



ESG Performance and Investment Efficiency in Sharia-Compliant Firms: Evidence from the JII-70

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Abstract: This study examines whether Shariah-compliant ESG performance enhances investment efficiency among firms included in the Jakarta Islamic Index 70 (JII-70) and how board characteristics condition this relationship. Using a balanced panel of 25 firms consistently listed in the Jakarta Islamic Index 70 (JII-70) from 2020–2023 (100 firm-years), this study measures investment inefficiency as the residual from an expected-investment model, where smaller absolute residuals indicate higher investment efficiency. Fixed-effects panel regressions with White cross-section robust errors are employed after Chow, Hausman, and diagnostic tests. The results show that ESG scores are negatively and significantly associated with investment inefficiency in most specifications, implying that stronger ESG performance improves capital allocation. Board gender diversity reduces inefficiency on average but weakens the marginal efficiency gains of ESG. Board independence does not significantly moderate the ESG–efficiency link. By contrast, board nationality diversity reinforces the positive effect of ESG on efficiency, while larger boards tend to increase the baseline level of inefficiency. Overall, the findings indicate that governance configuration plays a critical role in translating Shariah-aligned ESG initiatives into more efficient investment decisions among JII-70 constituents.

Keywords: Board characteristics, ESG, investment efficiency, Jakarta Islamic Index 70

1. INTRODUCTION

1.1 Background

Global momentum toward cleaner energy has accelerated sharply in recent years, with renewable-energy investment expanding and new sustainable-finance instruments proliferating. In Indonesia, the energy transition is particularly capital intensive: estimates suggest that achieving a credible shift from fossil fuels to renewables will require tens of billions of US dollars in cumulative investment over the coming decade. Policy initiatives such as the Just Energy Transition Partnership (JETP) and repeated issuances of Green Sukuk illustrate the government's commitment to mobilising large volumes of transition finance and directing them toward low-carbon infrastructure and nature-based solutions. In this landscape, investors and policymakers increasingly emphasize not only how much capital is raised, but whether that capital is deployed efficiently in projects aligned with long-term value creation.

Investment efficiency (IE) is central to this agenda. IE captures the degree to which a firm's realised capital outlays align with its underlying growth opportunities, minimising misallocation arising from under- or over-investment (Biddle et al., 2009; Engida et al., 2022). Empirical research typically measures IE using a residual-based

approach: expected investment is modelled on fundamentals such as sales growth, and the deviation of actual investment from this benchmark is interpreted as inefficiency (Engida et al., 2022; Farooq et al., 2022). Larger absolute residuals indicate that firms are either investing too little in value-creating projects or too much in projects with weak fundamentals, both of which can erode firm value and undermine the effectiveness of transition finance (Hammami & Hendijani Zadeh, 2019; Harymawan et al., 2022).

At the same time, environmental, social, and governance (ESG) performance has emerged as a key lens through which investors assess firms' long-horizon risks and opportunities. Strong ESG practices and transparent disclosure can build stakeholder trust, reduce information asymmetry, and ease access to capital, which in turn supports a more disciplined investment environment (Albuquerque et al., 2019; Chen et al., 2023; Gillan et al., 2021). These dynamics are particularly salient in capital-intensive, transition-exposed sectors where misallocation of funds has large and persistent consequences. For Indonesia's Shariah-compliant segment, represented by the Jakarta Islamic Index 70 (JII-70), ESG is also intertwined with Islamic principles emphasising fairness, accountability, and stewardship, making

the link between ESG, governance, and IE especially relevant.

Despite rapid growth in both ESG-linked financing and the IE literature, important gaps remain in emerging markets. Existing studies document that higher ESG performance and CSR disclosure are often associated with greater investment efficiency, yet integrated evidence on how specific board characteristics condition this relationship is still limited—particularly in transition-era Indonesia. In a setting where sustainable-finance commitments are expanding and governance quality can either safeguard or squander scarce capital, understanding the joint roles of ESG and board design in shaping IE becomes an urgent empirical and policy question.

1.2 Theoretical Review

Investment efficiency (IE) is commonly defined as the extent to which a firm's investment policy matches its set of positive-net-present-value opportunities, thereby minimising both under-investment in profitable projects and over-investment in value-destroying ones (Biddle et al., 2009; Engida et al., 2022). Empirically, IE is proxied by residuals from expected-investment models that relate investment to fundamentals such as sales growth and other firm characteristics; in this framework, larger absolute residuals signal greater misalignment—and hence lower efficiency—while residuals closer to zero indicate more efficient capital allocation (Engida et al., 2022; Farooq et al., 2022; Chen et al., 2011). This approach has been widely used to analyse how disclosure quality, CSR/ESG performance, and governance mechanisms affect firms' ability to channel capital into value-enhancing uses (Hammami & Hendijani Zadeh, 2019; Harymawan et al., 2022; Zamir et al., 2020).

ESG performance encompasses outcomes and practices across environmental, social, and governance dimensions, including the transparency of related disclosures. Stakeholder Theory posits that firms should attend to the interests of multiple stakeholder groups rather than shareholders alone; under this view, strong ESG practices build stakeholder trust, reduce information asymmetry, and foster a more favourable financing environment in which capital providers are more willing to support long-term projects (Freeman & Dmytriiev, 2017; Seow, 2024; N. Wang et al., 2024). Transparent ESG disclosure allows stakeholders to better assess risk and performance, easing financing frictions and encouraging more careful project screening (Cheng et al., 2014; Alsayegh et al., 2022; Jones et al., 2017). Agency Theory complements this perspective: high ESG performance is seen as a mechanism that aligns managerial and shareholder interests, constrains opportunistic behaviour, and serves as a credible signal of commitment to responsible conduct, thereby lowering monitoring costs and supporting more efficient investment decisions (Cook et al., 2019;

Hasnan et al., 2020; Samet & Jarboui, 2017; W. Wang et al., 2022). Together, these theories suggest that stronger ESG should improve IE by tightening project selection and mitigating misallocation.

Board characteristics provide an important internal governance channel through which ESG can be translated into concrete investment outcomes. Within an Agency framework, board size, independence, and diversity influence monitoring capacity, information flows, and the alignment of interests. An optimally sized board aggregates diverse expertise and improves oversight, whereas very large boards may suffer from coordination problems and diluted accountability (M. Ali, 2018; Elmghamez et al., 2024; Rossi et al., 2021). Board independence—captured by the proportion of non-executive, independent directors—is expected to enhance oversight of ESG initiatives, reduce agency frictions, and embed sustainability considerations into capital-budgeting routines (Ortas et al., 2017; Kyere & Ausloos, 2021; Salehi et al., 2022). Gender diversity on boards is associated with greater prudence, stronger stakeholder orientation, and richer ESG disclosure, channels that can support higher IE through improved screening and monitoring of investment projects (Birindelli et al., 2018; Shin et al., 2020; Farooq et al., 2023; Almutairi et al., 2025). Nationality diversity brings broader regulatory and cultural insight, enabling boards to align ESG practices with both local and international expectations and to navigate complex sustainability demands more effectively (Al-Hiyari et al., 2022; McGuinness et al., 2017; Shu et al., 2024).

These strands of theory and evidence converge on the idea that ESG and board characteristics jointly shape investment outcomes. ESG performance can create a governance-related foundation for disciplined capital allocation, but the extent to which ESG translates into higher IE is likely to depend on who sits on the board, how decisions are made, and how effectively ESG information is incorporated into strategic choices. In an emerging-market, transition-exposed context such as Indonesia's JII-70, where firms face both heightened sustainability expectations and significant investment needs, examining these interactions is particularly salient.

1.3 Research Hypotheses

Drawing on the Stakeholder and Agency perspectives and the IE literature, the first hypothesis focuses on the direct link between ESG performance and investment efficiency. Strong ESG practices and disclosure are expected to enhance transparency, reduce information asymmetry, and improve access to capital, thereby facilitating better screening and monitoring of investment projects. From an Agency standpoint, ESG can be viewed as an additional governance mechanism that aligns managerial choices with

long-term value creation. Accordingly, the study's baseline proposition is:

H1: ESG performance positively affects investment efficiency.

The remaining hypotheses examine whether board characteristics moderate this relationship. Board size reflects the scale of the board as a monitoring body. Within the Agency framework, an appropriately sized board can strengthen oversight of ESG commitments and ensure that sustainability information is effectively integrated into investment decisions. Larger boards may bring more diverse expertise and capacity to scrutinise complex ESG-intensive projects, potentially enhancing the way ESG supports IE, provided that coordination costs remain manageable (M. Ali, 2018; Elmghaamez et al., 2024; Al-Hiyari et al., 2025). This leads to the second hypothesis:

H2: Board size positively moderates the relationship between ESG performance and investment efficiency.

Board independence is captured by the proportion of non-executive, independent directors on the board. Independent directors are expected to provide more objective oversight, reduce the likelihood of entrenchment, and ensure that ESG initiatives are aligned with shareholders' long-term interests. Prior studies suggest that higher independence is associated with stronger ESG performance and better investment decisions, in part because independent directors can more effectively challenge management and demand accountability for ESG-related risks and opportunities (Ortas et al., 2017; Kyere & Ausloos, 2021; Al-Hiyari et al., 2025). On this basis, the third hypothesis is:

H3: Board independence positively moderates the relationship between ESG performance and investment efficiency.

Board gender diversity reflects the share of female directors or the heterogeneity of gender representation on the board. Research links greater female representation to heightened risk awareness, stronger stakeholder orientation, and improved information flows, factors that can reduce over-investment and enhance IE (Elmghaamez et al., 2024; Shin et al., 2020; Farooq et al., 2023). Gender-diverse boards are also associated with enhanced ESG disclosure and closer alignment with social and environmental objectives, mechanisms that may reinforce ESG's ability to discipline capital allocation (Birindelli et al., 2018; Huang, 2022; Almutairi et al., 2025). Thus, the fourth hypothesis states:

H4: Board gender diversity positively moderates the relationship between ESG performance and investment efficiency.

Finally, board nationality diversity captures the presence and mix of directors from different national backgrounds. Institutional Theory emphasises that cultural norms and regulatory environments shape corporate behaviour; multinational boards bring broader regulatory and cultural insight, which can help firms design ESG practices that meet both domestic and international expectations and support more efficient investment choices (Al-Hiyari et al., 2022; Wasiuzzaman & Subramaniam, 2023). From an Agency perspective, nationality diversity can further align stakeholder interests and strengthen monitoring of ESG-relevant risks, particularly in globally exposed industries (McGuinness et al., 2017). Accordingly, the final hypothesis is:

H5: Board nationality diversity positively moderates the relationship between ESG performance and investment efficiency.

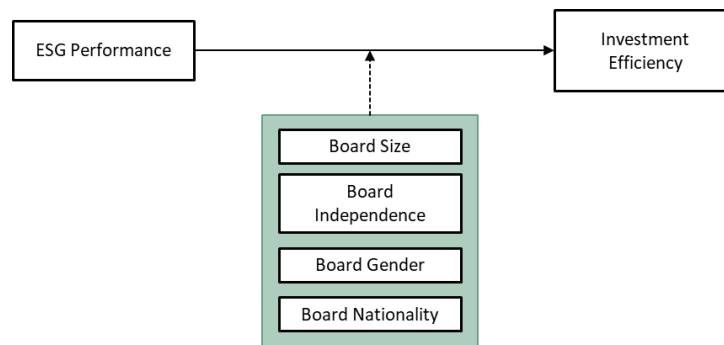


Figure 1. Research Framework

2. MATERIALS AND METHODS

This study employs a quantitative, explanatory research design to investigate whether Environmental, Social, and Governance (ESG) performance enhances investment efficiency and how board characteristics moderate this relationship among Jakarta Islamic Index 70 (JII-70) constituents. The data are structured as a balanced firm-year panel over the 2020–2023 period, enabling control for unobserved firm-specific heterogeneity and time-varying effects

when estimating the ESG–investment efficiency nexus and the role of board design.

2.1 Data and Sample

The study uses secondary data drawn from issuers' annual reports, sustainability reports, and financial statements, complemented with ESG scores from the Refinitiv database. The sampling technique is purposive, based on two core criteria: firms must (i) be consistently included in the JII-70 during 2020–2023, and (ii) have complete ESG scores available in Refinitiv for the same period.

These criteria ensure a balanced panel of observations, mitigate missing data problems, and enhance comparability of ESG measurement across firms. Applying these filters yields a final sample of 25 firms, producing 100 firm-year observations for analysis.

The sampled firms operate in a range of capital-intensive and sustainability-relevant sectors, including energy, mining, manufacturing, infrastructure, and consumer goods. Such sectoral diversity is important because investment decisions, risk profiles, and ESG exposure are likely to differ across industries, providing a rich cross-sectional variation in governance structures and sustainability practices. All financial and governance variables are constructed on an annual basis and aligned with the fiscal year corresponding to the ESG scores, so that each firm-year observation consistently reflects the same reporting period.

2.2 Variable Measurement

Investment efficiency (IE) is defined as the degree to which a firm’s investment outlays are aligned with its underlying growth opportunities, so that under- and over-investment are minimized. Consistent with prior work, IE is operationalized using a two-step residual-based approach in which investment is first modeled as a function of fundamentals such as sales growth and firm characteristics (Biddle et al., 2009; Engida et al., 2022; Farooq et al., 2022; Chen et al., 2011). The residual from this expected-investment model captures the deviation of actual investment from its benchmark and is interpreted as investment inefficiency: larger absolute residuals indicate more severe misallocation of capital, whereas values closer to zero imply more efficient investment behavior. In line with recent studies on IE and governance, the residual is retained as a continuous measure of investment inefficiency, so that empirical results must be read with the convention that a decline in IE corresponds to an improvement in efficiency (Engida et al., 2022; Harymawan et al., 2022; Zamir et al., 2020).

The key explanatory variable is ESG performance (ESG), understood as the firm’s aggregate performance and disclosure across environmental, social, and governance dimensions. Drawing on Stakeholder Theory, stronger ESG is expected to build stakeholder trust, reduce information asymmetry, and ease financing frictions, thereby supporting more disciplined capital allocation (Freeman & Dmytryiev, 2017; Cheng et al., 2014; Alsayegh et al., 2022; Jones et al., 2017). From an Agency

perspective, robust ESG policies and disclosure help align managerial and shareholder interests and function as a credible signal that lowers monitoring costs and narrows the scope for value-destroying projects (Hasnan et al., 2020; Samet & Jarboui, 2017; Cook et al., 2019; W. Wang et al., 2022). Following this literature, ESG is measured using the composite ESG score from Refinitiv, scaled between 0 and 1, where higher values denote better ESG performance and, conceptually, a stronger capacity to enhance investment efficiency (Chen et al., 2023; Huang, 2022; Zhou et al., 2022).

Board characteristics enter the model as moderators that condition the transmission of ESG into investment efficiency. Board size (B_SIZE) captures the scale of the board as a core internal governance mechanism that can either strengthen monitoring through a broader pool of expertise or weaken it when coordination costs dominate (M. Ali, 2018; Elmghaamez et al., 2024; Rossi et al., 2021). Board independence (B_IND), measured as the proportion of independent non-executive directors, reflects the capacity of the board to provide objective oversight, constrain managerial discretion, and embed ESG into capital-budgeting routines (Ortas et al., 2017; Salehi et al., 2022; Al-Hiyari et al., 2025). Board gender diversity (B_FEM), defined as the share of female directors, is theorized to be associated with greater risk awareness, stronger stakeholder orientation, and enhanced transparency, mechanisms that have been linked to both higher ESG quality and improved investment efficiency (Birindelli et al., 2018; Shin et al., 2020; Farooq et al., 2023; Almutairi et al., 2025). Board nationality diversity (B_NAT), proxied by the proportion of foreign directors, captures cross-border cultural and regulatory experience that can help firms interpret heterogeneous ESG expectations, deepen stakeholder engagement, and support more efficient allocation of capital in an increasingly globalized sustainability landscape (Al-Hiyari et al., 2022; McGuinness et al., 2017; Shu et al., 2024).

To isolate these effects, the empirical specification includes standard firm-level controls used in the IE literature, namely firm age, profitability, leverage, and size, which proxy for organizational maturity, internal resource-generation capacity, capital structure, and scale, respectively (Biddle et al., 2009; Engida et al., 2022; Harymawan et al., 2022).

A summary of variable operationalization is presented in Table 1.

Table 1. Operationalizations of Variable

Variable	Symbol	Operational definition	Measurement
Investment efficiency	IE	Deviation of actual investment from expected investment based on growth opportunities and fundamentals	Residual from investment model; smaller absolute value = higher efficiency

ESG performance	ESG	Firm-level sustainability performance on environmental, social, and governance dimensions	Refinitiv ESG score (0–1)
Board size	B_SIZE	Scale of the board of directors	Number of board members
Board independence	B_IND	Degree of board independence	Number of independent directors / total board members
Board gender diversity	B_FEM	Representation of female directors	Number of female directors / total board members
Board nationality diversity	B_NAT	Diversity of national backgrounds among directors	Number of foreign directors / total board members
Firm age	AGE	Corporate maturity	ln(years since listing)
Profitability	ROA	Firm's ability to generate earnings from assets	Net income / total assets
Leverage	LEV	Debt-based financing structure	Total liabilities / total assets
Firm size	SIZE	Economic scale of the firm	ln(total assets)

2.3. Research Model and Estimation Technique

The relationship between ESG performance, board characteristics, and investment efficiency is analyzed using panel-data regression, with firms as the cross-sectional units and years as the time dimension. The baseline model estimates the direct effect of ESG on investment efficiency while controlling for firm characteristics. Moderation is examined by including interaction terms between ESG and each board characteristic. In general terms, the empirical model can be written as:

$$IE_{it} = \alpha_i + \beta_1 ESG_{it} + \beta_2 B_{X_{it}} + \beta_3 (ESG_{it} \cdot B_{X_{it}}) + \delta_i$$

where IE_{it} denotes investment inefficiency for firm i in year t , ESG_{it} is ESG performance, $B_{X_{it}}$ represents the board characteristic under consideration (B_SIZE , B_IND , B_FEM , or B_NAT), $Controls_{it}$ is a vector of control variables (AGE , ROA , LEV , $SIZE$), α_i captures firm-specific fixed effects, λ_t captures time effects, and ε_{it} is the error term.

Model selection follows a standard sequence of specification tests. The Chow test is used to decide between pooled ordinary least squares and a fixed effects specification, while the Hausman test compares fixed effects and random effects to assess the consistency of the random effects estimator. In addition, a Breusch–Pagan Lagrange Multiplier test is applied to detect the presence of random effects relative to a pooled model. The combined test results indicate that the fixed effects model is the most appropriate specification across all estimated models, reflecting significant firm-specific heterogeneity and rejecting the random-effects assumption. Estimation is therefore conducted using firm fixed effects. To obtain

reliable statistical inference in the presence of potential heteroskedasticity and cross-sectional dependence, the study employs White cross-section heteroskedasticity-robust standard errors. Further diagnostic checks include assessing multicollinearity using centered Variance Inflation Factors, testing for heteroskedasticity, and examining serial correlation in the residuals. These diagnostics indicate no severe violations of classical assumptions, supporting the robustness of the estimated relationship between ESG performance, board structure, and investment efficiency.

3. RESULTS AND DISCUSSIONS

3.1 Descriptive Statistics and Correlations

Descriptive statistics in Table 2 show substantial cross-firm variation across all variables. ESG scores average 0.5462, with values ranging from 0.1654 to 0.8880, indicating that sampled firms differ widely in the depth and quality of their ESG practices. Boards have on average 6.35 members (3–15), with independent directors accounting for 38.7 percent of board seats, while gender and nationality diversity remain low: female directors comprise only 9.48 percent of boards on average, and foreign directors 15.28 percent. Firm age and size, measured in logarithms, average 1.59 and 13.72 respectively, while profitability and leverage exhibit considerable heterogeneity (mean ROA 0.0801, ranging from -0.0370 to 0.3479; mean leverage 0.5236 with a maximum of 3.6900). Investment inefficiency (IE) is centered around zero by construction, with a span from -0.0471 to 0.5588, suggesting meaningful differences in how closely actual investment aligns with benchmark opportunities across firms and over time.

Table 2. Descriptive Statistics

No	Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
1	ESG	0.54622	0.55455	0.88800	0.16540	0.18502	100
2	B_SIZE	6.35000	6.00000	15.00000	3.00000	2.50000	100
3	B_IND	0.387429	0.375000	0.833333	0.000000	0.134531	100
4	B_NAT	0.152833	0.000000	0.666667	0.000000	0.197915	100
5	B_FEM	0.094771	0.000000	0.333333	0.000000	0.117299	100
6	AGE	1.587714	1.653213	1.954243	0.903090	0.220814	100
7	ROA	0.080118	0.063200	0.347900	-0.037000	0.070219	100
8	LEV	0.523600	0.360000	3.690000	0.000000	0.576667	100
9	SIZE	13.71620	13.61532	14.64875	12.85552	0.412960	100
10	IE	-2.0E-08	-0.02002	0.558822	-0.04714	0.068583	100

The correlation matrix in Table 3 indicates mostly weak-to-moderate associations among the main variables. IE displays only small bivariate correlations with ESG (0.12) and board size (0.02), implying that no single predictor dominates the variation in IE in a simple linear sense. ESG is modestly associated with firm characteristics such as ROA, AGE, and B_SIZE, consistent with the idea that more profitable, mature, and larger firms tend to have more structured ESG practices. The

highest correlations naturally arise between interaction terms and their components (for example, ESG×B_FEM with B_FEM and ESG; ESG×B_SIZE with ESG and B_SIZE), a mechanical feature of moderation designs. Together with centered Variance Inflation Factors (VIFs) below the conventional threshold of 10, these patterns suggest that multicollinearity is not severe and that the model parameters are identifiable.

Table 3. Correlation Matrix

	IE	ESG	ESG× B_FEM	ESG× B_IND	ESG× B_NAT	ESG× B_SIZE	B_FEM	B_IND	B_NAT	B_SIZE	LEV	ROA	SIZE	AGE
IE	1.00													
ESG	0.12	1.00												
ESG×B_FEM	0.07	0.49	1.00											
ESG×B_IND	-0.04	0.68	0.48	1.00										
ESG×B_NAT	0.06	0.39	0.20	0.15	1.00									
ESG×B_SIZE	0.07	0.77	0.38	0.44	0.61	1.00								
B_FEM	0.02	0.29	0.93	0.33	0.07	0.18	1.00							
B_IND	-0.14	0.07	0.21	0.75	-0.15	-0.05	0.18	1.00						
B_NAT	0.05	0.16	0.05	-0.03	0.94	0.46	-0.03	-0.23	1.00					
B_SIZE	0.02	0.26	0.06	0.08	0.47	0.78	-0.03	-0.09	0.47	1.00				
LEV	0.08	-0.25	-0.27	-0.06	0.01	0.03	-0.22	0.14	0.14	0.42	1.00			
ROA	0.14	0.25	0.28	0.43	-0.17	0.09	0.17	0.27	-0.19	-0.06	-0.24	1.00		
SIZE	0.11	0.11	-0.22	-0.11	-0.03	0.32	-0.25	-0.18	-0.05	0.46	0.34	-0.16	1.00	
AGE	-0.24	0.32	0.26	0.43	0.03	0.38	0.21	0.29	-0.07	0.30	-0.11	0.27	0.07	1.00

3.2 Model Diagnostics and Estimation Choice

Variance inflation diagnostics in Table 4 show that, after mean-centering variables used in interaction terms, all VIF values remain below 10 across the five estimated models, with most

clustered close to unity. Slightly higher VIFs appear for specifications including board independence and nationality diversity, reflecting their interactions with ESG, but the magnitudes still fall within acceptable bounds for applied research.

Table 4. Centered VIF Scores (All Models)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
ESG	1.29923	2.94018	2.14303	1.63448	6.48649
AGE	1.24947	1.30511	1.69792	1.30142	1.45073
LEV	1.17622	1.66850	1.03903	1.55841	1.79981
ROA	1.30105	1.38163	1.70657	1.48717	1.30920
SIZE	1.16993	1.36516	1.14963	1.33433	1.56720
B_FEM	—	2.39534	—	—	—
B_FEM×ESG	—	4.29844	—	—	—
B_IND	—	—	7.36005	—	—
B_IND×ESG	—	—	5.11946	—	—
B_NAT	—	—	—	7.93476	—
B_NAT×ESG	—	—	—	7.11841	—
B_SIZE	—	—	—	—	6.97123

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
B_SIZE×ESG	–	–	–	–	3.12160

Heteroskedasticity tests (Table 5) indicate no systematic variance distortions: probability values for ESG, board variables, interactions, and controls are all above the 5 percent level across models, and the few marginal p-values remain

insufficient to reject homoskedasticity. Serial correlation tests based on Breusch–Godfrey LM statistics (Table 6) yield non-significant results, implying that residuals are not affected by problematic autocorrelation.

Table 5. Heteroskedasticity Tests – p-values

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
ESG	0.4676	0.6740	0.2902	0.6523	0.3986
AGE	0.0840	0.0637	0.1104	0.1280	0.1438
LEV	0.8717	0.1660	0.9355	0.8907	0.4685
ROA	0.6868	0.9517	0.9287	0.9434	0.9625
SIZE	0.4834	0.1575	0.5001	0.4195	0.3758
B_FEM	–	0.2791	–	–	–
B_FEM×ESG	–	0.2135	–	–	–
B_IND	–	–	0.3373	–	–
B_IND×ESG	–	–	0.4921	–	–
B_NAT	–	–	–	0.8326	–
B_NAT×ESG	–	–	–	0.8390	–
B_SIZE	–	–	–	–	0.1364
B_SIZE×ESG	–	–	–	–	0.9338

Table 6. Serial Correlation LM Test – p-values

Model	Prob. Chi-Square
1	0.3560
2	0.0521
3	0.1104
4	0.1671
5	0.2599

Model selection tests in Table 7 clearly favor firm fixed effects (FEM). Chow tests reject pooled OLS in favor of fixed effects for all five models, while Hausman tests systematically reject random

effects, indicating that unobserved firm-specific heterogeneity is correlated with the regressors and that random-effects estimates would be inconsistent

Table 7. Chow, Hausman, and LM Tests

	Model 1	Model 2	Model 3	Model 4	Model 5
Chow test – Cross-section F (p-value)	0.0042	0.0017	0.0036	0.0020	0.0097
Chow test – Cross-section Chi-square (p-value)	0.0001	0.0000	0.0001	0.0000	0.0003
Hausman test – Cross-section random (p-value)	0.0009	0.0272	0.0182	0.0033	0.0331
LM test – Breusch–Pagan (both) (p-value)	0.6096	0.1247	0.2388	0.4369	0.4059
Model selection	FEM	FEM	FEM	FEM	FEM

3.3 Regression Results

Table 8 reports the core panel regression results. Across Models 1–4, ESG performance is negatively and significantly associated with IE, with coefficients ranging from approximately –0.27 to –0.57 (p < 0.05). Given that IE is defined as investment inefficiency—so that lower values correspond to higher investment efficiency—these negative coefficients imply that stronger ESG

performance is systematically linked to more efficient capital allocation. Only in Model 5, which includes board size and its interaction with ESG, does the direct effect of ESG become statistically insignificant. Overall, the results support the first hypothesis (H1) that ESG performance enhances investment efficiency

Table 8. Panel Regression Model Results (Dependent Variable: IE)

Variable	Model 1 Coeff. (Prob.)	Model 2 Coeff. (Prob.)	Model 3 Coeff. (Prob.)	Model 4 Coeff. (Prob.)	Model 5 Coeff. (Prob.)
C	1.738 (0.253)	3.326 (0.106)	0.928 (0.605)	4.015 (0.376)	8.293 (0.167)

Variable	Model 1 Coeff. (Prob.)	Model 2 Coeff. (Prob.)	Model 3 Coeff. (Prob.)	Model 4 Coeff. (Prob.)	Model 5 Coeff. (Prob.)
ESG	-0.268 (0.015)	-0.563 (0.020)	-0.571 (0.046)	-0.250 (0.008)	0.020 (0.291)
AGE	0.121 (0.432)	0.080 (0.498)	0.031 (0.847)	0.398 (0.063)	-0.131 (0.476)
LEV	-0.053 (0.025)	-0.024 (0.307)	-0.001 (0.232)	-0.108 (0.046)	-0.117 (0.042)
ROA	1.901 (0.216)	1.112 (0.195)	1247.215 (0.271)*	-0.032 (0.742)	-0.008 (0.908)
SIZE	-0.130 (0.264)	-0.196 (0.161)	0.000 (0.167)	-2.489 (0.254)	-2.511 (0.210)
B_FEM	–	-0.175 (0.033)	–	–	–
ESG×B_FEM	–	1.992 (0.050)	–	–	–
B_IND	–	–	-0.342 (0.224)	–	–
ESG×B_IND	–	–	3.558 (0.573)	–	–
B_NAT	–	–	–	0.210 (0.001)	–
ESG×B_NAT	–	–	–	-0.503 (0.002)	–
B_SIZE	–	–	–	–	0.014 (0.018)
ESG×B_SIZE	–	–	–	–	0.003 (0.218)
R ²	0.505	0.540	0.521	0.535	0.534
Prob(F)	0.005	0.003	0.006	0.003	0.003

Among the control variables, leverage consistently enters the models with a negative coefficient and is statistically significant in several specifications (Models 1, 4, and 5), whereas firm age, firm size, and profitability do not exhibit stable or robust significance patterns across models. The overall model fit is acceptable for panel-data applications: the R-squared values range from approximately 0.505 to 0.540 and the F-statistics are significant at the 1 percent level in all five specifications, indicating that the set of regressors jointly explains a non-trivial share of the variation in investment inefficiency.

The moderation estimates show distinct coefficient patterns for the board variables. In Model 2, the coefficient on board gender diversity (B_FEM) is negative and statistically significant at conventional levels, while the interaction term ESG×B_FEM is positive and marginally significant at the 10 percent level. In Model 3, neither the main effect of board independence (B_IND) nor the ESG×B_IND interaction term is statistically different from zero.

In Model 4, board nationality diversity (B_NAT) has a positive and statistically significant coefficient, and the corresponding interaction term ESG×B_NAT is negative and significant at the 1 percent level. In Model 5, board size (B_SIZE) is positively signed and statistically significant, whereas the ESG×B_SIZE interaction term is not statistically significant.

3.4 Discussion

Investment inefficiency (IE) in this study is defined as the deviation of actual investment from an “expected” benchmark derived from an industry–year investment model; by construction, larger absolute residuals indicate more severe misallocation, while values closer to zero imply higher efficiency. It is therefore crucial to maintain the correct reading frame when interpreting coefficients: a **negative** coefficient on an explanatory variable implies that higher values of that variable are associated with **lower IE (higher**

efficiency), whereas a positive coefficient implies the opposite. This convention is especially important in moderation models, where interaction terms can otherwise be misread and the economic meaning of the estimates inadvertently reversed (Houcine et al., 2022; W. Wang et al., 2022; Zhong & Gao, 2017).

Empirically, the core hypothesis is supported. H1—that higher ESG performance improves investment efficiency—finds confirmation in Models 1–4, where ESG is negatively and significantly associated with IE ($\beta \approx -0.27$ to -0.57 , $p < 0.05$). Increases in ESG coincide with declines in investment inefficiency, consistent with Stakeholder and Agency perspectives that stronger ESG practices and disclosures build stakeholder trust, reduce information asymmetry, and ease financing frictions, thereby fostering a more disciplined investment environment (Freeman & Dmytriiev, 2017; Alsayegh et al., 2022; Cheng et al., 2014; Jones et al., 2017; Seow, 2024). From an Agency standpoint, high ESG performance also aligns managerial and shareholder interests, constrains opportunistic behaviour, and provides a credible signal that lowers uncertainty for capital providers (Cook et al., 2019; Hasnan et al., 2020; Samet & Jarboui, 2017; W. Wang et al., 2022). The only exception is Model 5, where the direct ESG effect becomes statistically indistinct once board size and its interaction are introduced, suggesting that the efficiency gains associated with ESG may be contingent on board architecture. This is in line with evidence that particular governance designs can amplify or dampen the transmission of ESG to investment discipline through channels of transparency, monitoring, and market reputation (Albuquerque et al., 2019; Ghoul et al., 2011; Sun & Zhang, 2021).

Turning to moderators, board gender diversity exhibits a nuanced pattern. The level effect of female representation (B_FEM) is negative and significant for IE, indicating that a higher female

share on the board is associated with **lower investment inefficiency**—consistent with evidence that more gender-diverse boards exhibit improved oversight, heightened risk prudence, and lower information asymmetry (F. Ali et al., 2021; Birindelli et al., 2018; Shin et al., 2020; Ullah et al., 2020). However, the interaction term $ESG \times B_FEM$ is positive and marginally significant, implying that the negative slope of ESG on IE becomes weaker as B_FEM increases. Substantively, this suggests **partial substitution**: some of the disciplinary function that would otherwise be attributed to ESG is already delivered by gender diversity itself, so the marginal efficiency benefit of ESG diminishes at higher levels of B_FEM (Arayssi et al., 2020; Romano et al., 2020). In governance terms, board–ESG complementarities remain, but the optimal mix between ESG capabilities and gender composition appears context-dependent. Consequently, the evidence does not support H4 in the sense of a uniformly positive moderating effect, even though the level effect of B_FEM is clearly efficiency-enhancing.

Other moderators display distinct dynamics. Board independence (B_IND) is insignificant both as a main effect and in interaction with ESG, indicating that, within this sample and time window, independence neither shifts IE directly nor systematically conditions the ESG–IE link (Ramdani & Witteloostuijn, 2010; Tran, 2019). A conservative interpretation is that ESG’s efficiency effect is relatively uniform across typical independence levels in JII-70 firms, or that cross-sectional variation in B_IND is insufficient to generate strong moderating patterns. This result is also consistent with prior work emphasising that the effectiveness of independence is highly contextual, varying with ownership structures, legal environments, and industry characteristics (Ortas et al., 2017).

By contrast, board nationality diversity (B_NAT) shows a trade-off. Its direct effect on IE is positive and significant, suggesting that more internationally diverse boards tend to start from a higher inefficiency baseline, plausibly reflecting added coordination complexity and more challenging decision processes. At the same time, the $ESG \times B_NAT$ interaction is negative and significant, indicating that **ESG’s ability to suppress IE becomes stronger as board nationality diversity increases**. In other words, when ESG performance is weak, the complexity associated with nationality diversity may dominate; but when ESG practices are strong, the broader regulatory and cultural insight brought by foreign directors helps firms interpret heterogeneous ESG expectations, deepen stakeholder engagement, and channel capital into more efficient uses (F. Ali et al., 2021; Harjoto et al., 2019; Al-Hiyari et al., 2022; Wasiuzzaman & Subramaniam, 2023). This pattern supports H5 and highlights nationality diversity as a genuinely **amplifying** moderator of the ESG–efficiency nexus.

Finally, board size (B_SIZE) exhibits a positive and significant level effect on IE, indicating that larger boards are associated with a higher inefficiency baseline—consistent with concerns about coordination frictions and diluted accountability in oversized boards (Agyei-Mensah, 2021; Rossi et al., 2021; Githaiga & Kosgei, 2023). However, the $ESG \times B_SIZE$ interaction is not statistically different from zero, implying that, within the observed range, ESG’s efficiency benefit is broadly similar for boards of different sizes. Put differently, board size primarily affects the **starting point** of IE rather than the slope of the ESG–IE relationship. These findings suggest that H2—which predicts a positive moderating role of board size—is not supported in this sample, and that simply enlarging boards is unlikely to magnify the efficiency gains from ESG in JII-70 firms.

The empirical platform supporting these inferences is robust. Centered VIF values remain below the conventional threshold of 10 across all models, with increases in VIF for interaction terms contained by mean-centering. Heteroskedasticity tests show no systematic variance distortion, and Breusch–Godfrey LM tests indicate no problematic serial correlation in the residuals. Model-selection diagnostics uniformly favour a firm Fixed Effects specification: Chow tests reject pooled OLS, Hausman tests reject Random Effects, and Breusch–Pagan LM statistics do not provide a compelling case for random components. Taken together, these diagnostics justify the use of Fixed Effects with heteroskedasticity-robust standard errors and support the reliability of the estimated signs and significances for testing H1–H5.

4. CONCLUSIONS

This study investigates whether ESG performance enhances investment efficiency and how board characteristics moderate this relationship among 25 firms consistently included in the JII-70 over 2020–2023 (100 firm-years). Using a residual-based proxy of investment inefficiency and fixed-effects panel regressions with robust standard errors, the analysis provides evidence that ESG performance is associated with more efficient capital allocation and that specific dimensions of board composition shape the strength of this effect in Indonesia’s Sharia-compliant capital market.

The moderation analysis refines this picture. Board gender diversity exerts a favourable level effect—higher female representation is associated with lower investment inefficiency on average—yet the positive and marginally significant $ESG \times B_FEM$ coefficient indicates that the marginal efficiency gain from ESG weakens as female share rises. This pattern is consistent with a **partial substitution** mechanism in which some governance benefits typically attributed to ESG are already delivered by gender-diverse boards, so that additional ESG improvements yield smaller incremental efficiency gains. Board nationality diversity, in contrast, raises the inefficiency

baseline but significantly **strengthens** ESG's ability to reduce IE, implying that globally attuned boards amplify the efficiency channel of ESG once credible sustainability practices are in place. By comparison, board independence does not show a robust direct or moderating effect, and board size elevates the inefficiency baseline without materially altering the ESG–IE slope. Taken together, the evidence indicates that (i) H1 is supported (ESG improves investment efficiency), (ii) H5 is supported (nationality diversity positively moderates the ESG–efficiency link), and (iii) H2–H4 are not supported in the sense of positive moderation, even though gender diversity has a beneficial level effect.

From a practical perspective, the findings suggest a **dual-track** agenda for JII-70 firms and their stakeholders. First, firms should continue to elevate the quality and transparency of ESG practices and disclosure, as these are associated with tighter project screening, reduced information frictions, and more disciplined capital allocation—an especially important priority as Indonesia channels substantial transition finance through instruments such as Green Sukuk and the Just Energy Transition Partnership. Second, boards should be configured not merely for compliance, but for **effectiveness**: maintaining an efficient board size, promoting meaningful nationality diversity (and gender representation for its direct efficiency benefits), and ensuring decision processes that embed ESG information into capital budgeting. For regulators and investors, the results underscore that ESG scores should be interpreted jointly with governance attributes, because similar ESG ratings may yield different real-economy outcomes depending on board structure. In sum, well-designed governance arrangements are critical for translating Shariah-aligned ESG commitments into verifiably efficient investment, helping to ensure that scarce transition-era capital is deployed toward the highest-value, sustainability-consistent opportunities in Indonesia's capital market.

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