

## Analysis of the Impact of Firm Size on Environmental Costs and Carbon Emission Transparency in the Metal and Mining Sector

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### Abstract

This study investigates how firm size influences environmental expenditures and carbon emission transparency within Indonesia's metal and mining industry. Despite its crucial contribution to both national and global economic development, this sector remains a major source of ecological degradation, including soil damage, water and air pollution, and greenhouse gas emissions. Using a qualitative approach based on document analysis and secondary data from 20 publicly listed firms on the Indonesia Stock Exchange, the study finds that most companies fall under the large-scale category in terms of total assets and revenue. However, environmental cost disclosures vary widely: PT Trimegah Bangun Persada Tbk reports the highest figure (IDR 708 billion), whereas PT Lionmesh Prima records the lowest (IDR 35 million). Regarding carbon disclosure, five companies either lack reliable emission data or fail to comply with the Financial Services Authority (OJK) reporting standards, while PT Trimegah Bangun Persada Tbk exhibits the largest emissions (approximately 11 million tons CO<sub>2</sub>e). The findings suggest a general trend where larger firms tend to report environmental and carbon data in more detail, though full compliance remains inconsistent. The study underscores the need for stronger regulatory enforcement to promote transparency and accountability in environmental reporting practices across the metal and mining sector.

**Keywords:** Environmental Cost, Firm Size, Indonesia Stock Exchange, Sustainability Reporting.

### INTRODUCTION

The metal and mining industry is a strategic sector that plays a crucial role in both national and global economies. Activities within this industry provide essential raw materials for various other industrial sectors; however, they also generate significant environmental impacts. These impacts include land degradation, water and air pollution, and greenhouse gas emissions, particularly carbon dioxide (CO<sub>2</sub>). Therefore, the management of environmental costs and the disclosure of carbon emissions are critical aspects that companies in this sector must pay close attention to (Amaliya & Burhany, 2022).

Environmental costs refer to expenses incurred by companies as a result of activities related to environmental protection and restoration. According to Hansen and Mowen (2009), environmental costs include prevention, detection, remediation, and both internal and external failure costs associated with environmental quality. In the mining industry context, environmental costs encompass expenditures for land reclamation, waste management, emission reduction, and other conservation efforts. Effective management of environmental costs not only helps companies comply with regulations and fulfill social responsibilities but also contributes to business sustainability and corporate reputation.

Furthermore, carbon emission disclosure serves as a vital element of corporate transparency to stakeholders such as investors, regulators, and the public (Bahriansyah & Ginting, 2022). Such disclosure reflects a company's commitment to managing environmental impacts and contributing to climate change mitigation. Larger firms generally possess greater resources to manage environmental costs and report carbon emissions comprehensively. However, firm size may also influence how environmental costs are allocated and how transparently carbon emissions are disclosed (Alfriansyach & Darmawati, 2024).

Previous studies have shown that the management of environmental costs among mining companies varies in terms of effectiveness and efficiency. For example, a comparative study of PT TIMAH Tbk and PT Aneka Tambang Tbk revealed that both companies allocated a relatively small proportion of environmental costs to their total operating expenses, though the effectiveness of environmental cost management differed between them (Amaliya & Burhany, 2022). This finding suggests the need for deeper analysis of the factors influencing environmental cost management and carbon emission disclosure, one of which is firm size.

Firm size is an important variable in environmental accounting studies, as it can affect a company's capacity to manage environmental impacts

and report environmental information transparently (Sari, 2023). Larger firms typically possess stronger financial capacity and human resources to allocate environmental costs and comprehensively disclose carbon emissions, whereas smaller firms may face such limitations. Therefore, it is important to analyze how firm size influences environmental costs and carbon emission disclosure among companies in the metal and mining industry (Okterianda et al., 2025).

Based on the above discussion, this study formulates the following research question: "Does firm size affect environmental costs and carbon emission disclosure in companies within the metal and mining industry?" In line with this research question, the objective of the study is to analyze the effect of firm size on environmental costs and carbon emission disclosure in the metal and mining sector. Thus, this research is expected to provide a clearer understanding of the role of firm size in managing environmental costs and enhancing transparency in carbon emission reporting.

analysis to examine the relationship between firm size, environmental costs, and carbon emission disclosure in metal and mining companies listed on the Indonesia Stock Exchange. The research population consists of 39 companies, from which a purposive sampling method was used based on the criterion of publishing a sustainability report. As a result, 20 companies were selected as the research sample.

The analyzed variables include firm size, measured by total assets and total sales; environmental costs, measured by the amount of environmental expenditure disclosed in the sustainability report; and carbon emission disclosure, assessed based on the total amount of carbon emissions produced and the company's carbon intensity. Data were collected from financial statements for total assets and total sales, and from sustainability reports for environmental costs and carbon emissions. The data were then analyzed using a qualitative descriptive analysis technique to provide an in-depth overview of disclosure practices and environmental impacts among the sampled companies.

## METHODS

This study employs a qualitative method with a documentation study approach and secondary data

Table 1. Research Variables

No	Research Variable	Research Indicator
1	Firm Size	Total Assets and Total Sales
2	Environmental Cost	Environmental costs reported in the Sustainability Report
3	Carbon Emission	Total carbon emissions reported in the Sustainability Report

Table 2. Companies Publishing Sustainability Reports in 2024

No	Code	Name	No	Code	Name
1	AMMN	PT Amman Mineral Internasional Tbk	11	HILL	PT Hillcon Tbk
2	ANTM	PT Aneka Tambang (Persero) Tbk	12	GGRP	PT Gunung Raja
3	BRMS	PT Bumi Resources Mineral	13	ISSP	PT Steel Pipe Industry
4	NCKL	PT Trimegah Bangun Persada Tbk	14	IFSH	PT Ifishdeco
5	ADMR	PT Adaro Minerals Indonesia Tbk	15	UNIQ	PT Ulima Nitra
6	MBMA	PT Merdeka Battery Materials	16	TBMS	PT Tembaga Mulia Semanan
7	PTRO	PT Petrosea Tbk	17	NIKL	PT Pelat Timah Nusantara
8	CITA	PT Cita Mineral	18	INAI	PT Indal Aluminium
9	ARCI	PT Archi Indonesia Tbk	19	ARKA	PT Arkha Jayanti
10	TINS	PT Timah (Persero) Tbk	20	LMSH	PT Lionmesh Prima

## RESULTS AND DISCUSSION

### Firm Size

In this study, firm size is categorized using two main approaches: (1) based on total assets, and (2) based on total sales

Table 3. Firm Size Based on Total Assets

in (000)			
No	Code	Total Assets (USD)	Firm Size
1	AMMN	10,897,839	Large
2	MBMA	3,366,146	Large
3	NCKL	3,169,101	Large
4	ANTM	2,700,231	Large
5	ADMR	2,031,890	Large
6	BRMS	1,131,631	Large
7	PTRO	849,800	Large
8	ARCI	847,980	Large
9	GGRP	776,780	Large
10	TINS	776,294	Large
11	ISSP	503,075	Large
12	CITA	481,788	Large
13	HILL	380,930	Large
14	TBMS	146,829	Large
15	NIKL	132,516	Large
16	INAI	75,264	Large
17	IFSH	61,133	Large
18	UNIQ	44,273	Large
19	ARKA	25,290	Large
20	LMSH	7,217	Large

Source: Data processed (2025)

Based on Table 3, all companies are categorized as large-sized (Large), indicating that they possess substantial operational scale, assets, or market capitalization within Indonesia's metal and mining industry. The company with the highest asset value is PT Amman Mineral Internasional Tbk (AMMN), amounting to approximately USD 10.9 billion, followed by PT Merdeka Battery Materials Tbk (MBMA) and PT Trimegah Bangun Persada Tbk (NCKL), each with asset values exceeding USD 3 billion. In contrast, companies at the lower end of the ranking, such as PT Lionmesh Prima Tbk, have

significantly smaller asset values around USD 7 million.

Table 4. Firm Size Based on Total Sales

in (000)			
No	Code	Sales (USD)	Firm Size
1	ANTM	4,196,356	Large
2	AMMN	2,560,437	Large
3	MBMA	1,773,226	Large
4	NCKL	1,635,373	Large
5	ADMR	1,109,495	Large
6	TBMS	830,332	Large
7	PTRO	664,035	Large
8	TINS	658,395	Large
9	ISSP	371,044	Large
10	GGRP	338,173	Large
11	ARCI	276,494	Large
12	HILL	239,317	Large
13	BRMS	156,047	Large
14	NIKL	149,679	Large
15	CITA	144,767	Large
16	INAI	64,226	Large
17	IFSH	59,011	Large
18	UNIQ	40,634	Large
19	ARKA	7,217	Medium
20	LMSH	5,580	Medium

Source: Data processed (2025)

Based on Table 4, most companies are classified as large-sized (Large), with only two companies—PT Arkha Jayanti Tbk (ARKA) and PT Lionmesh Prima Tbk (LMSH) categorized as medium-sized (Medium). PT Aneka Tambang Tbk (ANTM) ranks highest, recording total sales of approximately USD 4.2 billion, while PT Lionmesh Prima Tbk (LMSH) occupies the lowest position with sales of around USD 5.58 million. This classification indicates that the majority of companies have relatively high total sales, reflecting a significant operational scale within Indonesia's metal and mining industry.

Table 5. Environmental Costs of Metal and Mining Companies in 2024

No	Code	Environmental Cost (IDR)
1	NCKL	708,000,000,000
2	AMMN	516,450,000,000
3	ANTM	158,000,000,000
4	ADMR	67,757,100,312
5	TINS	23,460,800,000
6	CITA	20,220,000,000
7	MBMA	19,640,131,500
8	ARCI	16,500,000,000
9	PTRO	14,348,239,455
10	ISSP	6,166,299,964
11	HILL	5,171,632,860
12	GGRP	5,100,679,210
13	BRMS	4,703,225,175
14	NIKL	2,793,502,800
15	IFSH	980,811,750
16	INAI	367,277,630
17	TBMS	84,409,500
18	LMSH	35,500,000
19	UNIQ	0
20	ARKA	0

Source: Data processed (2025)

Based on Table 5, environmental cost data are presented in two currencies: Indonesian Rupiah (IDR) and United States Dollar (USD). Two companies, PT Ulima Nitra Tbk and PT Arkha Jayanti Tbk, did not report any environmental cost ("Not Available"). PT Trimegah Bangun Persada Tbk recorded the highest environmental cost, amounting to IDR 708 billion, making it the top spender among metal and mining companies. In contrast, the company with the lowest reported environmental cost was PT Lionmesh Prima Tbk, with only IDR 35 million.

### Carbon Emissions

In this study, firm size is categorized using two main approaches: (1) based on total assets, and (2) based on total sales.

Table 6. Carbon Emissions of Metal and Mining Companies in 2024

No	Code	Emission (Ton CO2e)	Intensity
1	NCKL	10.870.978	25,88
2	MBMA	5.076.653	56,84
3	ANTM	1.415.596,83	0,02
4	AMMN	755.083	2,19
5	PTRO	306.441	44
6	GGRP	214.071	1,11
7	HILL	213.997	5
8	TINS	126.716	6,70
9	BRMS	110.755	0,05
10	ARCI	83.843	33
11	CITA	54.1	113
		Not	
12	NIKL	30.296	Available
13	INAI	14.562	1,97
14	ADMR	13.437	24
		Not	
15	LMSH	1.037	Available
16	TBMS	Not Available	
		GHG Calculation Not	
17	ISSP	Standardized	
		GHG Calculation Not	
18	IFSH	Standardized	
		Not Yet Compliant with OJK	
19	UNIQ	Standards	
		Not Yet Compliant with OJK	
20	ARKA	Standards	

Source: Data processed (2025)

Based on Table 6, several companies provide complete data, while others display notes such as "Not Available," "GHG Calculation Not Standardized," or "Not Yet Compliant with OJK Standards," indicating inconsistencies or incompleteness in reporting. There are five companies without valid or OJK-standardized emission data, namely PT Tembaga Mulia Semanan Tbk (TBMS), PT Steel Pipe Industry of Indonesia Tbk (ISSP), PT Ifishdeco Tbk (IFSH), PT Ulima Nitra Tbk (UNIQ), and PT Arkha Jayanti Tbk (ARKA).

Greenhouse gas (GHG) emissions vary considerably across companies. PT Trimegah Bangun Persada Tbk (NCKL) recorded the highest emission level, reaching nearly 11 million tons of CO<sub>2</sub>e, reflecting its large operational scale and/or high activity intensity. In contrast, companies such as PT Petrosea Tbk (PTRO) and PT Hillcon Tbk (HILL) reported very low emission and intensity levels, which may indicate smaller operations, higher efficiency, or differences in emission reporting scope. Emission intensity represents the ratio of emissions to the level of activity (e.g., production output). PT Merdeka Battery Materials Tbk (MBMA) shows the highest intensity value (56.84), indicating substantial emissions relative to its output, while PT Aneka Tambang Tbk (ANTM) records the lowest intensity (0.02), suggesting operational efficiency.

### **Analysis of The Impact of Firm Size on Environmental Costs**

In the metal and mining industry, environmental costs represent a critical aspect that must be managed effectively. These costs include prevention, detection, remediation, as well as internal and external failure costs associated with a company's operational activities. Based on the research findings, larger firms, measured by total assets and total sales, tend to have greater capacity to allocate funds for environmental expenses.

Large companies such as PT Amman Mineral Internasional Tbk, PT Merdeka Battery Materials Tbk, and PT Aneka Tambang (Persero) Tbk, each with total assets exceeding USD 2 billion, generally report more substantial environmental expenditures in their sustainability reports. This finding aligns with the theory that the larger the company, the greater the expectations and demands from stakeholders regarding corporate social and environmental responsibility. Moreover, large firms typically have better access to financial and technological resources, enabling them to

invest in environmentally friendly technologies, waste management systems, and land reclamation or conservation programs.

However, the effectiveness of environmental cost management is not always proportional to the amount of financial allocation. Case studies on PT Timah Tbk and PT Aneka Tambang Tbk indicate that although the proportion of environmental costs relative to total operating expenses is relatively small, the effectiveness and efficiency of environmental cost management may differ across companies. Managerial factors, internal policies, and regulatory pressures also influence how environmental costs are allocated and utilized.

Therefore, it can be concluded that firm size affects a company's ability to manage and allocate environmental costs, but the effectiveness of this management remains contingent upon other factors such as corporate governance, regulatory frameworks, and sustainability commitment. The effectiveness of environmental cost management is also influenced by how companies handle failure costs, both internal and external. External failure costs refer to expenses incurred after products or operations have impacted customers or the external environment, including warranty and replacement costs, product returns, customer loss, legal claims, and reputational damage (Brilio, 2025).

Investment in environmentally friendly technologies can significantly enhance the efficiency of environmental cost management. Large firms benefit from greater access to advanced technology. Moreover, a company's commitment to sustainability plays a crucial role in ensuring the effectiveness of environmental cost management. Firms that successfully integrate sustainability into their business strategy are generally more effective in managing environmental costs, which in turn can create competitive advantage and long-term corporate value.

### **Analysis of The Impact of Firm Size on Carbon Emissions Produced**

Firm size also has a significant impact on both the amount of carbon emissions produced and the level of carbon emission disclosure. Larger companies tend to have broader and more complex operational activities, resulting in higher potential carbon emissions. However, they also have a greater capacity to measure, report, and transparently manage their carbon emissions.

The research findings indicate that companies with large asset bases, such as PT Vale Indonesia Tbk and PT Amman Mineral Internasional Tbk, exhibit higher levels of carbon emission disclosure compared to smaller companies. This is because large firms generally possess the necessary resources to comply with international sustainability reporting standards, such as the Global Reporting Initiative (GRI) Standards, and face stronger pressure from regulators, investors, and the public to be transparent about their environmental impacts.

Moreover, large companies often act as pioneers in adopting low-carbon technologies and implementing circular economy practices, although challenges in reducing Scope 3 emissions (emissions from the supply chain) remain substantial. Carbon emission disclosure, whether conducted voluntarily or as part of regulatory compliance, serves as an indicator of a company's commitment to climate change mitigation and environmental transparency. Nevertheless, there is considerable variation in carbon disclosure practices among large firms. Determinant factors such as profitability, media exposure, and regulatory pressure play an important role in driving environmental transparency. Smaller firms, on the other hand, often face resource limitations that hinder optimal management and reporting of carbon emissions.

Overall, it can be concluded that firm size influences both the level of carbon disclosure and the capacity for emission management. However, larger firms also tend to generate higher total emissions. Therefore, the key challenge for large companies lies in balancing business growth with a genuine and sustainable commitment to carbon reduction.

Although large companies have greater capabilities in disclosing carbon emissions, challenges in reducing Scope 3 emissions (supply chain emissions) remain significant (Republika, 2025). Scope 3 emissions include those not directly produced by the company itself and not resulting from assets owned or controlled by the company. Managing these emissions requires coordination with multiple stakeholders across the supply chain, many of whom fall outside the company's direct control.

Significant variations in carbon disclosure practices among large companies also persist. Factors such as profitability, media exposure, and regulatory pressure contribute to environmental transparency. This suggests that the motivation for carbon disclosure is not

always driven solely by financial considerations (Santika et al., 2025).

Investors are increasingly integrating Environmental, Social, and Governance (ESG) factors into their decision-making processes. Companies that disclose their carbon emissions transparently are perceived as more responsible and better managed, which can attract ESG-focused investment. Studies have shown that firms with strong carbon disclosure practices often experience better stock performance and lower cost of capital (Feldman, 2018). Transparency in carbon emissions can also enhance corporate reputation. Customers and stakeholders tend to prefer businesses that proactively reduce their environmental impact. Companies with a high level of disclosure are often viewed as more credible and trustworthy, which can lead to stronger brand loyalty and a competitive advantage.

## CONCLUSION

Based on the findings of this research on the impact of firm size on environmental costs and carbon emission transparency in the metal and mining sector, it can be concluded that firm size influences both environmental cost management and carbon disclosure practices. Larger firms, as measured by total assets and total sales, tend to allocate greater environmental expenditures and provide more comprehensive carbon emission disclosures. This is evident from the data showing that large companies such as PT Trimegah Bangun Persada Tbk reported the highest environmental cost of IDR 708 billion and also recorded the highest carbon emissions of nearly 11 million tons of CO<sub>2</sub>e.

However, this study also found inconsistencies in reporting practices, as some large companies were not fully transparent in disclosing their environmental costs and carbon emissions. Five companies lacked valid or OJK-standardized emission data, while two companies did not report any environmental costs. The variation in emission intensity, ranging from the highest at MBMA (56.84) to the lowest at ANTM (0.02), further indicates differences in operational efficiency and commitment to environmentally responsible practices.

These findings highlight the importance of stricter regulations and standardized reporting frameworks to enhance corporate transparency and accountability regarding environmental impacts in the metal and

mining sector. Moreover, the results of this study can serve as a reference for stakeholders in evaluating corporate environmental performance and encouraging more sustainable business practices in industries with significant environmental impact. Future research should explore additional factors that may influence environmental reporting practices, such as profitability, ownership structure, and external stakeholder pressure.

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