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Does Board Gender Diversity Weaken the Fraud Pentagon-Driven Financial Statement Fraud? Evidence from Indonesian Manufacturing Firms

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Abstract

Purpose: This study examines whether financial stability, external pressure, ineffective monitoring, and Chief Executive Officer (CEO) tenure raise financial statement fraud risk among Indonesian manufacturing firms and whether board gender diversity moderates these relationships.

Research Methodology: We built a balanced panel of 109 Indonesia Stock Exchange (IDX)-listed manufacturing firms via purposive sampling, yielding 327 firm-year observations (2022-2024). Fraud was measured using the Beneish M-Score and analyzed in Stata/MP 17 via conditional fixed-effects logistic regression, cross-validated against a pooled logistic regression with robust standard errors.

Results: Financial stability positively and significantly predicted fraud under both estimators. External pressure was significant only in the pooled model, and ineffective monitoring and CEO tenure were not significant. Board gender diversity significantly weakened the ineffective monitoring-fraud link in the primary model; however, this and three other moderations did not survive the robustness check.

Conclusions: Governance-moderation effects found under a single estimator may not survive an alternative specification, underscoring the value of testing governance mechanisms with more than one panel estimator.

Limitations: The three-year window restricted within-firm variation, excluding several sampled firms from the primary estimation and limiting the detection of some effects.

Contributions: To our knowledge, this is the first study to test board gender diversity as a moderator of each Fraud Pentagon mechanism–financial stability, external pressure, ineffective monitoring, and CEO tenure–individually rather than as a single average effect. This study offers Indonesian regulators and audit committees guidance for treating board gender diversity as a fraud-mitigating mechanism rather than an assumed safeguard.

Keywords: *Board Gender Diversity, Financial Statement Fraud, Fraud Pentagon, Indonesia, Manufacturing Firms*

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1. Introduction

Financial statement fraud drains value from shareholders, creditors, and employees and erodes the confidence that capital markets depend on. Cressey (1953) fraud triangle first explained fraud through pressure, opportunity, and rationalization; Wolfe and Hermanson (2004) added capability, and Crowe (2011) added arrogance, the belief that internal controls simply do not apply to oneself. Governance researchers have tested board gender diversity against these fraud-driving forces more than any other mechanism (Wahid, 2019). However, according to Wahid (2019) the evidence does not converge on how that constraint operates: some studies report a general, firm-wide misconduct-reducing effect, while others find that the effect is activated only once firm size or a second governance mechanism enters the model (Kwamboka, Githaiga, & Kinuthia, 2025; Nguyen, 2025) and none of the three isolates which specific fraud-driving force, pressure, opportunity, or arrogance, board gender diversity actually constrains. Agency theory (Jensen & Meckling, 1976) explains why this mechanism might work: monitoring reduces the information gap between managers and shareholders, and a more independent board narrows this gap further. This question is urgent in Indonesia. In early 2025, independent investigators found that eFishery, one of Indonesia's largest technology startups, kept two sets of financial statements: one for internal management and one for external stakeholders showing inflated revenue and profitability. The company was privately held, so Indonesia listed company disclosure rules never touched it: regulatory compliance alone did not stop the fraud and will not stop the next one.

Indonesia's regulator responded on October 31, 2024, when Otoritas Jasa Keuangan (OJK's) Regulation No. 12 of 2024 took effect, widening the legal definition of fraud and requiring financial institutions to build anti-fraud programs around four pillars: prevention, detection, investigation and sanctions, and ongoing monitoring, placing the burden of anti-fraud governance on the Board of Directors and Board of Commissioners and reinforcing Laws No. 4 of 2023 and No. 8 of 1995. Manufacturing firms provide this study with its sharpest test: since 2022, Indonesian manufacturers have absorbed an uneven post-pandemic demand recovery, commodity-driven input cost swings, and recurring supply chain disruption, and their heavier fixed-asset base means that the measures this study relies on show real variation rather than noise.

Three studies anchor this study's gap. Wahid (2019) uses an instrumental variable design on a large U.S. panel and finds that gender-diverse boards cut financial misconduct but measure only an average effect, not any single Fraud Pentagon mechanism. Kwamboka et al. (2025) study East African Community firms and find firm size, not gender diversity, moderates the audit committee-fraud link, while skipping the Pentagon's pressure, opportunity, and arrogance dimensions. Nguyen (2025) finds that board gender diversity predicts fraud in Vietnamese firms only once audit committee presence enters the model, but on an estimator that never tests whether the effect survives once fixed firm characteristics are stripped out. None of the three tests show whether board gender diversity moderates each Fraud Pentagon dimension on its own or whether its effect holds up under a different specification, a gap that matters because the choice of estimator can flip the answer.

Indonesia governance structure sharpens this test further. Where Wahid (2019) studies unitary U.S. boards, Indonesian public companies split authority across two tiers: a Board of Directors that runs daily operations and a Board of Commissioners that supervises it, with independent commissioners and audit committees layered on top. Board gender diversity grows through voluntary disclosure under POJK No. 33/POJK.04/2014, POJK No. 34/POJK.04/2014, and POJK No. 51/POJK.03/2017, not through the binding quotas that some European and East African jurisdictions now require. No prior study has used this institutional setting or dual estimator test to check whether the governance-moderation effect survives a method change. This study fills that gap directly by testing board gender diversity as a moderator of all four Fraud Pentagon mechanisms across a 2022-2024 panel of Indonesian manufacturing firms, estimated with a conditional fixed-effects logistic regression and cross-checked against a pooled logistic regression. This contribution is best read as a theoretical refinement rather than a new theory: agency theory's monitoring-substitution logic, that a strong governance mechanism can compensate for weak oversight elsewhere, has typically been tested as a single average effect. By disaggregating the moderating role of board gender diversity across the four

distinct vertices of the Fraud Pentagon and testing whether each moderation effect survives a change in the estimator, this study specifies a boundary condition that the existing literature has not: monitoring substitution is neither uniform across fraud-driving mechanisms nor invariant to how firm heterogeneity is treated. Agency theory by Jensen and Meckling (1976) grounds this design: it treats fraud as the product of unresolved conflict and information asymmetry between managers and shareholders, held in check only by the monitoring that the firm actually has in place. The panel adds weight: 109 manufacturing firms and 327 firm-year observations spanning the sector's post-pandemic recovery and OJK's tightened standards, a segment that most prior samples leave unexamined.

The results split cleanly into a robust finding and a fragile one, and that split is the study's real contribution: financial stability drives fraud under both estimation methods regardless of how firm heterogeneity is treated, while external pressure and board gender diversity's moderation of ineffective monitoring flips between significant and non-significant depending on the estimator, an instability this study treats as a finding rather than a footnote. This study has three objectives: to test whether financial stability, external pressure, ineffective monitoring, and Chief Executive Officer (CEO) tenure each raise the odds of financial statement fraud; to test whether board gender diversity weakens each of those four links, holding audit committee size and audit firm size constant; and to check whether any moderating effect found under conditional fixed-effects regression survives a pooled logistic regression on the full sample. Section 2 builds the hypotheses; Section 3 lays out the sample, variables, and models; Section 4 reports results against Indonesia's institutional context; and Section 5 closes with contributions, limits, and future directions.

2. Literature Review and Hypotheses Development

2.1 Grand Theory Framework

Agency theory provides the first pillar of this study's framework. Jensen and Meckling (1976) define a firm as a nexus of contracts and treat the relationship between a principal, the shareholder, and an agent, the manager, as the source of two structural problems. First, the agent holds more information about the firm's condition than the principal, an asymmetry that the agent can exploit. Second, the agent's incentives, which are tied to compensation and reputation, diverge from the principal's incentive to maximize firm value. Jensen and Meckling (1976) show that these two problems generate agency costs, chief among them the cost of monitoring the agent's behavior. When monitoring weakens, agents gain room to act opportunistically, and financial statement fraud becomes a visible outcome of that opportunism. This study treats agency theory as a mechanism for explaining why fraud occurs: managers conceal information or manipulate disclosures because weak oversight allows them to do so. The theory does not specify which observable characteristics signal this opportunism; that task falls to the Fraud Pentagon theory, the study's second pillar, giving this study both a causal explanation and measurable proxies for detecting fraud.

Agency theory answers the question of why a governance mechanism, such as board gender diversity, should matter at all: because any mechanism that narrows the information gap between agent and principal, or that raises the cost of acting opportunistically, directly attacks the two structural problems (Jensen & Meckling, 1976). Read as a single causal sequence, agency theory supplies the upstream cause, information asymmetry and incentive misalignment, that creates the underlying opportunity and motive for fraud, while Fraud Pentagon theory supplies the downstream, observable channel, decomposing that one agency problem into the five conditions: pressure, opportunity, rationalization, capability, and arrogance, through which it actually surfaces in a firm's financial and governance characteristics. Board gender diversity intervenes between the two links by raising the monitoring intensity of agency theory as the direct constraint on agent opportunism; it should specifically narrow the opportunity- and arrogance-linked vertices that the Fraud Pentagon attributes to weak oversight. This three-link sequence, agency conflict, operationalized through Fraud Pentagon proxies, moderated by board gender diversity's effect on monitoring intensity, is the causal mechanism for every hypothesis in Sections 2.2 and 2.3.

The Fraud Pentagon theory traces a direct lineage across four decades of fraud research and supplies the observable risk factors that this study tests empirically. Cressey (1953) proposed the original fraud

triangle after interviewing convicted embezzlers and identified three conditions that must co-occur for fraud to happen: pressure, a financial problem the offender cannot solve through legitimate means; opportunity, a perceived chance to exploit a position of trust without getting caught; and rationalization, the internal justification that lets the offender see the act as acceptable. Wolfe and Hermanson (2004) add capability, personal capacity, and organizational position needed to recognize and execute a fraud opportunity, producing the fraud diamond. Humphrey, Enofe, and Praise (2023a)note that capability remains difficult to observe directly and argue that the model still needs a workplace-condition element to explain why fraud persists even when capable individuals face credible sanctions. (Crowe, 2011) adds arrogance, the belief that internal controls and oversight do not constrain someone in their position, completing the Fraud Pentagon. Each element maps to observable, quantifiable firm characteristics rather than unobservable psychological states, which makes the theory testable with financial statement data. This study draws four of its five independent variables directly from this framework, treating each as an empirical proxy for one of the vertices of the Pentagon.

The two theories converge on the variables of this study in a direct and testable manner. Financial stability and external pressure operationalize the pressure vertex: when a firm's asset base destabilizes or its leverage climbs, management faces the kind of financial problem. Cressey (1953) identifies as the trigger condition, and agency theory explains why management might resolve that problem through concealment rather than through disclosure. Ineffective monitoring operationalizes the opportunity vertex directly, since weak board oversight is itself the agency cost of monitoring (Jensen & Meckling, 1976). Crowe (2011) found that Chief Executive Officer (CEO) tenure operationalizes the capability and arrogance vertices jointly, since a long-serving chief executive accumulates both the operational knowledge to exploit control weaknesses and the entrenched confidence associated with arrogance.Humphrey, Isenmilia, and Omoye (2023b) map this same five-part structure onto observable proxies, treating financial stability and external pressure as pressure indicators, ineffective monitoring as an opportunity indicator, and CEO tenure-linked capability alongside CEO duality as arrogance indicators, a proxy structure closely mirroring this study's four independent variables. Financial statement fraud, the dependent variable, is the point at which an unresolved agency conflict and a completed Fraud Pentagon condition produce a manipulated financial statement. Board gender diversity, the moderator, enters as a governance mechanism agency theory predicts will narrow the monitoring gap the Pentagon's opportunity vertex exploits, since female directors sit outside the informal networks that let weak oversight persist unchallenged.

2.2 Financial Stability, External Pressure, Ineffective Monitoring, and CEO Tenure

Financial stability and external pressure both operationalize the pressure vertex of the Fraud Pentagon, and agency theory explains why each pushes fraud risk upward. Financial stability captures the condition Cressey (1953) identified as the trigger: when a firm's asset base destabilizes, Jensen and Meckling (1976) predict that management, holding more information about the firm's true condition than shareholders do, faces a direct incentive to conceal that deterioration rather than disclose it. External pressure captures a related trigger: rising leverage signals that creditors expect a truthful account management that may not want to give (Siddiq, Achyani, & Zulfikar, 2017). Widiastika and Junaidi (2021) report a significant positive effect of financial stability, a pattern Ghafoor, Zainudin, and Mahdzan (2019) and Ebaid (2023) confirm internationally using the same Beneish M-score. Achmad, Ghozali, and Pamungkas (2022), Pamungkas and Utomo (2018), Evana, Metalia, Mirfazli, Georgieva, and Sastrodiharjo (2019), and Achmad, Ghozali, Helmina, Hapsari, and Pamungkas (2023) report the same positive pattern for external pressure, consistent with Dechow, Sloan, and Sweeney (1996), who find that firms facing SEC enforcement show a significantly greater need for external financing. Naldo and Widuri (2023) and Sidauruk and Abimanyu (2022) find no effect on separate Indonesian samples, reinforcing this inconsistency, which motivates H_1a and H_1b, respectively.

H_1a: Financial Stability has a positive effect on Financial Statement Fraud

H_1b: External Pressure has a positive effect on Financial Statement Fraud

Ineffective monitoring and CEO tenure operationalize the opportunity and capability arrogance vertices, tracing back to the same agency cost logic that grounds the pressure variables. Ineffective monitoring measures the opportunity vertex directly: Jensen and Meckling (1976) treat monitoring as the primary cost that constrains agent opportunism, so weak independent oversight hands management the room, Cressey (1953) identifies as the second necessary condition for fraud. Because this proxy enters the model without inverting its scale, a positive coefficient is only meaningful if a high independent-commissioner ratio fails to translate into substantive oversight, which is plausible given Indonesia's compliance-driven 30% floor, which firms can satisfy on paper without functional independence. CEO tenure captures capability and arrogance jointly: Wolfe and Hermanson (2004) argue that capability requires organizational knowledge an executive accumulates over time, and Crowe (2011) links arrogance to the entrenchment that the same tenure produces, since a longer-serving CEO faces a board less willing to challenge decisions. Shanikat and Aldabbas (2025) and Kaituko, Githaiga, and Chelogoi (2023) report the same positive effect internationally via lower board independence, while Achmad et al. (2022) find no significant effect, indicating that the opportunity mechanism does not operate uniformly across Indonesian sectors.

On CEO tenure specifically, Xu, Zhang, and Chen (2018) find that board age has a significant negative effect on fraud, while Seifzadeh, Rajaeei, and Allahbakhsh (2022) find that managerial entrenchment reduces fraud, arguing that entrenched managers protect long-term firm value rather than extracting short-term gains. This divergence sharpens the case for testing the effect of tenure on this study's own panel. Two further Indonesian studies add to this inconsistency: Sabrina, Fachruzzaman, Midiastuty, and Suranta (2020) find that ineffective monitoring falls short of significance once political connections and earnings management are controlled for, and Ruchiatna, Midiastuty, and Suranta (2020) test audit committee characteristics against a combined Beneish M-Score and Altman Z-Score measure.

International evidence supports each construct. Schrand and Zechman (2012) and Rijsenbilt and Commandeur (2013) link CEO overconfidence and narcissism to fraud among US firms, supporting the arrogance logic behind *H₂b*, while Lisic, Silveri, Song, and Wang (2015) find that large audit firms significantly reduce fraud in China, supporting audit firm size as a control variable. Chen, Firth, Gao, and Rui (2006) and Girau, Bujang, and Said (2022) find concentrated ownership and weak governance predict fraud in China and Malaysia, reinforcing the pressure and opportunity hypotheses; Uaiphon and Yangklan (2026) extend the Pentagon into a Fraud Hexagon in Thailand, finding pressure significant but arrogance is culturally contingent, and Ozkan and Alfarhan (2025) validate the Beneish M-Score across G7 economies, supporting its cross-context reliability.

H₂a: Ineffective Monitoring has a positive effect on Financial Statement Fraud

H₂b: CEO Tenure has a positive effect on Financial Statement Fraud

The Indonesian evidence behind these four hypotheses has three limitations this study addresses. First, every cited study relies on a pooled or random-effects estimator that mixes within-firm and between-firm variation; therefore, a reported effect may reflect stable differences between firms rather than a genuine year-to-year fraud mechanism. Second, most studies draw samples from before 2022, missing the post-pandemic period in which Indonesian manufacturers absorbed input-cost volatility and demand disruption severe enough to plausibly intensify all four mechanisms. Third, studies finding opposite-signed or null results, Rostami and Rezaei (2022) for ineffective monitoring and Xu et al. (2018) for board age, draw on samples with distinct governance structures that may decouple the pressure-fraud link this study's sample is built to capture. Testing all four hypotheses jointly, with an estimator capable of isolating within-firm variation, gives this study a direct way to determine which mechanism survives the scrutiny.

2.3 The Moderating Role of Board Gender Diversity

Board gender diversity enters this framework as a moderating variable, and agency theory supplies the mechanism through which it should weaken each of the four relationships proposed in *H₁a* through

H₂b. According to Jensen and Meckling (1976), female directors, occupying a position outside the informal networks through which weak oversight typically persists unchallenged, raise monitoring intensity in a way that a homogeneous board cannot replicate, while a more functionally independent board narrows the space in which pressure-driven concealment or arrogance-driven entrenchment can operate undetected (Crowe, 2011). Wahid (2019) tests a closely related claim directly and finds that gender-diverse U.S. boards experience significantly fewer financial misconduct events, supporting the general monitoring-reinforcement mechanism proposed in this study. Kwamboka, Githaiga, and Kinuthia (2025) extend this evidence to East African Community firms and find that audit committee gender diversity significantly reduces financial reporting fraud, although their model tests firm size rather than the four Fraud Pentagon mechanisms as the moderators. Achmad, Ghozali, and Pamungkas (2024) test a related interaction in Indonesian state-owned enterprises using the Fraud Hexagon model and find that the audit committee weakens only the collusion pathway, providing evidence that a single mechanism can concentrate on one fraud channel rather than operate uniformly. Nguyen (2025) adds a third data point from Vietnam, finding that board gender diversity predicts fraud only once audit committee presence enters the model, evidencing that the effect is conditional rather than unconditional, although her model, like that. Kwamboka et al. (2025) never isolates which specific Fraud Pentagon mechanism the conditional effect operates through. This gap, three studies documenting a general link but no test of which specific mechanism it weakens, sets up the four moderation hypotheses this study develops next.

International evidence deepens this base without testing the Fraud Pentagon-specific interaction. Cumming, Leung, and Rui (2015) find that board gender diversity moderates securities fraud among Chinese firms; Wang, Yu, and Gao (2022) find female leaders raise fraud-detection odds; and Yami and Poletti-Hughes (2022) find that independent female directors weaken the CEO power-fraud link, supporting *H₃d*. Wahyuningtyas and Aisyaturrahmi (2022) and Maulidi, Shonhadji, Fachruzzaman, Sari, Nuswantara, and Widuri (2023) link female CFOs to fewer fraud events, although the latter find this contingent on ownership and political connections. Not every result agrees with Wang, Ma, Xue, and Zhang (2024) who find gender diversity reduces firm performance in Japan, and Maxfield and Wang (2024)who find that the wider risk literature discordant, while Biduri and Tjahjadi (2024) find that ineffective monitoring and external pressure are significant in Indonesian Islamic banks without testing gender diversity as a moderator. Luhri, Mashuri, and Ermaya (2021) find that the audit committee moderates none of the five Pentagon elements, and Sa, Isthika, Triono, and Oktafiyani (2025) find that gender diversity and board size do not predict financial distress. Schwartz-Ziv (2017) shows that a critical mass of three or more women is often needed for gender diversity to matter, a threshold this study's mean of 0.725 falls short of, and Lokanan and Sharma (2025) show that machine learning can outperform traditional fraud-prediction models.

H₃a: Board Gender Diversity weakens the positive effect of Financial Stability on Financial Statement Fraud

H₃b: Board Gender Diversity weakens the positive effect of External Pressure on Financial Statement Fraud

Direct empirical tests of these specific interactions remain rare, and the closest available evidence provides a mixed verdict rather than a confirming one. Wahid (2019) runs the test most directly relevant to *H₃c*: a formal comparison of the effect of gender diversity on misconduct between well-governed and poorly governed U.S. firms, designed to check whether gender diversity substitutes for weak monitoring. The comparison finds that the coefficients are statistically indistinguishable across the two groups, meaning that gender-diverse boards help both groups by roughly the same margin rather than delivering an outsized benefit where monitoring is weakest. This complicates the substitution logic behind *H₃c* without ruling it out, since a U.S. unitary-board sample may not generalize to Indonesia's two-tier structure, where the independent-commissioner ratio used in this study is bound by a regulatory floor that leaves less genuine variation for gender diversity to substitute against. Because this ratio enters the model without inverting its scale (Section 2.2), *H₃c* predicts that board gender diversity weakens the positive IM-fraud relationship, specifically where the ratio reflects

compliance rather than substantive oversight. Lenard, Yu, York, and Wu (2017) offer indirect support for *H₃b*: firms with at least one female executive or director show a significantly lower likelihood of fraud litigation, even after controlling for leverage, although the study never tests gender diversity as a formal moderator of leverage. No study identified here tests *H₃a*, *H₃d*, or the ineffective-monitoring interaction behind *H₃c* as a direct, formally specified interaction term, precisely the gap filled by this study's four remaining hypotheses.

H₃c: Board Gender Diversity weakens the positive effect of Ineffective Monitoring on Financial Statement Fraud

H₃d: Board Gender Diversity weakens the positive effect of CEO Tenure on Financial Statement Fraud

H₃d carries the least direct precedent of the four, and this gap deserves explicit acknowledgment rather than a forced citation. Xu, Zhang, and Chen (2018) find that board age has a significant negative effect on fraud, moderated by the CEO-board age gap, while Seifzadeh, Rajaeei, and Allahbakhsh (2022) find that managerial entrenchment reduces fraud rather than raising it, arguing that entrenched managers protect long-term firm value once their position feels secure. Neither study tests whether board gender diversity moderates the tenure-fraud link; therefore, the theoretical case for *H₃d* rests on an extension rather than a replication: female directors Crowe (2011) imply that they sustain a board's willingness to challenge a long-serving CEO's decisions precisely because they sit outside the informal relationships that tenure builds over time. Testing all four together, using both a conditional fixed-effects estimator and a pooled robustness check, allows this study to determine not only whether board-gender diversity moderates each mechanism but also whether any effect found survives a genuinely different statistical test. Figure 1 summarizes the research model tested in this study

3. Research Methodology

3.1 Research Design and Sample Selection

We designed this study as a quantitative analysis of secondary panel data, combining cross-sectional observations of Indonesian manufacturing firms with a three-year dimension from 2022 to 2024. The panel is balanced by construction: every firm contributes exactly three annual observations, allowing us to exploit both cross-firm and within-firm variation in the conditional fixed-effects logistic model described in Section 3.4, which the study's central question, whether a governance-moderation effect survives once time-invariant firm heterogeneity is stripped out, requires.

We drew the target population from all manufacturing companies listed on the IDX at any point during 2022-2024, selecting the final sample through purposive sampling across five sequential criteria: continuous IDX listing throughout the period (dropping newly listed, delisted, or suspended firms); complete, audited annual reports for all three years; a fiscal year ending December 31 ensuring an identical twelve-month window; financial statements denominated in Indonesian Rupiah, excluding foreign-currency reporters whose translation would add noise to our asset- and leverage-based proxies; and positive net income throughout, since several Beneish M-Score components become uninterpretable on a loss-making basis. We adopt this screen because two of the eight components of the M-Score, the gross margin index and the sales, general, and administrative expenses index, are computed as ratios against a positive earnings base and produce economically meaningless or extreme values once that base turns negative. A constraint prior to Beneish-based fraud studies in Indonesia is handled in the same way (Suryani, Winarningsih, Avianti, Sofia, & Dewi, 2023; Achmad, Ghozali, & Pamungkas, 2022). We recognize that this screen is not costless: it removes financially distressed firm-years from the panel, and if distress itself correlates with fraud risk or board composition, our sample skews toward more stable firms, and our results may not generalize to loss-making companies, where pressure-driven fraud risk is plausibly highest. We treat this as an explicit scope condition rather than a hidden bias and return to it in the limitations discussed in Section 5.2 below. Applying these five criteria sequentially left us with a final sample of 109 manufacturing companies and a balanced panel of 327 firm-year observations.

3.2 Operational Definition and Measurement of Variables

Table 1 summarizes the operational definitions, measurement formulas, and primary sources for each of the eight variables.

Table 1. Operational definition and measurement of variables

Variables	Type	Measurement	Source
FRAUD	Dependent	Beneish M-Score; 1 if M-Score > -2.22, else 0	(Suryani et al., 2023); (Beneish, 1999)
FS	Independent	(Total Assett − Total Assett-1) / Total Assett	(Apriliana & Agustina, 2017)
EP	Independent	Total Debt / Shareholder Equity	(Khamainy et al., 2022); (Skousen et al., 2008)
IM	Independent	Independent Commissioners / Total Commissioners	(Yendrawati et al., 2019)
CEO	Independent	Consecutive years CEO has held office	(Seifzadeh et al., 2022)
FEM	Moderating	Number of female directors on the board	(Wahid, 2019)
ACS	Control	Total number of audit committee members	(Beasley, 1996)
ASIZE	Control	1 if audited by a Big Four firm, else 0	(Suryani et al., 2023)

We measured financial statement fraud, the dependent variable, using the Beneish M-Score, following the operationalization Suryani et al. (2023) apply and the model Beneish (1999) originally developed. We calculated the M-Score as -4.84 plus 0.92 times the days'-sales-in-receivables index, plus 0.528 times the gross margin index, plus 0.404 times the asset quality index, plus 0.892 times the sales growth index, plus 0.115 times the depreciation index, minus 0.172 times the sales, general, and administrative expenses index, plus 4.679 times the total accruals index, and minus 0.327 times the leverage index. We computed each of these eight component ratios as the current-year value relative to the prior-year value, drawing on receivables, cost of goods sold, current assets, property and equipment, sales, depreciation expense, administrative expenses, accruals, and total liabilities, as each firm reports them in its audited financial statements. Following Suryani et al. (2023) we coded firms with an M-score above -2.22 as 1, indicating a potential fraud signal, and coded all other firms as 0, which produced the binary dependent variable we use throughout the logistic regression models in Section 3.4.

We proxied financial stability, the first independent variable, with the asset change ratio, calculated as the difference between the current year's total assets and the prior year's total assets, divided by the current year's total assets, following Apriliana and Agustina (2017); we interpret a larger absolute change in either direction as evidence of instability in the firm's underlying asset base. We proxied external pressure with the debt-to-equity ratio, calculated as total debt divided by shareholder equity, following Khamainy et al. (2022) and grounded in the leverage-based pressure proxy Skousen et al. (2008) establish; we treat a higher ratio as evidence of heightened pressure from creditors. We proxied ineffective monitoring with the proportion of independent commissioners, calculated as the number of independent commissioners divided by the total number of commissioners on the board, following Yendrawati et al. (2019). We use this proxy directly, without inverting its scale, and treat the sign of its relationship with fraud as an empirical question rather than an assumption. We measured CEO tenure as the number of consecutive years the incumbent chief executive has held office up to the fiscal year under study, following Seifzadeh et al. (2022), and we treat this measure as capturing the managerial entrenchment we discussed in Section 2.2.

We measured board gender diversity, the moderating variable, as the raw count of female directors serving on the board of directors, following one specification Wahid (2019) uses; we chose a count-based rather than a binary measure specifically to preserve the variation our four continuous interaction terms require. This choice trades off with two common alternatives. A proportion-based

measure, female directors divided by board size, would confound board gender diversity with board size itself, since the proportion can rise either because a firm adds women or because it shrinks its board for unrelated reasons. A composition-based diversity index, such as the Blau or Shannon index, would instead compress our sample's already limited variation, a mean FEM of 0.725 and a maximum of 7, into a narrower range before estimating the four interaction terms. Therefore, we treat the raw count as the measure best suited to a moderator entering four separate interaction terms, at the cost of direct comparability with the proportion-based measure Kwamboka, Githaiga, and Kinuthia (2025) use, a trade-off we acknowledge rather than treat as costless. We measured audit committee size, the first control variable, as the total number of audit committee members, following Beasley (1996), for greater collective oversight capacity. We measured audit firm size, the second control variable, as a Big Four versus non-Big Four dummy, coded 1 when a Big Four firm audited the company and 0 otherwise, following Suryani et al. (2023), because Big Four auditors typically apply greater scrutiny to client financial statements.

3.3 Data Collection Method

We relied exclusively on secondary data from audited annual reports sourced primarily from the official Indonesia Stock Exchange website for the 2022-2024 fiscal years. Where an IDX-hosted filing was incomplete, we consulted the company's investor relations website for the equivalent audited report, ensuring that no firm-year observation relied on an unaudited or informally sourced document.

We extracted every financial-statement figure used to construct the Section 3.2 variables directly from each firm's audited financial statements and notes, and extracted governance data, independent commissioners, CEO tenure, female directors, audit committee size, and external audit firm identity from the same reports' governance and management-profile sections. Because Indonesia's capital market framework mandates these disclosures and requires independent audits before publication, we treat them as reliable and verifiable, consistent with prior Indonesian Fraud Pentagon research (Suryani, Winarningsih, Avianti, Sofia, & Dewi, 2023; (Achmad, Ghozali, & Pamungkas, 2022)).

3.4 Data Analysis Method

We performed all statistical procedures using Stata/MP Version 17 and ran the analysis through five sequential stages. In the first stage, we computed descriptive statistics, mean, standard deviation, minimum, and maximum, for every variable across the full 327 firm-year observations, which gave us an initial characterization of the sample before estimating any model. In the second stage, we assessed multicollinearity using pairwise Pearson correlations and variance inflation factors and evaluated each VIF value against the conventional threshold of 10.

In the third stage, we estimated our primary model, a conditional fixed-effects logistic regression, using Stata's clogit command with firm identity as the panel-conditioning variable. This estimator controls for unobserved, time-invariant firm heterogeneity by conditioning on each firm's within-panel variation in FRAUD, automatically excluding firms reporting no change in fraud status across 2022-2024 and reducing the estimation sample from 327 to 225 firm-year observations. We specified the model as logit in Formula 1.

$$P(FRAUD_{it}=1) = \beta_1(FS_{it}) + \beta_2(EP_{it}) + \beta_3(IM_{it}) + \beta_4(CEO_{it}) + \beta_5(FEM_{it}) + \beta_6(FS_{it} \times FEM_{it}) + \beta_7(EP_{it} \times FEM_{it}) + \beta_8(IM_{it} \times FEM_{it}) + \beta_9(CEO_{it} \times FEM_{it}) + \beta_{10}(ACS_{it}) + \beta_{11}(ASIZE_{it}) + \alpha_i \quad (1)$$

Where αi denotes the firm-specific fixed effect we condition out of the likelihood function, and where the four interaction terms test our four moderation hypotheses directly. In the fourth stage, we estimated a pooled logistic regression with heteroskedasticity-robust standard errors on the full, unconditioned 327-observation sample as a robustness check, using the same specification but omitting fixed-effects conditioning, allowing both within- and between-firm variation to inform the estimates. In the fifth stage, we evaluated each hypothesis primarily on Stage 3 results, using Stage 4 as a corroborating test, treating a hypothesis as supported when its coefficient carried the hypothesized sign and reached significance at or below 5% in the primary model, and reporting any hypothesis supported by only one method as an explicit robustness consideration.

4. Results and Discussions

4.1 Statistical Results

Table 2 shows that 40.4% of the 327 firm-year observations in our sample have a Beneish M-Score above -2.22, the threshold that signals a potential fraud indication. Financial stability averages 0.044, with a range of -0.825 to 0.415. The average external pressure was 0.381, with a range of 0.03 to 2.642. Independent commissioners occupy, on average, 42.9% of board seats. CEO tenure averages 7.294 years but ranges as high as 44 years, and female directors average just 0.725 per board, evidence that a substantial share of our sampled firm-years have no female board representation at all. Table 3 rules out multicollinearity as a concern: the highest pairwise correlation reaches only -0.313 (between external pressure and financial stability), and separately computed variance inflation factors average 1.08 across all variables, far below the conventional threshold of 10.

Table 3. Pairwise correlations

Variables	FRAUD	FS	EP	IM	CEO	FEM	ACS	ASIZE
FRAUD	1.000							
FS	0.114	1.000						
EP	0.072	-0.313*	1.000					
IM	-0.062	-0.128	0.046	1.000				
CEO	-0.074	-0.003	0.009	-0.055	1.000			
FEM	-0.085	0.016	-0.027	0.130	-0.064	1.000		
ACS	-0.037	-0.054	0.030	0.180*	-0.096	-0.034	1.000	
ASIZE	-0.052	-0.075	-0.072	0.037	0.012	0.118	0.223*	1.000

Table 2. Descriptive statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
FRAUD	327	.404	.491	0	1
FS	327	.044	.112	-.825	.415
EP	327	.381	.269	.03	2.642
IM	327	.429	.113	.25	.833
CEO	327	7.294	8.294	1	44
FEM	327	.725	1.008	0	7
ACS	327	3.043	.279	2	5
ASIZE	327	.425	.495	0	1

**** p<0.01, ** p<0.05, * p<0.1*

We select conditional fixed-effects logistic regression over a random-effects or pooled specification because our identification question is explicitly about within-firm variation: a random-effects logit assumes that the firm-specific effect is uncorrelated with the regressors, an assumption our governance variables, which change slowly and plausibly correlate with unobserved firm quality, are unlikely to satisfy, while a standard pooled logit cannot distinguish a genuine year-to-year fraud mechanism from a stable difference between firms. Conditional (fixed-effects) logit conditions out exactly that time-invariant firm heterogeneity, at the cost of dropping firms with no within-panel variation in FRAUD, a trade-off we treat as appropriate for this study's central question and revisit explicitly in Section 5.2. Our primary model, a conditional fixed-effects logistic regression, drops 34 of our 109 sampled firms because their fraud status never changes across 2022-2024, leaving 225 firm-year observations across 75 firms. We cross-validated this model against a pooled logistic regression with heteroskedasticity-robust standard errors, run on the full, unconditioned sample of 327 observations. Table 4 shows the two models agreeing on one result unambiguously: financial stability drives fraud risk upward, with a coefficient of 10.545 (p = .003) under fixed effects and 4.140 (p = .012) under the pooled specification, confirming H_1a at the 5% level for both methods.

Table 4. Conditional fixed-effects logistic regression and pooled logistic regression results

	Conditional FE Logit (N=225)				Pooled Logit, Robust SE (N=327)			
FRAUD	Coef.	St.Err.	p-value	Sig	Coef.	St.Err.	p-value	Sig

	Conditional FE Logit (N=225)				Pooled Logit, Robust SE (N=327)			
FS	10.545	3.583	.003	***	4.140	1.655	.012	**
EP	4.248	3.542	.230		1.664	.603	.006	***
IM	5.069	5.753	.378		.022	1.277	.987	
CEO	.086	.125	.494		-.011	.018	.557	
FEM	5.134	2.553	.044	**	.949	.692	.170	
FS_FEM	.353	4.422	.936		-1.673	1.751	.339	
EP_FEM	-2.426	3.317	.465		-1.352	.862	.117	
IM_FEM	-12.533	6.034	.038	**	-.807	1.007	.423	
CEO_FEM	-.031	.070	.659		-.024	.023	.299	
ASIZE	-.499	1.168	.670		.008	.261	.976	
ACS	2.832	1.888	.134		-.306	.400	.444	

Conditional FE Logit: Pseudo r-squared = 0.164; LR chi-square(11) = 27.078; Prob > chi2 = 0.004; AIC = 159.713; BIC = 197.290. Pooled Logit: Pseudo r-squared = 0.046; LR chi-square(11) = 20.068; Prob > chi2 = 0.044; AIC = 445.036; BIC = 490.516; standard errors are heteroskedasticity-robust (HC1).

**** p<.01, ** p<.05, * p<.1*

The remaining seven hypotheses were divided into three distinct patterns. External pressure shows the pooled model's clearest divergence from fixed effects: it reaches significance under the pooled specification (b = 1.664, p = .006), whereas the larger fixed-effects estimate (b = 4.248) loses significance (p = .230). Therefore, H_1b holds only when we do not strip out firm heterogeneity. Ineffective monitoring moved in the hypothesized positive direction under both models but never reached significance (p = .378 fixed effects, p = .987 pooled). CEO tenure follows the same positive pattern under fixed effects (p = .494) but turns marginally negative under the pooled model (b = -.011, p = .557), also short of significance, leaving H_2a and H_2b unsupported for the full sample.

Board gender diversity produces our second method-sensitive result. Its interaction with ineffective monitoring carries a coefficient of -12.533 (p = .038) under fixed effects, exactly the negative, fraud-weakening direction H_3c predicts, but that coefficient collapses to -0.807 (p = .423) under the pooled model, so H_3c survives only one of our two tests. The three remaining interaction terms never cross the significance threshold: external pressure (p = .465 and p = .117) and CEO tenure (p = .659 and p = .299) remain negative under both models, while financial stability's term is negative under the pooled model (p = .339) but turns marginally positive under fixed effects (b = .353, p = .936), leaving H_3a, H_3b, and H_3d unsupported. The FEM's direct coefficient reaches significance under fixed effects alone (b = 5.134, p = .044), a result outside our formal hypotheses, which we report for completeness. Neither control variable moves the needle: ASIZE posts p = .670 and p = .976; and ACS posts p = .134 and p = .444.

Table 5. Summary of hypotheses testing results across estimation methods

Hyp.	Statement	FE Logit (N=225)	Pooled Logit (N=327)	Consistent?
H_1a	Financial Stability has a positive effect on Financial Statement Fraud.	Supported (p=.003)	Supported (p=.012)	Yes
H_1b	External Pressure has a positive effect on Financial Statement Fraud.	Not Supported (p=.230)	Supported (p=.006)	No
H_2a	Ineffective Monitoring has a positive effect on Financial Statement Fraud.	Not Supported (p=.378)	Not Supported (p=.987)	Yes
H_2b	CEO Tenure has a positive effect on Financial Statement Fraud.	Not Supported (p=.494)	Not Supported (p=.557)	Yes

Hyp.	Statement	FE Logit (N=225)	Pooled Logit (N=327)	Consistent?
H₃a	Board Gender Diversity weakens the positive effect of Financial Stability on Financial Statement Fraud.	Not Supported (p=.936)	Not Supported (p=.339)	Yes
H₃b	Board Gender Diversity weakens the positive effect of External Pressure on Financial Statement Fraud.	Not Supported (p=.465)	Not Supported (p=.117)	Yes
H₃c	Board Gender Diversity weakens the positive effect of Ineffective Monitoring on Financial Statement Fraud.	Supported (p=.038)	Not Supported (p=.423)	No
H₃d	Board Gender Diversity weakens the positive effect of CEO Tenure on Financial Statement Fraud.	Not Supported (p=.659)	Not Supported (p=.299)	Yes

Table 5 summarizes all eight hypotheses, which were split six-to-two on method agreement. *H₁a*, *H₂a*, *H₂b*, *H₃a*, *H₃b*, and *H₃d* land on the same side of significance under both estimators, giving these six results a consistent, method-independent verdict. *H₁b* and *H₃c* do not: each depends on whether we condition out firm-level heterogeneity, and that dependence becomes the paper's central empirical puzzle, which we take up directly in Section 4.2.

4.2 Critical Discussion

Financial stability's robust, cross-method effect on fraud fits the specific pressures Indonesian manufacturers faced between 2022 and 2024: an uneven post-pandemic demand recovery, commodity-driven input-cost swings, and recurring supply chain disruption, all of which hit the asset base directly. Agency theory explains why instability produces manipulation rather than disclosure, as managers hold more information about the firm's true condition than shareholders. Fraud Pentagon theory supplies the channel, treating asset instability as the pressure vertex that management resolves through manipulation once monitoring proves too weak to stop it. A coefficient of 10.545 under fixed effects and 4.140 under the pooled model, both significant well past the 5% threshold, gives this mechanism real empirical weight, and five prior Indonesian studies converge in the same direction, suggesting a structural rather than sample-specific link. The eFishery case illustrates the stakes: even without formal disclosure obligations, a firm facing unstable performance found it easier to manipulate two sets of books than to disclose the truth. Regulators and boards should treat sharp year-on-year asset swings as active red flags rather than routine consequences of a volatile operating environment.

External pressure and board gender diversity's moderation of ineffective monitoring both flip between significant and non-significant depending on the estimator, a substantively important finding rather than a nuisance to explain away. External pressure reaches significance under the pooled model (b = 1.664, p = .006) but not under fixed effects (b = 4.248, p = .230), suggesting that the cross-sectional leverage-fraud association reported in six Indonesian studies likely reflects structural differences between firms rather than a within-firm pressure shock tied to a specific firm's leverage climbing in a specific year. Agency theory predicts fraud as a response to a shift in the agent's incentive environment, and persistently high leverage driven by subsector capital intensity does not represent that kind of shift, even though it may still correlate with fraud across a heterogeneous cross-section. A leverage level alone tells auditors less than one that has moved sharply relative to a firm's own history, and our within-firm null result suggests that the leverage-fraud link in the pooled-estimator literature may partly reflect firm heterogeneity rather than a live, year-to-year mechanism.

The moderation of ineffective monitoring by board gender diversity runs the same pattern in reverse: significant under fixed effects (b = -12.533, p = .038), and null under pooled (b = -0.807, p = .423). Indonesia's regulatory floor of at least 30% independent commissioners offers a plausible mechanism: the mean ratio of our sample (42.9%) sits comfortably above that floor, suggesting that many firms treat the requirement as a compliance target rather than as a genuine oversight. Once independence

becomes formulaic, female directors, operating outside the informal networks that allow compliance to persist unchallenged, gain real value that a homogeneous board cannot replicate. Crowe (2011)'s arrogance construct helps explain why this matters for the opportunity-arrogance pathway: a board that rubber-stamps independence on paper leaves room for entrenched confidence, and female directors narrow that room. We do not treat this result as settled: Wahid (2019) tests a nearly identical substitution hypothesis on more than 6,000 U.S. firms and finds no significant difference between well- and poorly governed boards, a far larger and more definitive test than ours. Our fixed-effects estimate carries a wide confidence interval (-24.359 to -0.706) from only 75 firms, which invites two readings: a genuine within-firm dynamic the pooled model dilutes past detection, or a small number of high-leverage observations exerting an outsized influence on a thin panel. This fragile result deserves a hedge, not a headline.

Ineffective monitoring and CEO tenure fail to reach significance under either model, and each failure points to a unique mechanism. Indonesia's 30% independent-commissioner floor likely compresses variation in ineffective monitoring around a compliance norm, consistent with two Indonesian studies reporting the same null result in less regulation-constrained samples, while two others, drawing on state-owned-enterprise and cross-industry samples where composition varies more around that floor, report a significant effect. This split strengthens, rather than weakens, our compliance-compression explanation. CEO tenure's null result may hide two offsetting forces: the capability-and-arrogance mechanism our hypotheses assume competes against a reputational-protection mechanism prior research documents, in which entrenched managers protect long-term firm value precisely because their reputational stake grows with tenure. Across our sample's wide tenure range of one to 44 years, a single linear coefficient cannot separate a CEO still building capability from one whose entrenchment cuts toward stewardship, and their cancellation, not their absence, may produce the null result. Future work splitting tenure into early, middle, and late bands could directly test this offsetting-mechanism explanation.

Three of our four moderation hypotheses, financial stability, external pressure, and CEO tenure, failed to reach significance under either model. External pressure and CEO tenure carry the hypothesized negative sign under both specifications; financial stability's interaction term does too under the pooled model, but turns marginally positive under fixed effects (b = .353, p = .936), a coefficient close enough to zero, relative to its standard error of 4.422, to be read as noise rather than a genuine reversal. This largely consistent directional pattern points to statistical power rather than regulatory floor-driven variance compression, which explains the null result of ineffective monitoring. Female board representation averages just 0.725 directors, sharply limiting the variation in the three interaction terms that need to be estimated precisely, especially once fixed-effects conditioning drops the estimation sample to 225 observations across 75 firms. Wahid (2019) needed more than 6,000 U.S. firms across an eleven-year window, roughly twenty-seven times our sample, to detect comparable effects, a scale that Indonesia's smaller listed-manufacturing pool cannot match. We read these three results as evidence of insufficient statistical power rather than an absent moderation effect: a null result born of thin data calls for a bigger sample, not a policy conclusion that the mechanism does not exist. Pooling data across ASEAN markets or extending the observation window well beyond three years would give these hypotheses a fairer test.

Collectively, our results extend agency theory and the Fraud Pentagon theory by showing that they work best in combination: agency theory explains why a governance mechanism, such as board gender diversity, should matter, while the Fraud Pentagon theory specifies which pressure, opportunity, or arrogance channel needs to be interrupted. Methodologically, our results show that a significant governance-moderation effect under one estimator can fail to replicate under another, a caution that the broader fraud-detection literature has not consistently built in. For Indonesian regulators, formal compliance with monitoring minimums should not substitute substantive fraud protection, since a firm can satisfy every governance checkbox and still carry real fraud risk. For the OJK, incorporating firm-specific trend indicators into the risk-based supervisory triggers under POJK No. 12 of 2024 would target the within-firm mechanisms identified as most credible by our fixed-effects results. For boards and audit committees, board gender diversity merits continued attention as

a complementary monitoring channel that appears to be activated specifically where formal oversight has become a checkbox rather than a genuine constraint, which can be confirmed by future research with larger or pooled samples.

5. Conclusions

5.1 Conclusion

Key findings: Financial stability drives fraud risk upward under both estimation methods, confirming the pressure mechanism at the core of the Fraud Pentagon theory, regardless of how firm heterogeneity is treated. External pressure and board gender diversity's moderation of ineffective monitoring behave differently: both flip between significant and non-significant results depending on the estimator, exposing a methodological fault line that the broader fraud-detection literature has not consistently addressed. Board gender diversity narrows the space ineffective monitoring leaves open for fraud under the primary specification, but that effect, along with three other hypothesized moderation pathways, does not survive the robustness check.

Theoretical contribution: Agency and Fraud Pentagon theories work best together, not apart: agency theory explains why board gender diversity should constrain fraud, while Fraud Pentagon theory specifies which pressure, opportunity, or arrogance channels that constraint needs to interrupt. Governance-moderation claims built on a single estimator deserve more scrutiny than the literature currently provides.

Extending the Fraud Pentagon theory: More specifically, these results point to a boundary condition that the original five-vertex framework does not anticipate. The Fraud Pentagon theory treats pressure, opportunity, rationalization, capability, and arrogance as vertices that are measured with comparable confidence. However, our findings show that the vertices differ sharply in terms of how estimator-robust their fraud links are. The pressure vertex, operationalized through financial stability, survives a complete change in the estimator. [Insert here] The opportunity vertex, operationalized through ineffective monitoring, only becomes visible via the moderating effect of board gender diversity once the model isolates within-firm variation. The Fraud Pentagon theory offers no basis for expecting asymmetry among its vertices. Our results suggest that the theory needs an explicit robustness dimension, whether a vertex's empirical support depends on within-firm or between-firm variation, alongside the five substantive vertices it already specifies.

Practical implications: For Indonesian regulators, this study's within-firm results suggest that formal compliance with monitoring minimums, such as the 30% independent-commissioner floor, should not be read as sufficient assurance against fraud, since a firm can satisfy that floor and still carry real fraud risk. Incorporating firm-specific trend indicators and year-on-year changes in assets or leverage into the risk-based supervisory triggers under POJK No. 12 of 2024 would target the within-firm mechanism identified as the most robust in this study. For boards and audit committees, board gender diversity is best treated as a complementary monitoring channel that appears to be activated specifically when formal independence has become a compliance checkbox rather than a genuine constraint. The evidence from this study supports this only provisionally, given its sensitivity to the estimation method.

5.2 Research Limitations

The three-year window compresses within-firm variation and forces the conditional fixed-effects model to drop 34 of the 109 sampled firms for showing no change in fraud status. Purposive sampling restricts the panel to profitable, continuously listed manufacturing firms, a screening choice that the Beneish M-Score's interpretability requires but one that narrows generalizability to loss-making firms and other sectors of the Indonesian economy. Secondary audited disclosures and a binary fraud proxy cannot capture how fraud is actually discovered, investigated, or contested inside a firm, nor distinguish deliberate manipulation from aggressive but lawful earnings management with full certainty. Female board representation averages just 0.725 directors, leaving three of four moderation interactions with too little variation to estimate precisely, a power constraint rather than evidence that the underlying mechanisms fail to operate.

5.3 Suggestions and Directions for Future Research

Researchers should extend the observation window to five or ten years and pool data across ASEAN markets to gain the within-firm variation and cross-country comparison that this three-year Indonesian panel cannot offer alone. Testing a curvilinear board-gender-diversity specification, rather than assuming a linear relationship, would reveal whether the fragile moderation results reflect a threshold effect that a simple linear term cannot capture. Dynamic panel estimators, such as system GMM, address the possibility that governance characteristics and fraud risk jointly determine each other rather than in one causal direction. Mixed-methods designs validating the Beneish M-Score against confirmed OJK enforcement outcomes and models adding whistleblowing-system presence and ESG disclosure quality as governance variables would push this framework further than the present design can test alone.

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Author Contributions

NW contributed to the conceptualization, research design, data collection, formal analysis, and drafting of the manuscript. ND contributed to the literature review and revision. BB contributed to data validation and revision. All the authors approved the final manuscript.

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