.000		
Green Innovation (GI)			1.000	
ROA				1.000

Source: Data Processed, 2025

Table 4 shows that all indicators in the Environmental cost, Carbon Productivity, Green Innovation, and Profitability variables have a loading value of 1.000, well above the minimum limit of 0.70. This indicates that each indicator is able to meet the convergent validity criteria for all variables in the model.

Construct Relibiality and Validity

Table 5. Reliability and Validity Test

Variable	Cronbach's Alpha	Composite Reliability	AVE
Environmental Cost (EC)	1.000	1.000	1.000
Carbon Productivity (CP)	1.000	1.000	1.000
Green Innovation (GI)	1.000	1.000	1.000
ROA	1.000	1.000	1.000

Source: Data Processed, 2025

The reliability test results in Table 5 show that the four variables have Cronbach's alpha, composite reliability, and AVE values of 1.000, respectively. These values exceed the general requirements (≥0.70 for reliability and ≥0.50 for AVE), indicating that the instrument used is highly reliable and consistent in measuring Environmental Cost, Carbon Productivity, Green Innovation, and Profitability**.**

Discriminant Validity

Table 6. Discriminant Validity Test

Variable	Environmental Cost	Carbon Productivity	Green Innovation	Profitabily
Environmental Cost (EC)	1.000			
Carbon Productivity (CP)	-0.209	1.000		
Green Innovation (GI)	0.075	0.119	1.000	
ROA	-0.365	0.242	0.195	1.000

Source: Data Processed, 2025

Based on the information in Table 6, discriminant validity is fulfilled because the square root of AVE for each construct is greater than its correlation with other constructs. For example,

the correlation between Green Innovation and Profitability is 0.195, and the correlation between Environmental cost and Carbon Productivity is -0.209, which is lower than the square root of AVE for each construct. These findings confirm that each construct has sufficient uniqueness and there is no overlap between variables, thus fulfilling discriminant validity.

Inner Model

Table 7. Direct Effect Test

	Path Coefficient	T-Statistic	P-Values	Results
Direct Effect				
EC > GI	0.104	0.662	0.508	Insignificant
EC > ROA	-0.350	4.448	0.000	Significant
CP > GI	0.141	1.143	0.254	Insignificant
CP > ROA	0.145	0.731	0.465	Insignificant
GI > ROA	0.204	2.084	0.038	Significant

Source: Data Processed, 2025

Based on Table 7, the results of the direct effect test show that Environmental cost do not have a significant effect on Green Innovation (t = 0.662; p = 0.508), but have a significant effect on profitability (t = 4.448; p = 0.000). Furthermore, Carbon Productivity is not proven to have a significant effect on either Green Innovation (t = 1.143; p = 0.254) or profitability (t = 0.731; p = 0.465). On the other hand, Green Innovation had a significant effect on profitability (t = 2.084; p = 0.038), so that only Environmental Cost and Green Innovation had a significant effect on the direct effect test.

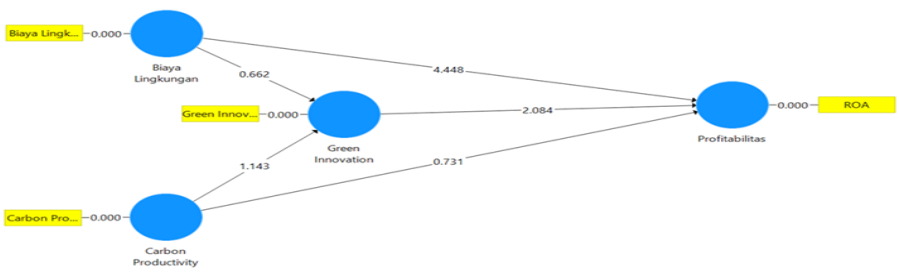
Table 8. Indirect Effect Test

	Path Coefficient	T-Statistic	P-Values	Results
Indirect Effect				
BL > GI > ROA	0.021	0.672	0.502	Rejected
CP > GI > ROA	0.029	0.998	0.319	Rejected

Source: Data Processed, 2025

Based on Table 8, the results of the indirect effect test confirm that Environmental cost on Profitability through Green Innovation are not significantly proven, with a t-statistic of 0.672 < 1.96 and a p-value > 0.05. This indicates that H_1 is rejected, and it can be concluded that Green Innovation cannot mediate the relationship between Environmental cost and Profitability. Furthermore, the indirect effect of Carbon Productivity on Profitability through Green Innovation is not significant with a t-statistic of 0.998 < 1.96 and a p-value > 0.05, so H_2 is rejected.
The inner model is presented in the following figure.

Figure 2 Inner Model



Source: Data Processed, 2025

DISCUSSION

Green Innovation Mediates Environmental cost on Profitability

The results show that Green Innovation (GI) does not mediate the effect of Environmental Cost on Profitability. The indirect effect through Green Innovation proved to be insignificant, while the direct effect of Environmental cost on Profitability remained significant. Based on the mediation classification according to Nitzl et al. (2018), this finding falls under the Only Direct Effect category. This means that the Green Innovation variable does not act as a mediator in the relationship between Environmental Cost and Profitability. In other words, an increase in Environmental Cost has a direct effect on Profitability, but not through Green Innovation. From a theoretical perspective, these results indicate that environmental investment has a direct impact on profitability without the need for Green Innovation. These findings are also consistent with research by Ibrahim et al. (2024) that found a significant relationship between environmental spending and corporate financial performance. The absence of the mediating role of Green Innovation suggests the possibility that corporate environmental investment has not been sufficiently directed to encourage innovation that impacts profits. Thus, in the relationship between Environmental cost and Profitability in this study, Green Innovation has not been proven to be a mechanism that channels influence, so that the dominant influence comes from the direct effect of Environmental cost on Profitability.

Green Innovation Mediates Carbon Productivity on Profitability

Contrary to previous findings, the effect of Carbon Productivity (CP) on Profitability was not found to be significant, either as a direct effect or through the mediation of Green Innovation. PLS-SEM analysis showed that the indirect effect of CP > GI > ROA was not significant, and the direct effect of CP > ROA was also not significant. In other words, an increase in a company's carbon productivity was not found to have an effect on profitability. This finding falls into the No Mediation – No Effect category (Nitzl et al., 2018). This situation of no mediation and no effect means that there is no significant relationship between carbon productivity and profitability, either directly or through green innovation as a mediator. These results are in line with the study by Tehananda et al. (2025), which found that carbon productivity does not have a significant effect on financial performance. One possible explanation is that the increase in carbon productivity has not been appreciated by the market or has not reached a scale that affects profit. Without external pressure or incentives such as carbon tax regulations, which convert low-carbon advantages into profits, the relationship between carbon productivity and profitability tends to be weak.

The inability of Green Innovation to mediate the relationship between Carbon Productivity and profitability indicates that Green Innovation cannot change the lack of influence of Carbon Productivity on Profitability. The condition where both the direct effect and indirect effect paths are insignificant suggests that the theoretical model variables may need to be reviewed or that the selected mediation variables are inappropriate. Another alternative for the positive impact of increased carbon productivity is environmental performance. Increased carbon productivity will first have an impact on environmental performance, not directly on profitability. Therefore, this No Mediation – No Effect finding signals for future researchers to re-explore the mechanism of how emission reduction efforts can create value for profitability.

CONCLUSION

Based on the results of the study, environmental cost was found to have a significant negative effect on company profitability, but this effect was not mediated by green innovation. Conversely, carbon productivity was not found to have a significant effect on profitability, either directly or indirectly through green innovation. On the other hand, green innovation had a

significant positive effect on profitability, but the green innovation variable could not act as a mediator in the relationship between the two independent variables and company profitability. These findings indicate that sustainability strategies based on environmental cost and green innovation can directly drive profitability, even though carbon productivity is not yet a determining factor in the current context.

LIMITATION

This research has limitations in terms of small sample size, narrow sector focus, and limited observation period, so the findings cannot be generalized widely. In addition, the results showing the insignificance of the mediation path indicate that the selection of mediating variables used may not be entirely appropriate in explaining the relationship between variables. Therefore, further research is recommended to expand the cross-sector and time period samples, while testing other mediating variables such as environmental performance for environmental cost and carbon productivity.

REFERENCES

Adamu Ibrahim, A., & Aminu Ibrahim, M. (2024). GREEN INNOVATION AND FINANCIAL PERFORMANCE OF CONSUMER GOODS FIRM IN NIGERIA: MODERATING EFFECT OF ENVIRONMENTAL COSTS. In International Journal of Entrepreneurship, Technology and Innovation (IJETI) (Vol. 1, Issue 2).

Agustia, D., Sawarjuwono, T., & Dianawati, W. (2019). The mediating effect of environmental management accounting on green innovation - Firm value relationship. International Journal of Energy Economics and Policy, 9(2), 299–306. https://doi.org/10.32479/ijeep.7438

Ahmed, I., Socci, C., Severini, F., Deriu, S., & Almonti, L. (2025). Reconciling economic targets and emission abatement in China: Insights from an environmental social accounting matrix. Energy Policy, 208. https://doi.org/10.1016/j.enpol.2025.114938

Akuma, J. K., Akude, D. N., Kwaning, E., & Amoah-Ahinful, I. K. (2025). Green Innovation and the Profitability of Manufacturing Firms: The Moderating Role of Intelligence Generation. International Review of Management and Marketing , 15(2), 146–156. https://doi.org/10.32479/irmm.17646

Aliamutu, K. F., Bhana, A., & Suknunan, S. (2023). The impact of environmental costs on financial performance: An explorative analysis of two plastic companies. Environmental Economics, 14(1), 13–23. https://doi.org/10.21511/ee.14(1).2023.02

Al-Mawali, H. (2021). Environmental cost accounting and financial performance: The mediating role of environmental performance. Accounting, 7(3), 535–544. https://doi.org/10.5267/j.ac.2021.1.005

Arnold-Keifer, S., Müller, J., & Mandel, T. (2025). Integrating environmental costs when calculating the energy efficiency potential. Cleaner Environmental Systems, 17. https://doi.org/10.1016/j.cesys.2025.100281

Astuti, T., & Ahmar, N. (2025). Effects of green intellectual capital, green accounting, and green innovation on firm value: The moderating role of return on assets. Environmental Economics, 16(1), 1–12. https://doi.org/10.21511/ee.16(1).2025.01

Azizah, N., & Cahyaningtyas, F. (2023). PENGARUH CSR, KINERJA LINGKUNGAN, DAN BIAYA LINGKUNGAN TERHADAP PROFITABILITAS (STUDI EMPIRIS PERUSAHAAN INDUSTRI DASAR DAN BAHAN KIMIA). Jurnal Ilmiah Bisnis Dan Ekonomi Asia. https://doi.org/10.32812/jibeka.v17i2.1557

Bagchi, P., Sahu, S. K., Kumar, A., & Tan, K. H. (2022). Analysis of carbon productivity for firms in the manufacturing sector of India. Technological Forecasting and Social Change, 178. https://doi.org/10.1016/j.techfore.2022.121606

Batool, F., Alhidary, I. A., Boda, J. R., Alwadi, B. M., Khudoykulov, K., & Haseeb, M. (2025). Balancing Sustainability and Profitability: The Financial Effect of Green Innovation in Chinese High-Pollution Industries. Sustainability (Switzerland), 17(8). https://doi.org/10.3390/su17083610

Cerciello, M., Busato, F., & Taddeo, S. (2023). The effect of sustainable business practices on profitability. Accounting for strategic disclosure. Corporate Social Responsibility and Environmental Management, 30(2), 802–819. https://doi.org/10.1002/csr.2389

Chai, S., Cao, M., Li, Q., Ji, Q., & Liu, Z. (2023). Exploring the nexus between ESG disclosure and corporate sustainable growth: Moderating role of media attention. Finance Research Letters, 58. https://doi.org/10.1016/j.frl.2023.104519

Chai, S., Yang, J., Bi, X., Tang, L., Zhang, M., & Zhu, J. (2025). Synergy or conflict? Assessing the combined emission reduction effects of environmental taxation and carbon trading in China's power sector. Utilities Policy, 98. https://doi.org/10.1016/j.jup.2025.102084

Climateworks Centre. (2025). Dekarbonisasi pada sektor manufaktur Indonesia Studi kasus subsektor makanan dan minuman, tekstil dan kimia F E B R U A R I 2 0 2 5.

Fatimah, A. N., Nurlaela, S., & Siddi, P. (2021). PENGARUH COMPANY SIZE, PROFITABILITAS, LEVERAGE, CAPITAL INTENSITY DAN LIKUIDITAS TERHADAP TAX AVOIDANCE PADA PERUSAHAAN MAKANAN DAN MINUMAN YANG TERDAFTAR DI BEI TAHUN 2015-2019. EKOMBIS REVIEW: Jurnal Ilmiah Ekonomi Dan Bisnis, 9(1), 107–118. https://doi.org/10.37676/ekombis.v9i1.1269

Febriani, D., & Darmawati, D. (2025). Pengaruh Carbon Productivity dan Biaya Lingkungan Terhadap Kinerja Keuangan Perusahaan dengan Financial Slacks Sebagai Pemoderasi. R2J, 7(3). https://doi.org/10.38035/rrj.v7i3

Freeman, R. E., & Verlag, R. H. (2004). The stakeholder approach revisited Zur Verfügung gestellt in Kooperation mit / provided in cooperation with. www.ssoar.info

Geldres-Weiss, V. V., Guerrero-Stuardo, P. E., Marinova, S., Ortiz-Cea, V., & Reveco, R. (2025). Firm-Level Carbon Productivity, Home Country Environmental Performance, and Firm Performance in the Exporting Meat Industry. Sustainability (Switzerland), 17(12). https://doi.org/10.3390/su17125381

Ghose, B., Makan, L. T., & Kabra, K. C. (2023). Impact of carbon productivity on firm performance: moderating role of industry type and firm size. Managerial Finance, 49(5), 866–883. https://doi.org/10.1108/MF-07-2022-0319

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. In European Business Review (Vol. 31, Issue 1, pp. 2–24). Emerald Group Publishing Ltd. https://doi.org/10.1108/EBR-11-2018-0203

Hertina Dede, Amiruddin, Heny Herawati, Alfiana, & Sri Hastutik. (2023). The Influence Of Capital Structure, Size, Profitability And Liquidity On The Value Of Manufacturing Companies On

The Indonesian Stock Exchange For The Period 2018-2022. Jurnal Ekombis Review, 11(2), 1767–1780. https://doi.org/10.37676/ekombis.v11i12

Heryanti, A., & Harahap, C. D. (2025). The Effect of Environmental Performance and Environmental Costs on Financial Performance with Good Corporate Governance as a Moderating Variable. IRJEMS International Research Journal of Economics and Management Studies Published by Eternal Scientific Publications, 118–124. https://doi.org/10.56472/25835238/IRJEMS-V4I7P115

Ju, W., & Jin, S. (2024). The impact of green innovation on the carbon performance of Chinese manufacturing enterprises: Moderating role of internal governance. Heliyon, 10(10). https://doi.org/10.1016/j.heliyon.2024.e31272

Juliani, T. V, & Fachruzzaman, F. (2024). The Impact of Disclosure of Leverage, Capital Intensity, Liquidity and Company Size on Tax Avoidance. EKOMBIS REVIEW: Jurnal Ilmiah Ekonomi Dan Bisnis, 12(1), 12. https://doi.org/10.37676/ekombis.v12i1

Jung, H., Song, S., Ahn, Y. H., Hwang, H., & Song, C. K. (2021). Effects of emission trading schemes on corporate carbon productivity and implications for firm-level responses. Scientific Reports, 11(1). https://doi.org/10.1038/s41598-021-91193-4

Kotango, J., Jeandry, G., & Ali, I. M. A. (2024). Dampak Penerapan Green Accounting, Kinerja Lingkungan dan Biaya Lingkungan terhadap Profitabilitas pada Perusahaan Pertambangan yang Terdaftar di Bursa Efek Indonesia Tahun 2018-2022. JURNAL EKSPLORASI AKUNTANSI, 6(1), 86–102. https://doi.org/10.24036/jea.v6i1.1443

Kundu, T., Patel, H., Kapoor, R., & Chang, C. Ter. (2025). Balancing carrots (incentives) and sticks (taxes): Policy design for low-carbon transition in the manufacturing sector with product substitution. Computers and Industrial Engineering, 211. https://doi.org/10.1016/j.cie.2025.111633

Li, J., Qu, S., Peng, Z., Ji, Y., & Boamah, V. (2024). The impact of green finance on carbon productivity: The mediating effects of the quantity and quality of green innovation. Journal of Environmental Management, 370. https://doi.org/10.1016/j.jenvman.2024.122952

Liu, J., & Oka, T. (2024). The decomposition of carbon productivity under the context of international trade. Ecological Economics, 225. https://doi.org/10.1016/j.ecolecon.2024.108337

Ma, C., & Peng, D. (2025). Government subsidies, environmental costs, and green innovation. International Review of Economics and Finance, 101. https://doi.org/10.1016/j.iref.2025.104237

Mckinsey. (2008). The carbon productivity challenge: Curbing climate change and sustaining economic growth. www.mckinsey.com/mgi.

Nitzl, C., Roldán, J. L., & Cepeda, G. (2018). Mediation Analyses in Partial Least Squares Structural Equation Modeling. Guidelines and Empirical Examples. https://www.researchgate.net/publication/315697051

Nurhalija, N., Mediaty, M., & Said, D. (2025). The Impact of Environmental Costs and Good Corporate Governance on Firm Value: A Systematic Review (pp. 1658–1664). https://doi.org/10.2991/978-94-6463-758-8_130

Oltulular, S. (2025). Energy Efficiency and Environmental Technologies in Carbon Emissions Reduction Strategies for a Sustainable Future: Estimation Through Simultaneous Equation Systems. Energies, 18(14). https://doi.org/10.3390/en18143596

Porles-Ochoa, F., & Guevara, R. (2024). Clean energy innovation, corporate carbon footprint and profits: Win-win strategic options. In Renewable and Sustainable Energy Reviews (Vol. 210). Elsevier Ltd. https://doi.org/10.1016/j.rser.2024.115255

Richards, D. J. . (1997). The Industrial green game : implications for environmental design and management. National Academy Press.

Safina, A., & Gunawan, J. (2025). Environmental Risk and Oil Prices Uncertainty: A Threat to Firm Profitability? International Journal of Multidisciplinary Research and Growth Evaluation, 6(4), 482–485. https://doi.org/10.54660/.ijmrge.2025.6.4.482-485

Saidi, J., Iznillah, M., & Andreas, A. (2025). BALANCING SUSTAINABILITY AND PROFITABILITY: OPTIMIZING INTELLECTUAL CAPITAL AND ITS CHALLENGES IN INDONESIAN MANUFACTURING COMPANIES. JRAK, 17(2), 33–47. https://doi.org/10.23969/jrak.v17i2.21906

Senna, A. L., & de Araujo Moxotó, A. C. (2025). Carbon emissions and financial performance in the Brazilian stock market. Journal of Environmental Management, 377. https://doi.org/10.1016/j.jenvman.2025.124698

Singh, S. K., Del Giudice, M., Chiappetta Jabbour, C. J., Latan, H., & Sohal, A. S. (2021). Stakeholder pressure, green innovation, and performance in small and medium-sized enterprises: The role of green dynamic capabilities. Business Strategy and the Environment, 31(1), 500–514. https://doi.org/10.1002/bse.2906

Siregar, I. F., Ismail, T., Taqi, M., & Soleha, N. (2024). Influence of ESG on Sustainability Reporting: Mediation Rule of Green Innovation and Investor Sentiment. International Journal of Energy Economics and Policy, 14(1), 452–463. https://doi.org/10.32479/ijeep.14988

Solovida, G. T., Izzaty, K. N., & Nugraha, S. I. (2025). Environmental management accounting and green practices as drivers of SME performance: evidence from an emerging economy. JAS (Jurnal Akuntansi Syariah), 9(1), 222–243. https://doi.org/10.46367/jas.v9i1.2441

Tehananda, D. L. A., Robiyanto, & Harijono, H. (2025). Carbon Productivity's Impact on Company's Financial Performance (Case Study of Companies Listed on IDX80 Stock Index). Journal of Management and Entrepreneurship Research, 5(2), 117–133. https://doi.org/10.34001/jmer.2024.12.05.2-53

Wang, J., Li, J., & Zhang, Q. (2021). Does carbon efficiency improve financial performance? Evidence from Chinese firms. Energy Economics, 104. https://doi.org/10.1016/j.eneco.2021.105658

Wang, J., & Yao, X. (2025). Corporate Environmental Expenditure, Signaling Mechanism, and Green Innovation Behavior: Evidence from Chinese A-Share Listed Firms. Sustainability (Switzerland), 17(20). https://doi.org/10.3390/su17209302

Wang, X., & Qiu, P. (2025). Relationship among environmental regulation costs, corporate accounting policies, and green innovation efficiency. Finance Research Letters, 77. https://doi.org/10.1016/j.frl.2025.107056

Wen, X., Cao, H., Li, H., Ge, W., Yang, N., Huang, X., Zhou, J., & Zhang, Q. (2025). From efficiency to effectiveness: A new method for diagnosing energy waste in manufacturing systems. Journal of Manufacturing Systems, 83, 517–545. https://doi.org/10.1016/j.jmsy.2025.10.003

Widyantoro, T., Rusmanto, T., Warganegara, D. L., & Furinto, A. (2025). Enhancing green innovation and financial performance: the role of stakeholder pressures and green dynamic capabilities. Frontiers in Climate, 7. https://doi.org/10.3389/fclim.2025.1599894

Xie, J., & Wang, Y. (2024). Does enterprise green innovation contribute to the carbon emission reduction? Evidence from China. Frontiers in Environmental Science, 12. https://doi.org/10.3389/fenvs.2024.1519258

Yan, J., Zhou, H., Mu, J., Zhang, Y., & Rahman, A. (2022). The synergistic effect of carbon performance and technological innovation on corporate financial performance. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.1060042

Yu, M., Sun, Q., & Huang, H. (2025). The impact of artificial intelligence on the green governance performance of enterprises. International Review of Financial Analysis, 106. https://doi.org/10.1016/j.irfa.2025.104548

Yuniarti, R., Soewarno, N., & Isnalita. (2022). GREEN INNOVATION ON FIRM VALUE WITH FINANCIAL PERFORMANCE AS MEDIATING VARIABLE: EVIDENCE OF THE MINING INDUSTRY. Asian Academy of Management Journal, 27(2), 41–58. https://doi.org/10.21315/aamj2022.27.2.3

Zhong, S., Su, B., He, J., & Ng, T. S. (2025). Moving towards a net-zero emissions economy in Indonesia. Science of the Total Environment, 1001. https://doi.org/10.1016/j.scitotenv.2025.180542