



## **Implementation of Carbon Emission Disclosure on Market Reaction with Green Investment as a Mediating Variable in Companies Listed on the Indonesian Carbon Exchange (IDX Carbon)**

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**Abstract**

**Background:** The Indonesian Carbon Exchange (IDX Carbon) has emerged as a critical mechanism for carbon trading, introducing carbon units as securities rather than commodities. Despite this development, challenges remain in ensuring the integrity of carbon markets, including issues of double counting, manipulation of carbon unit measurements, and regulatory gaps.

**Objective:** This study aims to examine the implementation of Carbon Emission Disclosure on Market Reaction with Green Investment as a mediating variable in companies listed on IDX Carbon.

**Methods:** This study employed a quantitative research approach using SmartPLS with PLS-SEM. Hypothesis testing applied a t-statistic threshold of 1.96 and a significance level of  $\alpha = 5\%$  ( $p\text{-value} < 0.05$ ).

**Results:** All variables had Cronbach's Alpha values above 0.95 and AVE values above 0.66, indicating high reliability and validity. The  $R^2$  value of Green Investment (Z) was 0.983 and Market Reaction (Y) was 0.925, indicating strong predictive relevance. Hypothesis testing revealed: (1) Green Investment significantly affects Market Reaction ( $t = 9.422$ ,  $p = 0.000$ ); (2) Carbon Emission Disclosure significantly affects Green Investment ( $t = 6.017$ ,  $p = 0.000$ ); (3) Carbon Emission Disclosure significantly affects Market Reaction ( $t = 2.655$ ,  $p = 0.000$ ); and (4) Carbon Emission Disclosure significantly affects Market Reaction through Green Investment as a mediating variable ( $t = 8.672$ ,  $p = 0.000$ ). All four hypotheses were accepted.

**Conclusion:** Carbon Emission Disclosure has a significant direct effect on both Green Investment and Market Reaction in IDX Carbon-listed companies. Green Investment also serves as a significant mediating variable between Carbon Emission Disclosure and Market Reaction, highlighting the importance of transparent carbon emission reporting in supporting sustainable finance in Indonesia.

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### INTRODUCTION

The carbon exchange in Indonesia, known as IDX Carbon, introduces carbon units as securities, unlike international exchanges that consider them as commodities (Narassimhan et al., 2022). This allows the management of carbon units as securities that can be resold in the form of derivatives, although this is contrary to the principle of 'retired carbon', where carbon units are supposed to be used once to reduce emissions (Blaufelder et al., 2021). Although carbon exchanges have been implemented, there are still several challenges that need to be overcome, such as the status of carbon units as securities or commodities (Green, 2021). In addition, current regulations are not fully able to overcome challenges such as double counting and manipulation of carbon unit measurements, which can reduce the integrity and trust of the carbon market (Schneider et al., 2021). Based on POJK 14/2023, trading of carbon units from abroad can be facilitated by carbon exchange organizers, but this opens the opportunity for double counting, where the same carbon unit can be counted by two different entities for the purpose of reducing their emissions. A case of double counting occurred on the European Union carbon exchange in 2010, which resulted in the exchange being temporarily closed and regulations being changed (Levy et al., 2021).

In the next development, Indonesia Commodity and Derivatives Exchange (ICDX), a futures exchange that provides a market for commodities and their derivatives in both physical form and as financial products, has planned to make carbon one of the commodities to be traded. The carbon trading scheme prepared by ICDX can be seen in Figure 1.

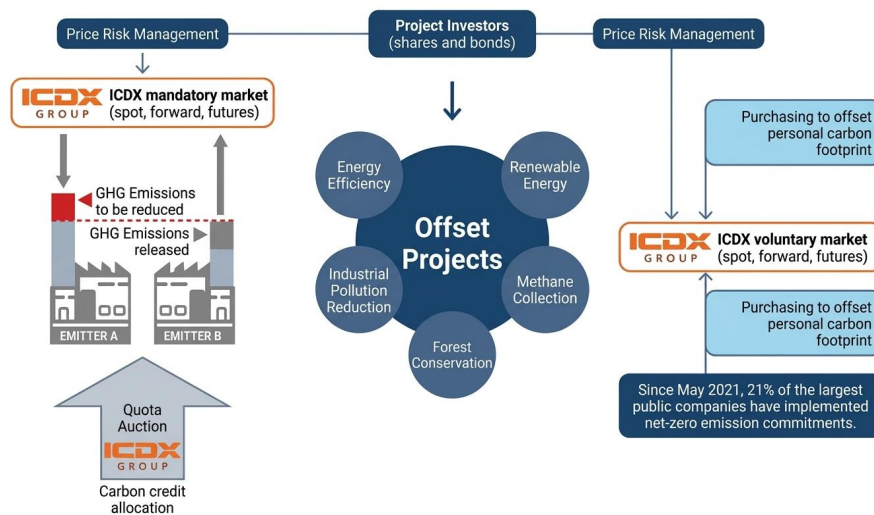
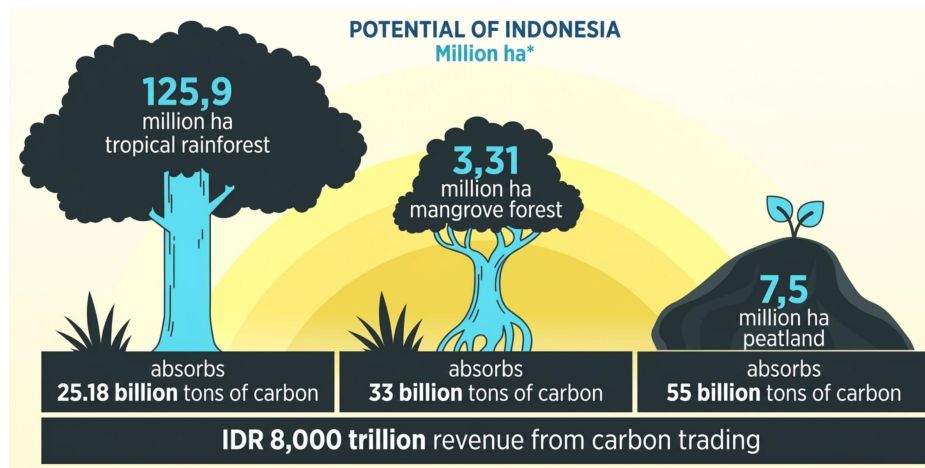


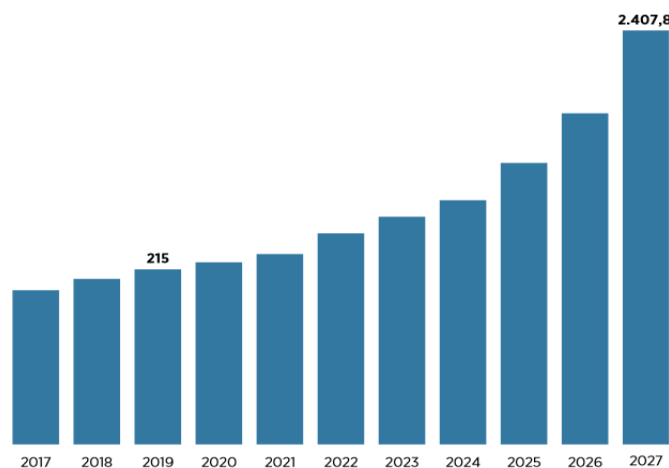
Figure 1. Carbon Trading Scheme

Presidential Regulation No. 98 of 2021 establishes the National Climate Change Control Registry System (SRN PPI) as a platform responsible for managing data and information related to climate change adaptation and mitigation actions in accordance with Indonesia's NDC targets (Hood et al., 2021). SRN PPI also adopts MRV to calculate the amount of GHG emissions released by an entity so that the data can be used to determine the NEK and its performance in climate change adaptation and mitigation actions (Wong & Fong, 2021). Furthermore, entities that produce carbon emissions can register and report their climate change adaptation and mitigation performance, NEK implementation, and resources to SRN PPI (Bank, 2023). The report will later be verified by the relevant ministry which is used as a basis for accessing the NEK mechanism, one of which is carbon trading (Narassimhan et al., 2022). Regarding the carbon trading mechanism itself, the regulation distinguishes between entities with GHG emission limits imposed and entities that do not have limits. At this stage, entities with limits will enter the Emissions Trading System mechanism, while entities that do not have limits will be under the emission offset mechanism.



**Figure 2.** Development of Carbon Trading

Carbon trading will be a breath of fresh air for sustainable economic growth and is expected to minimize the impact of climate change in the coming years. Carbon trading is one of the main instruments for countries in the world to reduce GHG emissions in order to meet the Paris Agreement commitments through their NDCs. The role of carbon trading around the world is growing, as seen from the significant increase in carbon allowance prices, especially in the European Union ETS, which experienced an 80% increase in carbon allowance prices. Meanwhile, the price of carbon allowances in the New Zealand ETS increased by 70%, the Western Climate Initiative (WCI) by 38%, and the Regional Greenhouse Gas Initiative (RGGI) by 15%. Several studies have predicted the value of carbon trading in the future. One of them, Coherent Market Insights, predicted that the global carbon market will be equivalent to US\$2,407.8 billion in 2027, compared to US\$215 billion in 2019, with a Compound Annual Growth Rate (CAGR) of 30.7% between 2020 and 2027.



**Chart 1.** Global Carbon Trade Value 2017 - 2027 (US\$ billion)

The importance of carbon trading is also inseparable from the risks of climate change. Based on S&P Global Market Intelligence (2019), 80% of the world's largest companies reported market and physical asset risks due to climate change. On the other hand, increasing pressure from investors and activists has led to divestment from several carbon-intensive industries.

Disclosure of carbon emissions is important because it is a form of transparency to stakeholders with reference to the company's efforts to address the impacts of climate change and global warming (Carbon Disclosure Project, 2009). Disclosure of carbon emissions is regulated in Law No. 40 of 2007 concerning Limited Liability Companies (Perseroan Terbatas/PT), Article 66 paragraph (2)c, which requires PT to include reports on social and environmental responsibility

activities in annual reports, and is further regulated in OJK (Otoritas Jasa Keuangan) Regulation No. 04/2016, which obliges issuers or public companies to include social and environmental responsibility reports in annual reports or sustainability reports. Laws and regulations also govern environmental management as stipulated in Law No. 32 of 2009 concerning Environmental Protection and Management. Environmental performance management aims to fulfill all environmental standards and requirements thoroughly and comprehensively. Environmental performance management is also a management effort to prevent environmental pollution, which is implemented through the "Green Industry" programme, whose goal is that the impact from an environmental standpoint leads to "Zero Impact" (Foundation, 2021).

In a broader international context, the obligation to disclose emissions and environmental responsibility is increasingly aligned with global sustainability reporting standards, where transparency is treated not only as compliance but also as a mechanism to reduce information asymmetry and improve investor decision-making (Christensen et al., 2021). Recent studies emphasize that corporate disclosure of carbon emissions is closely linked to market valuation, cost of capital, and reputational risk, meaning that stronger disclosure regimes can indirectly incentivize firms to improve environmental performance rather than merely reporting it (Bolton & Kacperczyk, 2021). In addition, environmental management approaches such as "green industry" and "net-zero" strategies are increasingly interpreted through the lens of transition risk and climate governance, where firms are expected to integrate environmental compliance, internal controls, and measurable decarbonization pathways into corporate strategy (Berg et al., 2022). Therefore, Indonesia's regulatory framework on CSR, sustainability reporting, and environmental management can be positioned within a global shift toward standardized, verifiable, and decision-useful climate disclosure that supports both regulatory oversight and sustainable finance development (Change, 2022).

Entities that have an environmental impact closely related to carbon emissions must align carbon emission reduction programs both internationally and nationally. The increasing attention to Greenhouse Gas (GHG) emissions furthermore has a consequence on disclosures related to carbon emissions produced by companies. Disclosure of carbon emission information is extremely important for stakeholders in providing confidence to company owners regarding the company's commitment to playing a role in maintaining environmental sustainability (Firmansyah, 2020). The information provided by the corporation to investors as shareholders can trigger investor reactions that are reflected in the company's value. The current market reaction tends to be influenced by the information provided by the corporation to the public. Investor reactions in the capital market are related to market performance that measures the company's success in the future. Information that is related to investors' desire for the company's prospects is considered positive data, so that investors have confidence in the company's future. Investors believe that the company's success can be achieved because company managers can create high company value. Therefore, investigating the company's expenditure in a study needs to be examined further.

According to Akhiroh & Kiswanto, (2016) carbon emission disclosure is a form of corporate contribution to environmental change, particularly global warming. The sustainability of a company certainly cannot be separated from the surrounding environment, so that in implementing corporate activities it is required to comply with the norms and standards that apply in society. This leads to an increase in the demand for information relating to environmental disclosure, particularly carbon emission disclosure. The information table of contents is euphemistic pre-owned by Irwhantoko & Basuki, (2016) in their evaluation to measurement copy discharge disclosure. CDP is established to encourage companies to disclose information pertaining to corporate activities related to energy use and climate change. On the authority of Ghomi & Leung, (2013) the undisputed issue of climate change and global warming has contributed to triggering the materialization of contemporary environmental changes.

According to Hartono, (2016) market reaction is indicated by changes in the price of the securities concerned. This response may be measured using return as price changes or by using abnormal returns. Hartono (2013) stated that market reaction is reflected by the price changes of the securities concerned. Suganda (2018) stated that trading volume activity is an indicator that can be used to analyze capital market responses to information that occurs in the capital market.

Information that emerges or occurs can influence stock price movements in the capital market, which will cause changes in supply and demand.

According to Zhang & Berhe, (2022) green investment is a conceptualization of channeling funds mobilized from the government or companies to invest this capital in environmental goods and services, such as protecting ecosystem diversity and mitigating losses from environmental damage. Rachman (2018) stated that green investment focuses on core business processes (SDA, natural resources), creating additional contemporary renewable energy sources (EBT), and implementing clean water and air projects, which are investment activities in companies that conduct green investment activities. The IMF defines green investment as an investment required to reduce greenhouse gas emissions and air pollution without affecting the business processes of public and private non-energy companies.

### METHOD

The research method used in this study was a quantitative approach. Data processing in this study used SmartPLS SEM (Partial Least Square – Structural Equation Modeling). PLS was used to explain the relationships between variables and to conduct hypothesis testing. The author employed a separate partial least squares approach for this study, as the variables could be measured based on their indicators, allowing for clear and comprehensive computations.

Hypothesis testing was evaluated using t-statistic and p-values (Hussein, 2015). At an alpha level of 5%, the t-statistic threshold used was 1.96. H<sub>0</sub> was rejected and H<sub>a</sub> was accepted when the t-statistic exceeded 1.96. H<sub>a</sub> was similarly accepted when the p-value was less than 0.05.

### RESULTS AND DISCUSSION

#### Results

##### *Evaluation of Measurement Model (Outer Model)*

The measurement model (outer model) is confirmatory factor analysis (CFA) by testing the validity and reliability of latent constructs. The following are the results of the outer model testing in this study.

##### *Validity Test*

This study uses SmartPLS 3.0 software to assess the validity and reliability of the measurement instrument. To test the validity of the data, convergent validity can be used to examine the loading factor values, and discriminant validity can be used by looking at the cross-loading values.

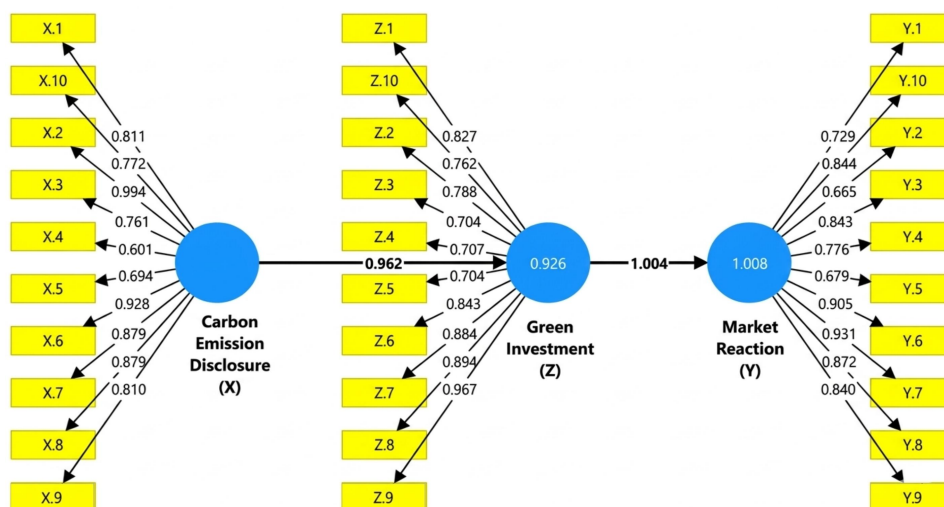


Figure 1. Outer Model

1. Convergent Validity

Convergent validity of the construct with the reflective indicator construct is assessed based on the correlation coefficient between the latent score/component score and the composite score calculated by PLS. Based on Table 4.1 above, it can be seen that each loading factor value has passed the threshold of 0.7, so that it can be concluded that each indicator in this study is valid. Therefore, these indicators can be used to measure the research variables.

2. Discriminant Validity

Discriminant validity compares the Average Variance Extracted (AVE) values of each construct with the correlation coefficients between other constructs in the model. Based on Table 4.1 above, each cross-loading value of each indicator has a higher correlation coefficient with its own construct compared to other variables. Hence, the indicators presented above are confirmed as valid constructs.

Reliability Test

An instrument can be said to be reliable by looking at the *Average Variance Extracted* (AVE) greater than 0.5, Cronbach Alpha greater than 0.6, and composite reliability greater than 0.7.

**Table 1.** Calculation of AVE, Cronbach Alpha, and Composite Reliability

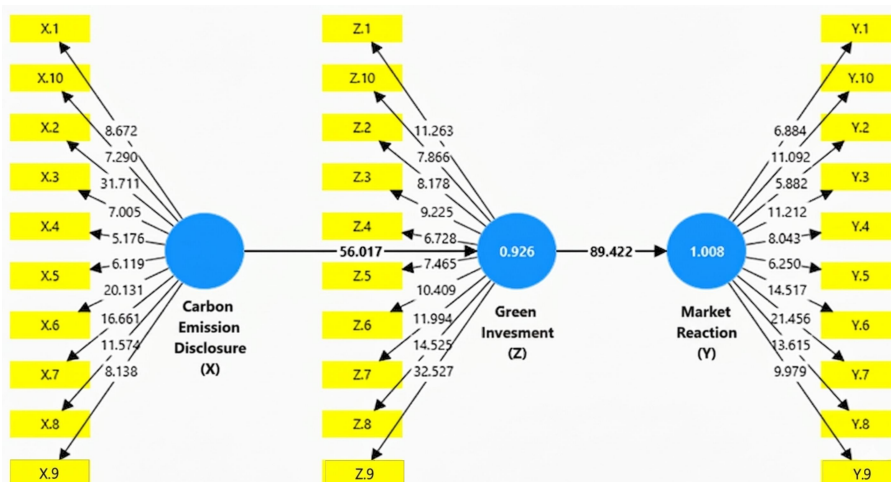
|                                | Cronbach's alpha | Rho_a | Rho_c | AVE   |
|--------------------------------|------------------|-------|-------|-------|
| Green Investment (Z)           | 0.953            | 0.958 | 0.954 | 0.679 |
| Carbon Emission Disclosure (X) | 0.955            | 0.964 | 0.956 | 0.689 |
| Market Reaction (Y)            | 0.950            | 0.955 | 0.951 | 0.661 |

Source: Processed primary data (2024)

Based on Table 1, the Cronbach Alpha value of the Market Reaction variable (Y) is 0.950, the Carbon Emission Disclosure variable (X) is 0.955, and the Green Investment variable (Z) is 0.953. From the reliability test results above, it can be seen that each indicator is reliable in measuring their latent variables.

Structural Model Evaluation (Inner Model)

Evaluation of the structural model can be seen from several indicators including the coefficient of determination ( $R^2$ ), Predictive Relevance ( $Q^2$ ), and Goodness of Fit Index (GoF) (Hussein, 2015). The results of the structural model displayed by SmartPLS 3.0 in this study are as follows:



**Figure 2.** Structural Model (Inner Model)

Source: Primary data processed by Smart PLS 4 (2024)

*R2 (R-square) results*

In assessing the model with PLS, it is evaluated by examining the R<sup>2</sup> for each endogenous latent variable. The results of the R<sup>2</sup> values in this study are as follows:

**Table 2.** Correlation Value (r2)

|                                | <b>R-square</b> | <b>Adjusted R-square</b> |
|--------------------------------|-----------------|--------------------------|
| Green Investment (Z)           | 0.892           | 0.983                    |
| Carbon Emission Disclosure (X) | 0.899           | 0.925                    |

Source: Processed primary data (2024)

Based on the calculation results using bootstrapping in Table 4.14 above, the R<sup>2</sup> value of the Green Investment (Z) variable is 0.983, which means that the Carbon Emission Disclosure (X) and Market Reaction (Y) variables explain Green Investment (Z), or in other words, the contribution of the Carbon Emission Disclosure (X) and Market Reaction (Y) variables is 98.3%.

It is recognized that the R<sup>2</sup> value of the Carbon Emission Disclosure variable (X) is 0.925, which means that the Green Investment (Z) and Market Reaction (Y) variables explain Carbon Emission Disclosure (X), or in other words, the contribution of the Carbon Emission Disclosure variable (X) is 92.5%.

*Hypothesis Testing*

Based on the results of the outer model conducted, each hypothesis test has met the requirements, so they can be used as analysis models in this study. Hypothesis testing in this study takes into account an alpha of 5%, which means that if the t-statistic value  $\geq 2.048$  or the probability value  $\leq$  the level of significance ( $\alpha = 5\%$ ). The threshold of 0.05 means that the probability of error is only 5%, and the remaining 95% is used to accept the hypothesis.

Hypothesis testing in this study is divided into two parts, namely direct effect testing and indirect effect testing (mediation). Direct effect testing uses bootstrapping on SmartPLS 3.0 software, while indirect effect testing uses t-statistics on the indirect effect.

**Table 3.** Path Coefficients

|       | <b>Original Sample (O)</b> | <b>Sample Mean (M)</b> | <b>Standard Deviation (STDEV)</b> | <b>T statistics (O/STDEV)</b> | <b>P Values</b> |
|-------|----------------------------|------------------------|-----------------------------------|-------------------------------|-----------------|
| Z → Y | 0.985                      | 0.937                  | 0.011                             | 9.422                         | 0.000           |
| X → Z | 0.962                      | 0.965                  | 0.017                             | 6.017                         | 0.000           |
| X → Y | 0.966                      | 0.970                  | 0.023                             | 2.655                         | 0.000           |

Source: Processed primary data (2024)

*Indirect Effect Testing*

The indirect effect test is conducted by testing the significance of the indirect effect of the independent variable (Variable X) on the dependent variable (Variable Y) through the mediating variable (Variable Z), with the condition that the t-statistic value is  $> 2.048$ . The indirect effect can be said to be significant if both direct effects that form it are significant. The results of this test can be seen in the following table:

**Table 4.** Indirect Effect

|           | <b>Original Sample (O)</b> | <b>Sample Mean (M)</b> | <b>Standard Deviation (STDEV)</b> | <b>T statistics (O/STDEV)</b> | <b>P Values</b> |
|-----------|----------------------------|------------------------|-----------------------------------|-------------------------------|-----------------|
| X → Z → Y | 0.811                      | 0.802                  | 0.094                             | 8.672                         | 0.000           |

Source: Processed primary data (2024)

Carbon Emission Disclosure (X) has a significant effect on Market Reaction (Y) through Green Investment (Z). Based on the test results in Table 4.12, it can be seen that the t-statistic value of the relationship between the Carbon Emission Disclosure variable (X) and the Market Reaction variable (Y) through the Green Investment variable (Z) is 8.672 with a sig. of 0.000. The test results show that the t-statistic  $\geq 1.96$  and the sig. value  $\leq$  level of significance ( $\alpha = 5\%$ ). Thus,

the fourth hypothesis is accepted.

### **Discussion**

Based on Table 3, the test results for each hypothesis are as follows:

- a. Green Investment (Z) influences Market Reaction (Y).

Based on the test results in Table 3, the t-statistic value of the relationship between the Green Investment variable (Z) and the Market Reaction variable (Y) is 9.422 with a sig. of 0.000. The test results show that the t-statistic  $\geq 1.96$  and the sig. value  $\leq$  level of significance ( $\alpha = 5\%$ ). Thus, the first hypothesis is accepted.

- b. Disclosure of Carbon Emissions (X) has an impact on Green Investment (Z).

Based on the test results in Table 3, the t-statistic value of the relationship between the Carbon Emission Disclosure variable (X) and the Green Investment variable (Z) is 6.017 with a sig. of 0.000. The test results show that the t-statistic  $\geq 1.96$  and the sig. value  $\leq$  level of significance ( $\alpha = 5\%$ ). Thus, the second hypothesis is accepted.

- c. Disclosure of Carbon Emissions (X) affects Market Reaction (Y).

Based on the evaluation results in Table 4.3, the t-statistic value of the relationship between the Carbon Emission Disclosure variable (X) and the Market Reaction variable (Y) is 2.655 with a sig. of 0.000. The test results indicate that the t-statistic  $\geq 1.96$  and the sig. value  $\leq$  level of significance ( $\alpha = 5\%$ ). Thus, the third hypothesis is accepted.

Carbon Emission Disclosure (X) has a significant effect on Market Reaction (Y) through Green Investment (Z). Based on the test results in Table 4.12, it can be seen that the t-statistic value of the relationship between the Carbon Emission Disclosure variable (X) and the Market Reaction variable (Y) through the Green Investment variable (Z) is 8.672 with a sig. of 0.000. The test results show that the t-statistic  $\geq 1.96$  and the sig. value  $\leq$  level of significance ( $\alpha = 5\%$ ). Thus, the fourth hypothesis is accepted.

### **CONCLUSION**

Based on the evaluation results and the analytical discussion presented in the preceding chapter, several conclusions can be drawn. First, the empirical test results indicate that the first hypothesis, which examines the effect of Green Investment (Z) on Market Reaction (Y), is accepted. Second, the findings show that the second hypothesis, concerning the influence of Carbon Emission Disclosure (X) on Green Investment (Z), is also accepted. Third, the analysis confirms that Carbon Emission Disclosure (X) has a significant effect on Market Reaction (Y), leading to the acceptance of the third hypothesis. Finally, the test results demonstrate that Carbon Emission Disclosure (X) affects Market Reaction (Y) through Green Investment (Z), thereby supporting and accepting the fourth hypothesis.

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### **AUTHOR CONTRIBUTION STATEMENT**

Rico Nur Ilham conceptualized the research, designed the methodology, and conducted data analysis. Muammar Khaddafi assisted with data collection, literature review, and manuscript drafting. Mangasi Sinurat contributed to the research design and analysis. Irada Sinta provided expertise on carbon emission disclosure and revised the manuscript. Irshad Ahmad Reshi reviewed the methodology and helped with final revisions. All authors approved the final manuscript.

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