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Does Business Intelligence Reverse the Negative Impact of ESG on Firm Value?

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ABSTRACT
Environmental degradation in Indonesia has increased significantly in recent decades, thereby increasing the importance of Environmental, Social, and Governance (ESG) factors in corporate decision-making. This study aims to analyse the impact of ESG implementation on company value and investigate the moderating effect of business intelligence (BI) on this relationship. This research uses data panels from 35 listed non-financial companies on the Indonesia Stock Exchange, covering the period from 2018 to 2023. A total of 201 observations were collected through purposive sampling. We used descriptive statistics and Fixed Effects regression methods to analyse the data using a data panel approach. The findings show that ESG implementation is associated with a decrease in firm value. This suggests that such initiatives were still perceived primarily as symbolic activities that imposed additional costs and responded to external pressures rather than being fully embedded in corporate strategy. BI, when considered independently, also exhibits a negative relationship with firm value. Nevertheless, the correlation between ESG and BI yields a positive impact, implying that effective BI governance enhanced the credibility and strategic relevance of ESG information. The combined effect appeared to strengthen market perceptions and supports long-term formation firm value. This study provides empirical insights regarding literature that discusses the inconsistent link on the relationship of ESG and firm value in developing countries and emphasizes the strategic role of BI as an information governance mechanism that can increase the relevance of ESG for investors.

1. INTRODUCTION

Multinational companies are faced with the reality that their business activities contribute to environmental damage. Therefore, environmental issues have become a global concern that is frequently a major topic in various meetings between world leaders. World Development Indicators | the World Bank data shows that countries in the ASEAN region, such as Indonesia, Thailand, and Malaysia, are experiencing economic losses due to carbon dioxide emissions. In 2021, the losses caused by carbon dioxide emissions in Indonesia reached US $7.432 billion, or 2.4% of the Gross National Income of US $143 trillion, equivalent to Rp392.53 trillion. Other ASEAN countries, such as Malaysia and Thailand, recorded losses of US$5.715 billion (around 0.5% of GDP, equivalent to Rp81.80 trillion). According to the data, Indonesia is the country that has the biggest economic losses because of actions that are harmful to the environment. ESG implementation performance in a company is often linked to its efforts to incorporate ESG practices into its business operations. ESG performance activities are closely related to company operations, such as pollution control, employee protection, responsible use of natural resources, and business transparency. This affects the investment behaviour of stakeholders. Therefore, companies are beginning to reflect ESG considerations in their investment and operational choices (Eliwa et al., 2021).

Empirical studies consistently demonstrate a positive relationship between ESG scores and firm value. Companies that demonstrate high ESG implementation tends to generate more positive investor ratings, which are reflected in higher market valuations (Aboud & Diab, 2018; Fatemi et al., 2018). Firms with high levels of ESG reporting are considered capable of reducing the negative impact of greenhouse gas emissions reporting, so that this synergy can increase firm value (Kim & Kim, 2024). Companies in the ASEAN region have also been able to prove that good ESG performance provides a good image, thereby increasing firm value (Adeneye et al., 2023). Not only do they have a good image, companies with good ESG performance are able to improve financial

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efficiency, especially in optimizing capital structure management and building trust in the financial market. Shareholders as investors appreciate companies whose business practices are environmentally and socially friendly and have good governance. According to Seok et al. (2024), companies that invest in environmental initiatives are perceived as more responsible by shareholders.

For Indonesian public companies, ESG practices have not yet had a stable impact on increasing firm value. ESG practices are still considered purely philanthropic activities that do not provide direct benefits to shareholders. The disclosure of ESG performance by public companies in Indonesia is still not strong enough to have a direct impact on firm value. Investors have not yet factored ESG performance into their investment decisions based on data regarding company activities (Sumarno et al., 2023). The overall ESG scores of companies in the ASEAN region also have a negative effect on the value of those companies. Higher ESG scores decrease firm value (Prabawati & Rahmawati, 2022). Investors in developing countries hardly focus on non-financial factors. However, different results were shown in the study by Melinda & Wardhani (2020), which proved that the ESG index scores of companies in 22 asian countries significantly affect firm value as measured by Tobin's Q. However, Meini & Setijaningsih (2024) and Pardamean & Gunawan (2025) reveal that ESG aspects are very important. ESG is not only for increasing firm value, but it also demonstrates the company's resilience and sustainability.

Previous studies have not provided clear and consistent findings regarding the relationship between ESG and firm value. One possible explanation is that the benefits of ESG practices depend on how effectively companies transform ESG-related information into strategic inputs. BI is an internal capability that is often not thought of in this context. Many people think of BI as just a way to speed up the flow of information, but Qaffas et al. (2023) emphasized BI is a strategic technology to handle, combine, and improve ESG information. This relationship is highly relevant because companies that do not have a robust information processing system may find it difficult to translate ESG activities into measurable value for investors. Moreover, Wang & Xia (2024a) emphasize that BI supported by strong information governance can improve a company's overall performance. Similarly, the results from Lim & Teoh (2020) show that strategic BI implementation can strengthen a company's ESG performance. These results show that BI not only makes ESG reporting better, but it also strengthens the ESG activities increase a firm's value, especially through data-driven decision-making and better internal efficiency.

OECD (2024) shows that Indonesian companies' investments in Artificial Intelligence (AI) technology have grown rapidly since 2020, going from almost nothing before 2019 to more than US$ 0.2 billion (around Rp 34.58 trillion) in the first quarter of 2024. The significant increase investment shows that Indonesia is beginning to strengthen its capabilities in AI and BI to increase corporate value. In Indonesia, the integration of BI for ESG purposes remains constrained, despite the ongoing expansion of digital investment. Research conducted so far has examined at BI as a strategic or mediating tool (Qaffas et al., 2023). However, the moderating role on the links between ESG performance and firm value in Indonesia has not been examined. This gap highlights the importance of determining whether the increasing adoption of technology in Indonesia can reduce inconsistent results for ESG performance and firm value that were identified in earlier studies.

This research offers both theoretical and practical contributions. The proposed approach develops signal theory by establishing a conceptual framework that identifies BI as a moderating variable. When BI facilitates the processing, integration, and presentation of ESG information, it can enhance company value by improving ESG disclosure. BI provides high-quality, timely, and reliable ESG information. Consequently, investors have a better understanding of the company. Companies can demonstrate more effectively that they are utilizing business intelligence to meet their ESG responsibilities. Consistent indicators contribute to increasing firm value over the long term. This study stresses the key role of management in executing effective BI governance, facilitating organizations to produce high-quality information for internal decision-making and external stakeholders.

ESG on Firm Value

Legitimacy theory by Suchman (1995) holds that companies use ESG programs to gain approval and acceptance from society. By using ESG programs, companies try to show that their choices are based not just on making money but also on doing what is right and being responsible to society. Sharing information about ESG programs is a good way for companies to gain public approval, thereby improving their reputation and increasing their value. Several earlier studies have supported this idea. Melinda & Wardhani (2020) and Maji & Lohia (2023) found that ESG disclosure serves as an effective legitimacy mechanism that enhances firm value, especially in Asian and Indian contexts. ESG activities increase transparency and minimize information asymmetry between companies and investors, thereby reducing perceived market uncertainty and risk. This situation will assist them in making strategic decisions. The impact of ESG is to increase the confidence of capital providers and ultimately drive an increase in company value (Adeneye et al., 2023; Bagh et al., 2024). The implementation of ESG in companies is also associated with efforts to gain legitimacy. According to legitimacy theory, ESG performance and disclosure help companies build stakeholder trust. This legitimacy reduces risk perception and makes it easier

for companies to obtain lower-cost financing (Eliwa et al., 2021). In the context of Asian countries, ESG also contributes to increasing firm value, including the resilience and long-term sustainability (Melinda & Wardhani, 2020).

The projects reduced operational and regulatory risk, which is beneficial for the firm value. The social aspect includes things like protecting human rights, keeping workplace safe at work, and getting involved in the community (Wasiuzzaman et al., 2023). All of these contribute to higher productivity, lower turnover, and a better public image, which considered as factors that improve firm value. The governance aspect, on the other hand, stresses openness, responsibility, moral management through compliance, internal controls, a reducing conflict of interest (Kuzey et al., 2023). Strong governance reduces information more equal and builds investor trust, which raises firm value. Empirical evidence supports these mechanisms, indicating that companies with strong ESG performance can increase their value because they are able to better control risks and have superior operational competencies that provide quality assurance for stakeholders (Angir & Weli, 2024; Fatemi et al., 2018). Overall, consistent ESG implementation improves reputation, enhances operational resilience, and fosters lasting growth, all of which result in higher firm value. According to above description, the hypothesis proposed in this research is:

H_1: ESG performance has a positive impact on firm value.

Business Intelligence as a Moderator in the ESG–Firm Value Relationship

According to Spence (1973) signalling theory, a company can reduce information asymmetry by sending credible signals between management and investors. One thing that shows how committed a company is to sustainability is the concrete way that it uses ESG practices to promote good governance, long-term sustainability, and social responsibility. Any quality information from a company to investors will signal to investors and increase the firm's value (Fatemi et al., 2018). In accordance with this theory, companies are expected to convey favourable information to external parties to strengthen market valuation. Several studies support this theory, as shown in Azimli and Cek (2024) research, which states that ESG disclosure can reduce the inequality in investor perceptions of a company.

In addition, according to Madison and Schiehll (2021), publicly available ESG information does not fully meet investor needs, both due to differences in disclosure compliance levels and companies' limitations in adequately explaining material ESG information. These limitations can reduce the relevance of ESG information in investment decision-making and weaken its influence on company value. Therefore, Ahmad et al. (2023) emphasizes the importance of integrating smart technology in sustainability reporting. Technology facilitates the automation of ESG data collection and analysis, resulting in more accurate and timely information. Chen and Zhang (2025) demonstrate that the deployment of smart technology within organizations can enhance ESG performance. Integrating business intelligence into company operational processes can improve environmental, social, and governance practices.

Qaffas et al. (2023) demonstrate that big data analytics capabilities improve BI infrastructure, accordingly, improving company performance through more effective information management. Similarly, Liu et al. (2025) find that uniting artificial intelligence and digital transformation is a key determinant of successful ESG strategy implementation. Technological improvements improve information quality and support more accurate decision-making. Additionally, Ningtyas et al. (2026) provide evidence for legitimacy theory by showing that the application of technology in ESG activities increases disclosure and reporting credibility, thereby strengthening stakeholder belief. By upgrading data integration, analytical capacity, and quality of information disclosure, BI empowers companies to manage ESG initiatives more effectively, thereby increasing market value and financial indicators. Therefore, the moderation hypothesis proposed in this study is:

H_2: BI strengthens the positive association between ESG performance and firm value.

2. METHOD

The study population comprises approximately 800 non-financial companies that were listed on the Indonesia Stock Exchange (IDX) between 2018 and 2023. The sample method employed was purposive sampling. The first screening was based on Refinitiv companies with ESG data, totalling 68 of this data, 33 companies lacked complete ESG data for the 2018–2023 period. To ensure data validity and integrity in the longitudinal study, only companies with complete ESG data for five to six consecutive years were included in the analysis. Based on these criteria, only 35 companies (210 observations) were selected.

This study did not use financial services companies. The restriction was made considering that companies in the financial sector, such as banking, insurance, and financing institutions, have regulatory characteristics, reporting structures, and business models that are fundamentally different from those in the non-financial sector. Financial industry companies are subject to more comprehensive disclosure requirements and are under strict monitoring (Subhani et al., 2025). Following the sample selection process presented in Table 1, only 35 firms met

the study criteria. This relatively small number is primarily due to the limited availability and consistency of ESG data in the Refinitiv database for non-financial companies listed on the Indonesia Stock Exchange during the 2018–2023 period. This condition indicates that ESG disclosure practices in Indonesia are still developing. Consequently, the limited sample size may restrict the generalizability of the study's findings. As a result, only 201 observations were analysed in this study, as shown in Table 1.

Table 1. Summary of Purposive Sampling of Non-financial Companies Listed on the IDX

No	Research Criteria	Total
1	Companies of non-financial sector listed on the IDX	800
2	Companies that do not have ESG data based on the Refinitiv database	(732)
3	Companies ESG data for the 2018-2023 period is unavailable sequentially	(33)
4	Companies that have complete ESG data for 6 consecutive years in the period 2018–2023	35
5	Total observation companies in the period 2018-2023	210
6	Firm-year observations with incomplete control variable data	(9)
7	Firm-year observations used in study	201

Table 2 shows all the variables in this research. The independent variable is Environmental, Social, and Governance (ESG). Dependent variables are firm value represented by the natural logarithm of Tobin's Q (FV/TQ). Additionally, this study includes leverage (LEV), inventory intensity (INVINT), sales growth (SG), government policy (GOVPOL) denotes as a control variable. And it employs business intelligence (BI) as moderating variable.

Table 2. Variable Definitions and Measurements.

Variable	Definition	Measurement
ESG	Score represents the level of disclosure of information related to ESG (Kuzey et al., 2023; Wasiuzzaman et al., 2023).	*ESG overall score* (Refinitiv)
FV	Firm value shows how confident the market is, how well the company is doing financially, and how much it could grow in the future (Wong et al., 2021).	$Tobin's\ Q = \frac{Market\ Value\ of\ Equity\ (MVE)}{Book\ Value\ of\ Total\ Assets}$
BI	BI is a set of methods, processes, and technologies that organizations use to collect, process, analyze, and present data (Bahrami & Shokouhyar, 2022a; Balachandran & Prasad, 2017).	The study measured BI using 24 keywords, including Optimization, Regression, Simulation, Data Visualization, Dashboard, Open System Network, Data Warehouse, Big Data, Cloud-Based Service, SQL, Data Mining, Dynamic Capability View, Innovative Capabilities, MapReduce, Business Intelligence, Database, Power BI, Sales Data Analysis, Data Synchronization, Operational Efficiency, Predictive Analytics, ERP, SAP, and Accurate. Each keyword is assigned a binary value, where K_i =1 if the company demonstrates the presence of the keyword, and K_i = 0 otherwise. The BI score is calculated as $BI\ Score = \frac{\sum_{i=1}^{24} K_i}{24}$ where K_i represents the score of keyword *i*. The resulting *BI score* ranges from 0 to 1, where 0 indicates

		no BI adoption and 1 indicates full adoption across all BI keywords.
LEV	Denote financial risk that can influence market perception (Aboud & Diab, 2018; Aydoğmuş et al., 2022).	$Leverage = \frac{Total\ Liability}{Total\ Assets}$
INVINT	The ratio shows how much of a company's assets are in the form of inventory (Fan & Chen, 2023).	$Inventory\ Intensity = \frac{Total\ Inventory}{Total\ Assets}$
SG	A measure of how well a business is operating (Wang & Xia, 2024; Ye et al., 2020).	$Sales\ Growth = \frac{Current\ Period\ Sales - Prior\ Period\ Sales}{Pri\ or\ Period\ Sales}$
GOVPOL	An external factor that can affect the business climate (World Bank, 2018-2023). Government policy is measured using six dimensions of indicators from the Worldwide.	Governance Indicators (WGI): voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption. These six indicators reflecting the governance quality, which can affect the business environment and strategic decisions of companies, such as how they implement ESG. WGI indicator values are multiplied by the size of firm.

3. RESULT AND DISCUSSION

Table 3 reports the summary statistics for 201 firm-year observations. Firm value (LogTQ) shows considerable variation (mean = -0.285; S.D. = 1.06). The average ESG score is 52.8, indicating a moderate level of ESG engagement with substantial dispersion (S.D. = 18.5). Leverage (mean = 0.256) indicates a moderate reliance on debt financing. Sales growth (LogSG) and inventory intensity (LogINVINT) demonstrate considerable variability across firms, whereas government policy (GOVPOL) remains relatively stable throughout the observation period. BI, with a mean of 0.267, shows a low to moderate level of implementation. The transformed variables exhibit approximately symmetric distributions, with no evidence of extreme skewness. Logarithmic transformations effectively stabilize the dispersion of firm value, inventory intensity, and sales growth. The dataset demonstrates adequate cross-sectional variability, supporting reliable regression estimation.

Table 3. Descriptive Statistics

Variable	N	Mean	Median	*S.D.*	Minimum	Maximum
LogTQ	201	-0.285	-0.288	1.060	-2.830	2.840
ESG	201	52.800	53.200	18.500	13.100	89.200
LEV	201	0.256	0.223	0.191	0.000	0.785
LogINVINT	201	-2.840	-2.460	1.540	-6.650	-0.578
LogSG	201	0.604	0.585	0.291	0.000	4.230
GOVPOL	201	1.48e+03	1.48e+03	61.500	1.33e+03	1.66e+03
BI	201	0.267	0.250	0.129	0.042	0.625

Source: Gretl output

Notes: ESG: of Environmental, Social, and Governance, LEV: Leverage, LogINVINT: Log Inventory Intensity, LogSG: Log Sales Growth, GOVPOL: Governance Policy, BI: Business Intelligence, LogTQ: Log Tobin's Q.

This regression model tests the influence of ESG variables on firm value, measured by LogTQ as the dependent variable. In addition, this regression also analyses whether moderator variables influence the association between independent variables and dependent variables. Gretl was used to process the data. The multiple linear regression equation proposed in this study is as follows:

$$LogTQ_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 LEV_{it} + \beta_3 LogINVINT_{it} + \beta_4 LogSG_{it} + \beta_5 GOVPOLit + \varepsilon_{it} \quad (1)$$

$$LogTQ_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 LEV_{it} + \beta_3 LogINVINT_{it} + \beta_4 LogSG_{it} + \beta_5 GOVPOL_{it} + \beta_6 BI_{it} + \beta_7 (ESG_{it} \times BI_{it}) + \varepsilon_{it} \quad (2)$$

where: TQ is Tobin's Q, which represents the market value of a company; ESG is an environmental, social, and governance score of company; BI is a business intelligence of company; ESG×BI is an interaction of ESG score with business intelligence of company; LEV is a leverage of company; LogINVINT is an inventory intensity of company; LogSG is a sales growth company; GOVPOL is a government policy of company; ε it is an error.

Table 4. Pearson Correlation Matrix

	LogTQ	ESG	Lev	LogINVINT	LogSG	GovPol	BI
LogTQ	1.0000	0.1393	-0.5399***	0.2278***	-0.0856	-0.3638***	-0.2385***
ESG		1.0000	-0.2877***	-0.2542***	0.1546*	0.1337	0.4390***
LEV			1.0000	-0.4934***	0.0196	0.1779*	0.1588
LogINVINT				1.0000	-0.0578	-0.2368***	-0.4989***
LogSG					1.0000	0.0121	0.0051
GOVPOL						1.0000	0.2036***
BI							1.0000

Note(s): ***p < 0.01, **p < 0.05, *p < 0.1

Table 4 presents the correlation matrix. Firm value (LogTQ) is negatively correlated with leverage (LEV), government policy (GOVPOL), and business intelligence (BI), indicating that these variables move in opposite directions. Conversely, LogTQ is positively correlated with capital intensity (LogINVINT). ESG shows a positive correlation with BI and sales growth (LogSG), but a negative correlation with LEV and LogINVINT. GOVPOL demonstrates negative correlations with LogTQ and LogINVINT, but positive correlations with BI and LEV. ESG does not show a significant correlation with LogTQ, suggesting that investors may prioritize financial measures over sustainability disclosures when valuing firms. All correlation coefficients are below 0.80, indicating no serious multicollinearity concerns.

Table 5. Multicollinearity Test Results (Variance Inflation Factor)

ESG	LEV	LogINVINT	LogSG	GOVPOL	BI
1.741	1.409	1.576	1.040	1.085	1.586

The Variance Inflation Factor (VIF) values presented in Table 5 range from 1.040 to 1.741, which is substantially below the commonly accepted threshold of 5. These results indicate an absence of multicollinearity among ESG, LEV, LogINVINT, LogSG, GOVPOL, and BI, thereby confirming the suitability of these variables for regression analysis.

Panel model selection was conducted using the Breusch–Pagan and Hausman tests. Breusch–Pagan LM test (LM = 322.837; ρ-value < 0.001) rejected the pooled ordinary least squares model, indicating that a panel model was more appropriate. The Hausman test produced a statistic of 12.2504 with a ρ-value of 0.0315 (< 0.05), which led to the rejection of the Random Effects model's consistency. Therefore, the Fixed Effects model was chosen because this model considers individual heterogeneity related to independent variables.

Table 6 shows the results for how ESG, LEV, LogINVINT, LogSG, and GOVPOL affect firm value LogTQ. The F-test indicates that the model is significant overall (F = 18.327; ρ-value < 0.001), indicating that the independent variables together influence the dependent variable. The R^2 value increased from 0.3051 in Table 6 to 0.3278 in Table 7, indicating an increase in explanatory power of 2.27 percentage points or approximately 7.44%. This indicates that adding BI as a moderator variable enhances the model's ability to predict firm value.

Table 6. Regression Results for Model 1

	Coefficient	Std. Error	t-ratio	ρ-value
Const	5.3530	1.3980	3.830	0.0005***
ESG	−0.0102	0.0049	−2.079	0.0452**
LEV	−1.2290	0.6453	−1.905	0.0652*
LogINVINT	0.1409	0.1085	1.299	0.2028
LogSG	−0.0222	0.1095	−0.202	0.8409
GOVPOL	−0.0029	0.0010	−2.936	0.0059***
Within R^2	0.3051			
S.E. of regression	0.3258			
Prob (F-statistic)	0.0000			

F-statistic	18.327***

Source: Gretl output
Note(s): *** ρ < 0.01, ** ρ < 0.05, * ρ < 0.1

The test findings in Table 6 show that ESG has a negative, statistically significant effect on firm value (β = −0.0102, ρ-value = 0.0452), thereby rejecting H_1. This result differs from several studies in Indonesia that argue that ESG is very important not only for increasing firm value but also for demonstrating the company's resilience and sustainability (Meini & Setijaningsih, 2024; Pardamean & Gunawan, 2025). This result indicates that a higher ESG score leads to a lower firm value. This finding is consistent with Angir & Weli (2024), Fatemi et al. (2018), Siva Anindhita Yori & Putri Rahmawati (2025), and Sumarno et al. (2023) which shows that ESG practices in Indonesia have not been responded to positively and have even lowered firm value. Investors do not always view more ESG reporting as increasing a company's value. This is because it regularly involves significant expenses and complex processes that do not yield rapid financial returns. Consequently, ESG activities are frequently perceived as an extra cost that may reduce expected profits and potentially lower the value of the company (Firmansyah et al., 2023). At the international level within ASEAN, Prabawati and Rahmawati (2022) was found that when companies have high ESG scores, it causes their value to decrease. Therefore, this situation is not beneficial for companies with high ESG scores.

These results do not completely support the signalling theory, which states that voluntary disclosure sends a positive signal about a company's long-term prospects. Instead, investors mainly focus on profitability as the main indicator of firm performance and prospective returns, while non-financial factors such as ESG receive less attention (Prasetyo et al., 2025; Siva Anindhita Yori & Putri Rahmawati, 2025). As a result, ESG disclosure may be seen as a financial load rather than a way to add value. This view is consistent with Truong (2025), who finds that shareholders in ASEAN countries still view ESG investment as an additional financial cost for firms. Among the control variables, GOVPOL also has a negative, highly significant effect (β = −0.0029, ρ-value = 0.0059), suggesting that changes in policy conditions are associated with a decline in firm value. LEV has a negative effect at the 10% significance level (β = −1.2290, ρ-value = 0.0652), showing a slight negative link with firm value (Renaldo et al., 2023). In contrast, LogINVINT and LogSG do not have significant effects, as shown by their higher p-values (ρ-value > 0.05).

The addition of the BI variable, which acts as a moderator in the relationship between ESG and firm value, maintains the significance of model 2 in Table 7 (F (7,34) = 18.227, ρ-value < 0.001)). These findings indicate that the moderating effect of BI does not weaken the model but rather strengthens its ability to describe the variation in the dependent variable.

Table 7. Regression Results for Model 2 (with Moderation)

	Coefficient	std. error	t-ratio	p-value
Const	5.8927	1.3924	4.232	0.0002***
ESG	−0.0242	0.0079	−3.068	0.0042***
LEV	−1.1825	0.6614	−1.788	0.0827*
LogINVINT	0.1951	0.1053	1.852	0.0727*
LogSG	−0.0045	0.1143	−0.040	0.9686
GOVPOL	−0.0027	0.0010	−2.710	0.0105**
BI	−3.1610	1.5472	−2.043	0.0489**
ESG×BI	0.0550	0.0264	2.081	0.0450**
Within R-squared	0.3278			
S.E. of regression	0.3225			
Prob (F-statistic)	0.0000			
F-statistic	18.227***			

Source: Gretl output
Note(s): ***p < 0.01, **p < 0.05, *p < 0.1

Table 7 indicates that BI has a significant negative effect on firm value (β = −3.161, ρ-value < 0.05), suggesting that increased investment in BI is perceived by investors as a cost, thereby reducing expected returns. These results support Rana et al. (2022) who argue that high BI, if not supported by adequate governance, data quality, and employee training, can result in operational inefficiencies and suboptimal decisions. Although BI solutions have the potential to increase profitability and reduce risk, their challenging implementation can incur significant expenses and inefficiencies, leading to BI investments being viewed as a financial burden that reduces company value (Yiu et al., 2021). Several previous studies also support these outcomes. For example, Bahrami & Shokouhyar (2022) emphasized that BI can become an inefficient solution if not suitably managed, while Rana et

al. (2022) showed that uniting business analytics with AI may have negative consequences when implementation errors occur or when the system is incompatible with enterprise needs.

In Table 7, although ESG has a negative effect on firm value, the interaction between ESG and BI shows a positive effect (β = 0.055, ρ-values < 0.05). So that the H_2 hypothesis was proven. The positive moderating role of BI shows that BI reduces the negative effect of ESG on company value. The correlation between ESG and BI is positive and significant, also demonstrating that BI's ability transforms ESG from a cost that reduces value to an investment that increases value. This indicates that BI can help companies manage and communicate ESG initiatives effectively, changing the market's unfavourable perception of ESG.

Previous research shows that BI does not always directly increase firm value due to high implementation costs in the early stages. However, according to Wahua and Yonney Ahlijah (2020), BI provides long-term strategic benefits by improving decision-making quality and the effectiveness of corporate strategies. In the context of this study, BI serves as a factor that strengthens ESG's influence on firm value, rather than a direct driver of firm value.

This means that ESG is not enough without ESG data management facilitated by BI, which can affect company value. These results support the research of Heredia et al. (2022) which shows that technological capabilities can strengthen the influence of digital capabilities on company performance. In this study, BI is considered a technological capability that can strengthen ESG's influence on company value. These results also support Ningtyas et al. (2026) findings that the application of technology in ESG activities increases the transparency and credibility of reporting, thereby strengthening stakeholder trust. They also support Liu et al. (2025) findings that the existence of AI and digital transformation determines the success of ESG strategy implementation.

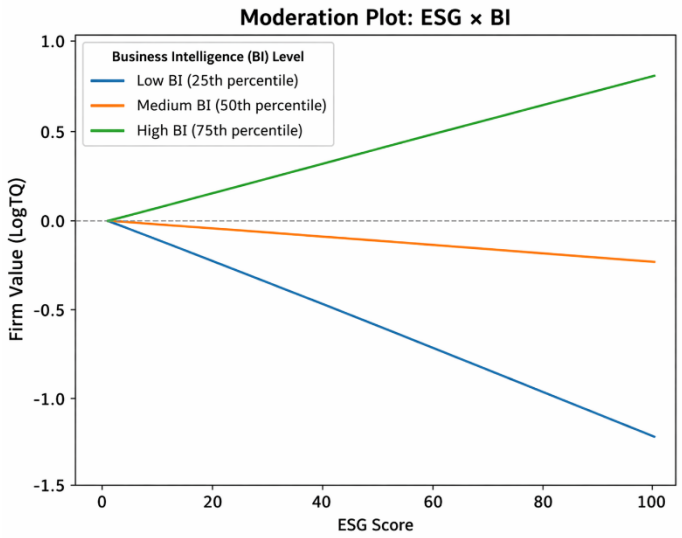

Figure 1. Interaction Plot: The Moderating Effect of BI on the ESG-FV Relationship
Source: Output processed from Gretl

The ESG×BI moderation plot in Figure 1 supports the interaction test findings by showing the correlation between ESG and firm value at different BI levels. To identify the region of significance in the moderation interaction, this study uses the Johnson-Neyman technique introduced by Johnson and Neyman (1936), which determines the threshold value at which the effect of the independent variable on the dependent variable changes significantly. The regression equation used is:

$$LogTQ = \beta_0+\beta_1 ESG+\beta_2 BI+\beta_3(ESG\times BI) + \varepsilon \quad (3)$$

where: β_1 is ESG coefficient, β_3 is ESG×BI interaction coefficient, and BI is BI rate.

To determine the BI threshold value in the correlation between ESG and firm value, a marginal effect analysis of the moderation model was used. Mathematically, the marginal effect of ESG on firm value is formulated as follows

$$\frac{\partial(LogTQ)}{\partial ESG} = \beta_1 + \beta_3(BI) \quad (4)$$

The threshold value is obtained by equating the marginal effect with zero, based on Table 7, β1=−0.0242 and β3=0.0550, so that −0.0242 + 0.0550×BI=0

$$BI(Threshold) = \frac{0.0242}{0.0550} \approx 0.44$$

The analysis results show that the BI threshold is 0.44. Importantly, BI is treated as a continuous variable in the regression analysis. Therefore, this threshold does not represent a binary classification, but rather indicates the level of BI at which the marginal effect of ESG on firm value changes sign. When BI < 0.44, the effect of ESG on firm value is negative (shown by the blue line), which means that ESG reduces the value of the company. When BI approaches 0.44, the impact of ESG becomes neutral (orange line). Meanwhile, when BI > 0.44, the impact of ESG becomes positive (green line), indicating that ESG increases firm value.

Figure 1 demonstrates that BI enhances the effect of ESG factors on company value. At low BI levels, increased ESG engagement reduces company value, suggesting that, in the absence of sufficient analytical competence, investors perceive ESG initiatives as a cost burden without direct economic benefits. At moderate BI levels, the negative impact of ESG diminishes, indicating that improved analytical capacity increases the relevance of ESG information. At high BI levels, ESG positively influences company value, suggesting that BI enables firms to manage, analyse, and communicate ESG information to investors more effectively.

These findings indicate that BI plays an important role in changing the direction of the relationship between ESG and company value from negative to positive. Therefore, the effectiveness of ESG in creating company value is highly dependent on the company's ability to utilize BI governance to improve the quality, transparency, and credibility of its information. This finding is in accordance with the research by Han & Lee (2024), which shows that ESG interacts with digital capabilities to influence corporate business performance. However, unlike that study, which placed ESG as a moderating variable, this study places BI as a moderating variable in the relationship between ESG and company value. Nevertheless, both studies consistently show that the interaction between ESG and information technology plays an important role in increasing company value.

4. CONCLUSION

The implementation of ESG in companies is not automatically perceived positively by investors, as it is still considered a form of normative compliance that incurs costs without providing direct economic benefits. This perception is reflected in company value, where ESG has been shown to depress firm value due to high implementation costs and uncertainty about short-term benefits. These findings indicate that investors tend to use a cost-benefit perspective when evaluating ESG investments, suggesting that ESG has not yet created economic value that increases company value when the available information is not relevant.

However, the findings of this study indicate that BI plays an important role as a moderating variable in this relationship. Although BI does not directly increase firm value, it can improve the effectiveness of ESG implementation by improving the quality of information, strengthening internal control systems, and improving the company's analytical capabilities. With BI, ESG information becomes more transparent, credible, and relevant to investors, thereby helping to reduce scepticism and improve ESG's ability to create company value. These findings support legitimacy theory and signalling theory, which describe that ESG implementation alone is not enough to elicit a positive response from investors without the support of an information system that can improve the credibility and transparency of information. In this case, BI does not directly increase company value, but through its interaction with ESG, BI is able to strengthen the influence of ESG on firm value.

In theory, this study supports legitimacy theory. Companies implemented ESG practices to gain stakeholder approval, but this approval only occurs when stakeholders believe these practices are genuine and deliver financial benefits. Without strong information system support, ESG is often seen as an extra cost, creating a gap in which investors do not see it as adding value. In practice, this study shows that using BI in ESG management is very important, so that ESG is seen to get ahead of competitors and create long-term value, rather than just a cost.

This study has several limitations. First, because it only considers non-financial companies in Indonesia, the results might not apply to other types of businesses or locations. Second, the data spans 2018 to 2023, including the COVID-19 pandemic, a period that changed how companies handle ESG and how investors behave. This is primarily due to the limited availability and continuity of ESG data in the Refinitiv database during the 2018–2023 period. Third, the relatively small sample size is mainly due to the limited availability and continuity of ESG data in the Refinitiv database during the 2018–2023 period. Finally, since the study considers only one country, it cannot compare how rules and systems across countries affect the link between ESG and company value. Upcoming research should address this study's deficiencies by including financial institutions and additional industrial sectors and by using data from multiple countries. A complete study of ESG factors and BI is needed to understand their complex effects. Comparing results across countries and sectors will help clarify how ESG and BI interact in different institutional, economic, and regulatory settings, hence strengthening the generalizability of the findings. A key limitation is that BI is measured using keyword-based disclosure, which reflects signalling rather than actual implementation or usage intensity. Future research should employ more direct measures, such as system adoption or BI investment.

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