

The Effect of Green Intellectual Capital and Carbon Performance on Carbon Emission Disclosure

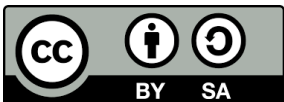
^{1*}Enjelly Widarta, ²Selvy Metta Pratama

^{1*} Sekolah Tinggi Ilmu Ekonomi Tri Bhakti, Bekasi, Indonesia

²Institut Bisnis dan Informatika Kwik Kian Gie, Jakarta, Indonesia

Email : selvymetta@gmail.com

Corresponding author e-mail: lenyenjelly@gmail.com

Article Info	Abstract
<p>Keywords:</p> <ul style="list-style-type: none">○ Green Intellectual Capital○ Carbon Performance○ Carbon Emission Disclosure	<p>Purpose – This study aims to obtain empirical evidence on the influence of Green Intellectual Capital and Carbon Performance on Carbon Emission Disclosure.</p> <p>Design/methodology/approach – Quantitative research methods using secondary data and content analysis. The population in this study were companies in the Raw Materials sector that published annual reports audited by independent auditors and sustainability reports listed on the Indonesia Stock Exchange in 2022-2024. A purposive sampling method obtained panel data of 198 observations. The analytical technique used to test the hypothesis was multiple linear regression analysis using Eviews 9 software.</p> <p>Findings – The results of this study found that Green Intellectual Capital and Carbon Performance have a positive and significant effect on carbon emission disclosure.</p> <p>Research limitations/implications – This study discusses carbon emission disclosure and other factors such as Green Intellectual Capital and Carbon Performance, focusing on companies in the Raw Materials sector. This study uses a carbon emission disclosure checklist as a measure of carbon emission disclosure.</p> <p>Keywords – Carbon Emission Disclosure, Green Intellectual Capital and Carbon Performance</p> <p>JEL : M14</p>
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INTRODUCTION

Climate change and global warming have become major global concerns. Carbon dioxide (CO₂) emissions are among the greenhouse gases that contribute most significantly to the acceleration of global warming. Indonesia is listed among the ten largest carbon-emitting countries in the world. The trend of carbon emissions in Indonesia has shown a significant increase, rising by approximately 13.4% compared to the previous year. This increase is mainly driven by the growing consumption of fossil energy, particularly coal, oil, and natural gas. The



basic materials sector, which includes mining, chemical, and metal industries, is one of the major contributors to carbon emissions due to its energy-intensive production processes and heavy reliance on fossil fuels. In addition, as part of the international community, Indonesia has committed to achieving Net Zero Emissions (NZE) by 2060 (<https://www.iea.org>, n.d.).

Compared to the energy or manufacturing sectors, carbon emission disclosure in the basic materials sector remains relatively low. However, based on sustainability reports from the 2022–2024 period, companies in this sector have begun to face increasing pressure from investors and stakeholders to demonstrate better carbon performance. This issue is particularly interesting to examine because the basic materials sector plays a crucial role in the supply chain of other industries and has significant potential to reduce national carbon emissions.

Based on POJK No. 51/POJK.03/2017, a sustainability report is defined as a report on a company's economic, social, and environmental performance, which includes indicators related to carbon emissions. These indicators must be disclosed, commonly referred to as Carbon Emission Disclosure, with the main objective of informing the public about corporate environmental management practices. Public companies listed on the Indonesia Stock Exchange have been required to publish sustainability reports since 2021. The existence of POJK No. 51/2017 is particularly important because the financial sector plays a strategic role in directing capital allocation toward sustainable economic activities. Through increased transparency and disclosure of sustainability information, especially carbon emissions, investors and stakeholders can assess the climate-related risks faced by companies. Thus, this regulation is expected to encourage companies to be more accountable in managing their environmental impacts and to support the achievement of Indonesia's national NZE target.

Nevertheless, in practice, the level of carbon emission disclosure in Indonesia remains relatively low, particularly in the basic materials sector. This sector is characterized by high emission intensity due to its dependence on natural resource extraction and large-scale energy consumption. In addition, the sector has complex supply chains, resulting in a significant proportion of emissions falling under Scope 3, which are difficult to measure and report accurately. The limited disclosure of carbon emissions in the basic materials sector is also influenced by several factors, including the absence of mandatory and uniform reporting standards, limited technical capacity of companies to measure emissions, and the principle-based nature of existing regulations. As a result, carbon emission reporting remains largely voluntary and does not yet fully reflect the actual environmental performance of companies.

Based on these conditions, there is a clear gap between Indonesia's national commitment to achieving NZE by 2060 and the actual practice of carbon emission disclosure at the corporate level, particularly in the basic materials sector. Therefore, this study is important to examine the role of POJK No. 51 of 2017 in encouraging carbon emission transparency and to analyze the factors contributing to the low level of disclosure in this sector. The findings of this study are expected to provide both academic and practical contributions in supporting the strengthening of sustainability policies and accelerating the achievement of Indonesia's Net Zero Emission target.

Several factors are considered to influence corporate carbon emission disclosure, including Green Intellectual Capital and carbon performance. These variables are selected as the main focus of this study because they are assumed to affect the extent of carbon emission disclosure. Green Intellectual Capital reflects a company's commitment to environmental

innovation and sustainability (Chen, 2008). Carbon performance reflects a company's ability to reduce emissions through lower carbon intensity, substitution or minimization of carbon-intensive materials, and reduced energy consumption (Shaharudin & Fernando, 2021).

Green Intellectual Capital is one of the factors influencing carbon emission disclosure. Studies conducted by Maria Yanida, Pipin Fitriasaki, and Ni Putu Agustinawati (2025), as well as Pande Ketut Adinda Dharma Putra and Lindrianasari (2024), indicate that Green Intellectual Capital has a positive effect on carbon emission disclosure. This is because it serves as an internal foundation that enables companies to respond more effectively to external pressures, while carbon performance reflects the extent to which firms meet societal expectations regarding environmental responsibility. Thus, Green Intellectual Capital plays an important role as an internal mechanism that strengthens the effectiveness of sustainable finance policies in promoting carbon emission transparency.

However, research by Farra Febiana Rachmasari, Muhammad Yusuf, and Dwi Handarini (2025) shows that Green Intellectual Capital has a negative effect on carbon emission disclosure. This is because the three components of green intellectual capital – green human capital, green structural capital, and green relational capital – have not been effectively integrated to support environmental transparency. Green human capital tends to focus more on internal efficiency rather than external reporting, and environmental evaluations are often overlooked. Green structural capital, such as ISO 14001 certification, is often administrative in nature and does not necessarily reflect a genuine commitment to emission reporting. Meanwhile, green relational capital exerts limited pressure, as external stakeholders such as consumers and suppliers still prioritize price and product quality over environmental concerns.

Carbon performance is another factor influencing carbon emission disclosure. Studies by Hanisyah Iratiwi and Virna Sulfitri (2023), Linda Anisa Rahmawaty and Cicely Delfina Harahap (2024), Dwi Ratmono, Darsono, and Selviana (2021), as well as Fatimah Aulia Rahman and Mujiyati (2024) indicate that carbon performance has a positive effect on carbon emission disclosure. This is because improved carbon performance reduces absolute greenhouse gas emissions and increases efficiency by lowering emissions per unit of output (Ong et al., 2021).

However, contrasting results were found by Farra Febiana Rachmasari, Muhammad Yusuf, and Dwi Handarini (2025), who reported a negative relationship between carbon performance and carbon emission disclosure. High emission levels do not necessarily encourage companies to be more transparent. In some cases, companies deliberately limit disclosure to avoid reputational risks and potential public scrutiny, especially when adequate environmental management strategies are not in place.

Based on these phenomena and prior studies, this research is motivated to examine companies in the basic materials sector to determine whether Green Intellectual Capital and carbon performance influence carbon emission disclosure, particularly among companies listed on the Indonesia Stock Exchange (IDX) during the 2022–2024 period. Accordingly, this study is entitled “The Effect of Green Intellectual Capital and Carbon Performance on Carbon Emission Disclosure.”

LITERATUR REVIEW

Green Intellectual Capital

Green intellectual capital refers to an organization's capacity to create, manage, and apply environmentally oriented knowledge and competencies that facilitate sustainable innovation and enhance the efficient use of natural resources. From the perspective of stakeholder theory, this form of intellectual capital plays a crucial role in responding to the growing information demands of stakeholders regarding corporate environmental performance. Employees who possess strong environmental knowledge, technical expertise, and sustainability awareness are better equipped to generate accurate environmental data and support transparent environmental disclosure, thereby reducing information asymmetry between firms and stakeholders. Safitri et al., (n.d.).

Carbon Performance

Carbon performance constitutes an essential element in determining the extent of carbon emission disclosure within corporate climate governance. It represents a firm's capacity to systematically quantify, control, and minimize greenhouse gas emissions through well-established monitoring and mitigation mechanisms. Companies exhibiting stronger carbon performance generally have more dependable emissions data, which supports higher-quality and more transparent disclosure practices. In addition, the adoption of emission reduction programs and formalized carbon management frameworks motivates firms to report their environmental initiatives in a more comprehensive manner. From the stakeholder theory viewpoint, expanded carbon disclosure addresses growing expectations for environmental transparency and accountability, whereas from the legitimacy theory perspective, such disclosure functions as a strategic response to align corporate activities with prevailing social and regulatory norms. Accordingly, strong carbon performance not only reflects effective environmental management but also serves as a critical determinant of the breadth and credibility of carbon emission disclosure. (Hoffmann & Busch, 2008).

Carbon Emission Performance

Carbon emission disclosure represents the degree to which companies communicate information related to their greenhouse gas emissions and climate-related activities as part of their environmental accountability. This disclosure plays an essential role in improving corporate transparency by enabling stakeholders to evaluate how firms manage environmental impacts and respond to climate change challenges. Beyond serving as an informational tool, carbon emission disclosure also reflects a firm's strategic orientation toward sustainability and its efforts to meet increasing regulatory and societal expectations. (Sulaiman, 2025)

Hypotheses development

Green Intellectual on carbon emission disclosure.

Yanida et al. (2025) also stated that one component of green intellectual capital, namely green human capital, encompassing academic level, age, and gender, can increase the level of individual and corporate environmental awareness, thereby encouraging attention and innovation in environmental protection. The greater a person's environmental knowledge, the

higher their pro-environmental actions. To explain the influence of Green Intellectual Capital on carbon emission disclosure, the researcher formulated the following hypothesis:

H₁: Green Intellectual Capital has a positive influence on carbon emission disclosure.

Carbon performance on carbon emission disclosure.

According to Ratmono et al. (2021), companies with the best carbon performance receive incentives to differentiate themselves from other organizations with poor carbon performance. Companies with the best carbon performance are motivated to maintain and consistently inform the public about updates to their carbon profiles, providing specific, objective, credible, and comprehensive carbon emissions disclosures for other organizations that have not yet implemented this method. To explain the influence of carbon performance on carbon emission disclosure, the researcher formulated the following hypothesis:

H₂: Carbon performance has a positive influence on carbon emission disclosure.

RESEARCH METHOD

The population in this study was companies in the Raw Materials sector listed on the Indonesia Stock Exchange (IDX). The population in this study was 114 companies from the Raw Materials sector that had undergone audits. Based on population determination using purposive sampling techniques, the following criteria were used as the basis for sample selection in this study:

1. Companies in the Raw Materials Sector listed on the Indonesia Stock Exchange (IDX) from 2022 to 2024.
2. Companies in the Raw Materials Sector that published Annual Reports between 2022 and 2024.
3. Companies in the Raw Materials Sector that published sustainability reports between 2022 and 2024.

Based on the established criteria, 66 of the 114 companies in the Raw Materials Sector met the criteria to be sampled in this study during the 2022-2024 period, resulting in 198 data observations.

Table 1. Operationalization of Research Variable

Type	Variable	Formula	Source
Independent Variable	Green Intellectual Capital	$GIC = n/k$ $n = \text{disclosed indicators}$ $k = \text{Total of all indicators}$	(Pande Ketut Adinda Dharma Putra, Lindrianasari, 2024)
	Carbon Performance	Carbon performance = Total Emisi Scope 1 + Total Emisi Scope 2	

Type	Variable	Formula	Source
		Total sales in the Current Period	(Fatimah Aulia Rahman,Mujiyati, 2024)
Dependent Variable	Carbon Emission Disclosure	Assign a score to each carbon emissions disclosure item. The maximum score is 18. If a company discloses an item, it will be given a score of "1," and if not, it will be given a score of "0." The total score is calculated using the following formula: Total items disclosed CED = $\frac{\text{Total items specified}}{\text{Total items specified}}$	(Yulian Maulida & Indah Bayunitri, 2021)

RESULTS

Before proceeding to the hypothesis test stage, the researcher first determines the most suitable regression model to be used in this study. The initial step in the model selection process is carried out through the chow test, which aims to compare and select the best model between Common Effect Model, Fixed Effect Model, and Random Effect Model. The process in determining the estimation model is as follows:

Chow Test

The Chow test is used to compare whether the Common Effect Model (OLS) or Fixed Effect Model is more appropriately used in analyzing panel data. The goal is to see if differences between individuals (firms) significantly affect the model.

Decision-making criteria based on probability values (Prob) Cross Section F:

1. If the probability value < 0.05, then the model used is the Fixed Effect Model.
2. If the probability value > 0.05 then the Common Effect Model is more suitable.

Decision-making criteria based on the value of F calculated:

1. If the value of F is calculated > F table, then the better model is the Fixed Effect Model.
2. If the value of F is calculated < F table, then the more appropriate model is the Common Effect Model.

Table 2. Uji Chow

Effects Test	Statistic	d.f.	Prob.
Cross-section F	9.776314	(65,130)	0.0000
Cross-section Chi-square	351.042718	65	0.0000

Source : Processed data (2025)

Based on the results of the Chow Test conducted using E-Views 9, a cross-section probability value of F was obtained of 0.0000, which is smaller than the significance level of 5% ($\alpha = 0.05$). These results show that the most suitable model is the Fixed Effect Model (FEM). Therefore, it is necessary to perform the Hausman Test to determine which model is more appropriate to use between the Fixed Effect Model and the Random Effect Model.

Hausman Test

Thirst test is used to determine the best model between the Fixed Effect Model and the Random Effect Model in the analysis of panel data. This test helps assess whether differences between individuals have a relationship with independent variables in the model.

Decision-making criteria based on probability values (Prob):

1. If the probability value < 0.05 , then the more suitable model is the Fixed Effect Model.
2. If the probability value > 0.05 , then the more appropriate model to use is the Random Effect Model.

Decision-making criteria based on Chi-Square values:

1. If the Chi-Square value is calculated $>$ Chi-Square table, then the Fixed Effect Model is better used.
2. If the Chi-Square value is calculated $<$ Chi-Square table, then the Random Effect Model is more precise.

Table 3. Uji Hausman

Test Summary	Chi-Sq. Statistic	Chi-Sq. D.f.	Prob.
Cross-section random	1.127657	2	0.5690

Sumber : Data yang diolah (2025)

Hasil Uji Hausman menunjukkan nilai probabilitas sebesar 0,5690, yang lebih besar dari tingkat signifikansi 5% ($\alpha = 0,05$). Dengan demikian, model yang paling tepat digunakan adalah Random Effect Model.

Uji Lagrange Multiplier (LM)

Uji Lagrange Multiplier (uji LM) digunakan untuk memilih apakah model Common Effect atau Random Effect yang paling tepat digunakan.

Kriteria pengambilan keputusan:

1. Jika signifikansi pada Both Breusch-Pagan $< 0,05$ maka model yang lebih baik adalah Random Effect.
2. Jika signifikansi pada Both Breusch-Pagan $> 0,05$ maka model yang lebih baik adalah Common Effect.

Kriteria pengambilan keputusan berdasar nilai LM:

1. Jika nilai LM $>$ chi square tabel maka model yang lebih baik Adalah Random Effect.
2. Jika nilai LM $<$ chi square tabel maka model yang lebih baik Adalah Common Effect.

Table 4. Uji Lagrange Multiplier (LM)

	Test Hypothesis Cross-section	Time	Both
Breusch-Pagan	108.5056 (0.0000)	1.082131 (0.2982)	109.5877 (0.0000)



Honda	10.41660 (0.0000)	-1.040255 --	6.630079 (0.0000)
King-Wu	10.41660 (0.0000)	-1.040255 --	0.775103 (0.2191)
Standardized Honda	10.55281 (0.0000)	-0.634479 --	1.574124 (0.0577)
Standardized King-Wu	10.55281 (0.0000)	-0.634479 --	-1.579407 --
Gourierieux, et al.*	--	--	108.5056 (< 0.01)

*Mixed chi-square asymptotic critical values:

1%	7.289
5%	4.321
10%	2.952

Source: Processed data (2025)

Based on the results of the Lagrange Multiplier test, the significance value for Both Breusch-Pagan is 0.000. This result is less than the significance level value ($\alpha = 0.05$). Thus, the best model used is the Random Effect Model (REM).

Hypothesis Testing

The Hypothesis in this study can be determined using a partial test to identify whether each independent variable has a significant individual effect on the dependent variable. The calculated t-statistic value will be obtained for each relationship or path. The hypothesis test was set a significance level of 0.05 and 0.25. The Calculation results in this study, using the direct effect of the independent variable on the dependent variable, yield the following result:

Tabel 2. Path Coefisient Test

Variabel	Prediksi	Coefficient	t-Statistik	Prob
C		0.560900	18.26786	0.0000*
GIC	+	0.208641	5.270388	0.0000*
CP	+	0.001468	0.745976	0.4566**

* = Significance 5% ** = Significance 25%

GIC= Green intellectual capital , CED= Carbon emission disclosure, CP= Carbon performance.

Source: Processed data (2025)

DISCUSSIONS

Green Intellectual Capital influences carbon emission disclosure.

Based on the parrsial test (t-test) using the Random Effect Model (REM) test, it shows a coefficient value of 0.208641 with a probability value of 0.0000* because this study uses the one tail hypothesis, the probability value divided by 2 (two) $0.0000/2 = 0.0000$ is smaller than the significant level at the level of $\alpha = 5\%$ (0.05). This shows that Green Intellectual Capital (X1) has a positive effect on Carbon Emission Disclosure (Y) and there is a significant influence between Green Intellectual Capital (X1) on Carbon Emission Disclosure (Y), so that hypothesis one (H1) is accepted. The higher the management of environment-based intellectual capital owned by a company, the higher the disclosure of carbon emissions. These results support an understanding in sustainability theory that emphasizes the importance of integrating economic, social, and environmental aspects in long-term business strategies. In this context, Green Intellectual Capital represents intangible assets that support sustainability through Green Human Capital, Green Structural Capital, and Green Relational Capital. This hypothesis is in line with previous research by Maria Yanida, Pipin Fitriasari, Ni Putu Agustinawati (2025) and Pande Ketut Adinda Dharma Putra, Lindrianasari (2024), which showed that green intellectual capital has a positive effect on carbon emission disclosure. In other words, it can be concluded that the more resources and knowledge the Company has in its green intellectual capital, the faster the Company will disclose its carbon emissions. In contrast to farra febriana's (2025) research which explains that green intellectual capital has no effect on carbon emission disclosure.

Carbon Performance Affects Carbon Emission Disclosure

The results of the study show that carbon performance (KK) has a positive influence on carbon emission disclosure (PEK). The estimated coefficient of the KK is 0.001468, with a t-value of 0.7459 and a p-value of 0.4566. Because this study used a one-way test, the adjusted p-value became 0.2283, which is below the significance level of $\alpha = 0.25$. Therefore, these results support the acceptance of Hypothesis 2. The use of the 25% significance level is considered appropriate given the nature of environmental and social research, particularly in the context of carbon disclosure, which is still largely voluntary in Indonesia. Reliance on secondary data and the non-financial nature of variables can reduce statistical strength, thus justifying a more flexible significance threshold. The positive coefficient indicates that companies with better carbon performance are likely to disclose more carbon-related information. These findings are consistent with legitimacy theory, which states that companies with superior environmental performance are more likely to communicate those achievements to gain or maintain legitimacy in society. As a result, improved carbon performance drives greater transparency in carbon emissions disclosure. This is in line with the findings of Hanisyah Iratiwi, Virna Sulfitri (2023), Linda Anisa Rahmawaty, Cicely Delfina Harahap (2024), Dwi Ratmono, Darsono Darsono, Selviana Selviana (2021) and Fatimah Aulia Rahman, Mujiyati (2024) which indicate that carbon emission disclosure is significantly positively influenced by carbon performance. In contrast to farra febriana's (2025) research which explains that Carbon Performance has no effect on the disclosure of

carbon emissions

CONCLUSIONS

Green Intellectual Capital has a positive effect on Carbon Emission Disclosure in companies within the basic materials sector. This finding indicates that Green Intellectual Capital enhances both individual and organizational environmental awareness, thereby encouraging greater attention to environmental protection and innovation. The higher the level of environmental knowledge possessed by individuals within a company, the stronger their pro-environmental behavior tends to be. Based on the research results, Green Intellectual Capital – particularly green structural capital – plays a significant role in promoting carbon emission disclosure. Therefore, the Financial Services Authority (Otoritas Jasa Keuangan) is encouraged to strengthen the implementation of POJK No. 51 of 2017 by emphasizing the development of companies' internal systems, such as environmental policies, emission measurement systems, and sustainability governance. In addition, companies are expected to view carbon emission disclosure not merely as an administrative obligation, but as an integral part of their long-term sustainability strategy.

This study has several limitations, including the relatively low level of statistical significance for some variables and the reliance on secondary data derived solely from annual reports and sustainability reports, which may lead to disclosure bias. Therefore, future research is recommended to employ longer observation periods, incorporate additional relevant variables, and combine quantitative and qualitative approaches in order to provide a more comprehensive understanding of the factors influencing carbon emission disclosure.

Carbon performance has a positive effect on carbon emission disclosure in companies within the basic materials sector, indicating that better carbon performance encourages greater transparency in environmental reporting. This finding suggests that carbon performance plays a crucial role in motivating firms to disclose emission-related information more openly. Therefore, regulators should place greater emphasis on improving the quality of corporate carbon performance rather than merely ensuring compliance with reporting requirements. Strengthening emission management systems, enhancing the transparency of environmental data, and implementing clearer carbon performance evaluation standards are essential to promote more credible and meaningful disclosure. In this context, carbon emission disclosure should not be viewed solely as an administrative obligation but as a reflection of a company's genuine commitment to environmental sustainability.

This study has several limitations, including the relatively low statistical significance of certain variables and the reliance on secondary data derived from annual and sustainability reports, which vary in disclosure quality across firms. Future research is therefore encouraged to employ longer observation periods, expand data sources, and integrate quantitative and qualitative approaches to provide a more comprehensive understanding of the determinants of carbon emission disclosure.

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