

Market Integrity by Design: Governance Intelligence in Malaysia

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Abstract

This study examines whether governance quality, ownership concentration, ESG disclosure and trading-information anomalies are associated with market integrity risk among non-financial publicly listed companies in Malaysia. Using a balanced panel of 40 Bursa Malaysia companies from 2016 to 2025 (400 firm-year observations), the paper separates explanatory association from predictive early warning through firm and year fixed effects with firm-clustered standard errors, dynamic sensitivity analysis, upper-tail quantile regression, machine-learning classification and illustrative conditional 2026-2030 scenario projections. Board independence and ESG disclosure are consistently associated with lower market integrity risk, whereas ownership concentration, volatility and digital trading intensity are associated with higher risk. Upper-tail evidence indicates that concentrated ownership is especially consequential when board independence is weak. In the fitted random-forest model, ownership concentration produces the largest permutation-importance signal for suspicious market-integrity classification. The study interprets these layers according to distinct evidential roles: regression estimates describe conditional associations, machine learning provides early-warning discrimination, and scenario paths illustrate sensitivity to alternative governance and market conditions. The paper contributes a four-hypothesis governance-intelligence framework linking governance, disclosure and market signals to risk-based surveillance, board oversight and stakeholder value without treating statistical anomalies as proof of misconduct.

Keywords: Corporate Governance, Market Integrity Risk, Ownership Concentration, Board Independence, ESG Disclosure, Trading Anomalies, Bursa Malaysia, Machine Learning, Stakeholder Value

Introduction

Capital markets perform a public-interest function by allocating savings to productive investment, disciplining managerial conduct and transmitting firm-specific information to investors and society. Weakening market integrity affects more than just traders. Financing

costs may rise, trust in financial reporting may fall, regulatory confidence may erode and inefficient capital allocation may impose wider economic costs. For an emerging and middle-income economy such as Malaysia, market integrity is therefore not merely a trading-compliance matter; it is a governance, accounting, financial-reporting and stakeholder-value issue.

This paper uses the expression "trading anomalies" in a narrow analytical sense. It refers to statistically unusual trading-information signals, particularly abnormal cumulative adjusted volume turnover, liquidity turnover, volatility, digital trading intensity, news tone deviation and suspicious market-integrity flags. These signals are treated as early-warning indicators of market-integrity risk, not as legal findings of manipulation or misconduct. The distinction is important because the paper analyses governance intelligence and predictive risk signals rather than accusing any firm, director, shareholder or trader of unlawful conduct.

Malaysia provides a timely setting because its public listed companies operate within a governance and sustainability-reporting environment that is becoming more demanding. The Malaysian Code on Corporate Governance emphasises long-term value and wider stakeholder interests (Securities Commission Malaysia, 2021). Bursa Malaysia has strengthened sustainability-reporting expectations, while the National Sustainability Reporting Framework and the IFRS Sustainability Disclosure Standards push corporate reporting toward greater comparability and decision usefulness (Bursa Malaysia, 2022, 2024; IFRS Foundation, 2023a; IFRS Foundation, 2023b; IFRS Foundation, 2025; Securities Commission Malaysia, 2024). The OECD Corporate Governance Factbook also notes the continuing importance of sustainability assurance and governance-code development in Malaysia (OECD, 2025).

Existing Malaysian and emerging-market governance studies establish important associations between board monitoring, ownership arrangements, reporting quality and firm outcomes (Hasan et al., 2022; Miao et al., 2023; Salleh, 2024; Bagh et al., 2025; Natto & Mokoaleli-Mokoteli, 2025). Sustainability studies further connect board characteristics and ESG or integrated-reporting quality (Cooray et al., 2020; Anyigbah et al., 2023; Najaf et al., 2025). These contributions clarify governance and disclosure mechanisms, but their principal outcomes are typically firm performance, reporting quality or sustainability performance, rather than a distinct market-integrity risk construct that joins governance conditions to abnormal trading-information signals. Accordingly, the gap is not the absence of governance or predictive research, but the limited articulation of how these literatures can jointly inform a cautiously interpreted market-integrity risk framework in Malaysia.

Market microstructure research provides a complementary information-risk foundation for this argument. Kyle (1985) shows how informed and noise trading jointly shape price discovery and market depth; Glosten and Milgrom (1985) demonstrate how asymmetric information can be reflected in transaction prices and spreads; and Hasbrouck (1991) shows that trades carry information that is incorporated into prices over time. These insights do not imply that unusual trading is unlawful. Rather, they justify treating abnormal volume, liquidity, volatility and digitally intensified trading as signals about the information environment that warrant contextual interpretation alongside governance and disclosure quality.

The study is organised around four theoretically aligned channels: board independence, ownership concentration, ESG disclosure quality and trading-information anomalies. Annual and firm-level descriptive evidence, upper-tail analysis, predictive classification and conditional scenario projections are used to triangulate these channels rather than to multiply hypotheses. This design keeps the inferential claims distinct: panel regressions describe conditional associations, quantile analysis examines high-risk observations, machine learning evaluates early-warning discrimination, and scenario paths illustrate conditional futures rather than deterministic forecasts.

The contribution is explicitly differentiated into conceptual, methodological and practical dimensions. Conceptually, the study positions market integrity risk as an information-governance outcome at the intersection of independent board oversight, concentrated ownership, ESG disclosure and trading-information pressure. It extends governance-performance and disclosure-quality perspectives by asking how these channels coexist in a market-surveillance setting and by distinguishing risk signals from established misconduct. Methodologically, it organises firm and year fixed-effects estimates, dynamic and upper-tail sensitivity analysis, and machine-learning classification as complementary but non-equivalent forms of evidence; combining established techniques is not, by itself, claimed as a new estimator. Practically, the four-hypothesis framework links interpretable monitoring channels to risk prioritisation for regulators, boards and investors. Claims of empirical novelty are restricted to the proposed integration and its application to the stated Malaysian analytical panel, rather than to methodological invention or universal superiority over prior models.

Theoretical Foundation and Hypotheses

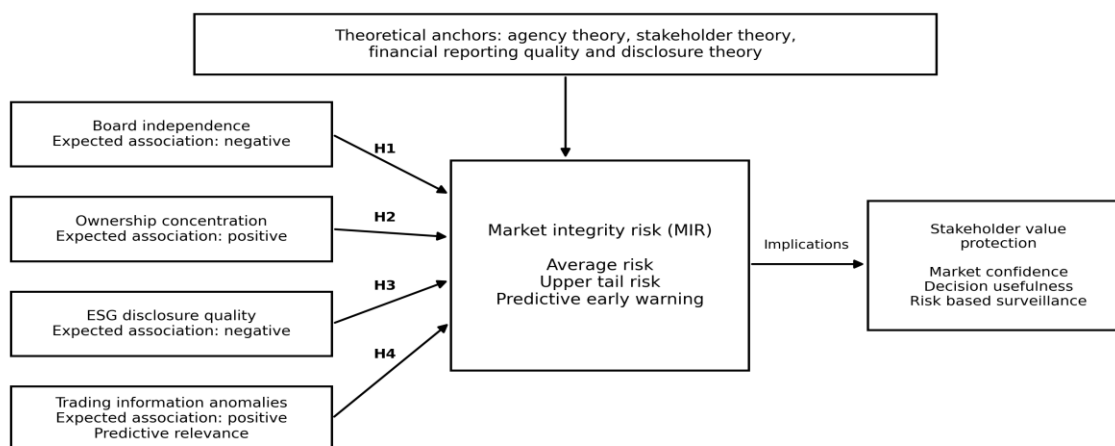
Theoretical positioning

The paper is anchored in agency theory, stakeholder theory and the financial-reporting-quality literature. Agency theory explains why independent monitoring can reduce opportunism and protect minority shareholders when ownership and control create conflicts of interest (Jensen & Meckling, 1976). Stakeholder theory extends the argument by treating fair markets and credible disclosure as part of a wider social contract between companies and the communities that supply capital, labour, legitimacy and trust (Freeman, 1984).

Financial-reporting and disclosure theories explain the information channel through which governance influences market integrity. Disclosure reduces information asymmetry, while earnings quality and audit quality affect the reliability of public information (Dechow & Dichev, 2002; Dechow et al., 2010; DeFond & Zhang, 2014; Healy & Palepu, 2001). In a high-speed trading environment, credible reporting and timely disclosure become more important because weak signals, rumours and delayed announcements can be rapidly amplified through digital trading activity.

The conceptual model in Figure 1 integrates the three theoretical lenses rather than using them as parallel citations. Agency theory supplies the internal-monitoring mechanism: stronger independent oversight is expected to constrain information advantages and opportunistic behaviour. Financial-reporting and disclosure theory supplies the information mechanism: higher-quality ESG and corporate disclosure can reduce uncertainty and improve decision usefulness. Stakeholder theory supplies the consequence mechanism: credible

markets protect not only shareholders but also creditors, employees, auditors, regulators and communities that depend on trustworthy corporate information. Trading-information anomalies are positioned as observable market signals that may reveal pressure around this governance-information architecture. Accordingly, Figure 1 links each independent variable directly to market integrity risk through H1-H4 and then connects lower integrity risk with stakeholder value protection.



Authors' research model: four hypothesis paths are shown directly and independently.

Figure 1 Conceptual research model for predictive governance and market integrity

Note. Source: Authors' model developed from agency theory (Jensen & Meckling, 1976), stakeholder theory (Freeman, 1984), disclosure and audit-quality literature (Dechow & Dichev, 2002; Dechow et al., 2010; DeFond & Zhang, 2014; Healy & Palepu, 2001), sustainability-reporting literature (Cooray et al., 2020; Anyigbah et al., 2023; Appiagyei & Donkor, 2023; Veeravel et al., 2024; Najaf et al., 2025; AlHares, 2025), and Malaysian governance and sustainability-reporting guidance (Securities Commission Malaysia, 2021, 2024; Bursa Malaysia, 2022, 2024; IFRS Foundation, 2023a, 2023b, 2025; OECD, 2025). H1-H4 are shown as direct hypothesis paths; the arrows indicate expected associations, not causal identification.

Research questions and four major hypotheses

Table 1 links each research question to one major hypothesis. The wording is deliberately associational because the panel design does not identify causal effects. Machine-learning classification, permutation importance and conditional scenario projections are used as supporting impact analyses: they strengthen interpretation and early-warning usefulness but are not treated as additional hypotheses or as proof of misconduct.

Table 1

Research questions and hypotheses

RQ	Research question	Hypothesis	Statement	Decision rule
RQ1	Is greater board independence associated with lower market integrity risk?	H1	Greater board independence is expected to be associated with lower market integrity risk.	Negative and statistically significant board-independence coefficient in the primary model, with consistent robustness evidence.
RQ2	Is ownership concentration associated with higher market integrity risk, especially when board independence is low?	H2	Greater ownership concentration is expected to be associated with higher market integrity risk, especially under low-board/high-owner conditions.	Positive and significant ownership coefficient and a positive upper-tail low-board/high-owner condition.
RQ3	Is stronger ESG disclosure quality associated with lower market integrity risk?	H3	Higher ESG disclosure quality is expected to be associated with lower market integrity risk.	Negative and statistically significant ESG disclosure coefficient, with consistent robustness evidence.
RQ4	Are trading-information anomalies associated with higher market integrity risk and useful for early-warning classification?	H4	Higher trading-information pressure is expected to be associated with higher market integrity risk and to provide useful predictive signals.	Positive anomaly-related coefficients together with classification and permutation-importance evidence indicating useful early-warning discrimination.

Literature Review

Governance monitoring, ownership and reporting quality

Corporate governance studies generally support the view that board structure, audit committee quality, ownership arrangements and strategic governance capability influence firm outcomes, although the direction and size of effects vary across institutional settings (Bagh et al., 2025; Hasan et al., 2022; Miao et al., 2023; Natto & Mokoaleli-Mokoteli, 2025; Salleh, 2024). In emerging markets, concentrated ownership may provide long-term commitment and monitoring, but it can also generate private-information advantages and minority-shareholder risk when independent oversight and disclosure discipline are weak.

The sustainability and integrated-reporting literature further shows that governance, ESG disclosure and firm performance are increasingly connected. Cooray et al. (2020), Anyigbah et al. (2023), Appiagyei and Donkor (2023), Veeravel et al. (2024), Najaf et al. (2025) and AlHares (2025) collectively indicate that sustainability reporting is part of a broader information architecture rather than a peripheral disclosure exercise. In the market-integrity context, this means that credible ESG disclosure can reduce uncertainty, strengthen stakeholder trust and support the quality of price discovery.

Market integrity, information asymmetry and the digital trading environment

Market integrity depends partly on whether prices and trading activity reflect information in an orderly and interpretable way. Classical microstructure models show that private information, liquidity demand and market-making interact to determine price discovery, spreads and transaction dynamics (Kyle, 1985; Glosten & Milgrom, 1985). Empirical work further demonstrates that trades can reveal information gradually through subsequent price revisions (Hasbrouck, 1991). In this study, those insights provide a theoretical basis for examining trading information pressure as a risk signal while preserving an explicit boundary between statistical abnormality and regulatory misconduct.

Trading anomalies are important because abnormal price-volume behaviour can occur before weak governance becomes visible in annual reports or audit files. Loughran and McDonald (2011) demonstrate that textual information can carry financially relevant signals, while the present study extends that logic by incorporating news tone, abnormal volume, liquidity, volatility and digital trading intensity into a market-integrity framework. Digital trading may improve access and liquidity, but it may also accelerate the spread of weak or incomplete signals, particularly where disclosure is delayed or ownership is concentrated.

Research connecting artificial intelligence and accounting offers an important point of comparison. Svanberg et al. (2022) use machine learning to rate corporate-governance performance, whereas Li (2025) and Shaban (2025) examine AI in relation to reporting quality, transparency or governance practices. These studies establish that algorithmic assessment can complement traditional financial and governance analysis. Their central constructs, however, should not be conflated with the present study's suspicious market-integrity flag or bounded MIR index. The present study does not claim that machine learning in governance is new; its narrower proposed contribution is to combine governance and disclosure variables with trading-information anomalies while treating predicted flags as screening information rather than verified misconduct.

In relation to closely associated sustainability studies, Cooray et al. (2020) investigate governance and integrated-reporting quality, while Najaf et al. (2025) focus on board characteristics and ESG performance in Malaysia's sustainability-reporting context. Those studies offer stronger direct precedent for the governance and disclosure channels than for a market-integrity outcome. Likewise, Veeravel et al. (2024) demonstrate quantile-based analysis in ESG research, meaning that the present use of upper-tail regression should be understood as a transfer of an established method to a different risk question, not as an original econometric technique. The distinguishing theoretical proposition is that governance and disclosure can be considered together with observable market-information pressure in assessing where further surveillance attention may be warranted.

Predictive analytics and stakeholder value

The predictive component of the study draws on machine-learning and explainability literature. Random forests are used because ensemble tree methods can detect non-linearities and interactions (Breiman, 2001), while gradient boosting offers an alternative sequential learning approach (Friedman, 2001). Model evaluation follows the principle that predictive validity should be assessed by held-out performance rather than in-sample fit (Hastie et al., 2009; Pedregosa et al., 2011). Permutation importance and interpretable

machine-learning principles help explain which variables drive the predictive signal (Lundberg & Lee, 2017; Molnar, 2022).

Research gap

The comparison with prior studies identifies three specific gaps. First, governance-performance research (Miao et al., 2023; Bagh et al., 2025) and governance-disclosure research (Cooray et al., 2020; Najaf et al., 2025) illuminate distinct corporate outcomes, but do not directly establish the four-channel market-integrity interpretation evaluated here. Second, governance-focused machine learning (Svanberg et al., 2022) demonstrates the feasibility of prediction, while the present study deliberately separates explanatory panel associations, upper-tail patterns and classification performance into different evidential claims. Third, governance and anomaly research needs transparent safeguards against conflating constructed risk indices, mechanically overlapping predictors and legally substantiated misconduct. The conceptual advance is the specified linkage between governance monitoring, disclosure quality and trading-information risk; the methodological contribution is their disciplined triangulation with established econometric and predictive tools. Neither contribution implies causal identification or independently validated enforcement detection.

Methodology

Research design, data and variables

The study uses a balanced analytical panel of 40 non-financial companies listed on Bursa Malaysia and observed annually from 2016 to 2025, yielding 400 firm-year observations. Financial institutions are excluded because banks, insurers and related entities operate under prudential regulation and accounting structures that are not directly comparable with non-financial sectors. The source manuscript does not document a probability-sampling mechanism; accordingly, the 40-firm panel is treated conservatively as an analytical sample rather than as a representative probability sample of the full market. Journal-level replication should report the initial eligible population, firm-screening sequence, data-completeness rules and sector composition. Statistical inference refers to the sampled firms and period, and wider market generalisation is made cautiously.

The retained variables are limited to those required by the four hypotheses and the governance-intelligence dashboard. Table 2 distinguishes the market-integrity outcome from governance, ownership, disclosure and trading-information predictors. Board independence, ownership concentration and ESG disclosure quality represent the three governance-information channels, whereas volatility, digital trading intensity and related anomaly measures describe the trading-information environment. Firm size, audit quality, institutional ownership, foreign ownership and regulatory-surveillance intensity are retained as controls or predictive features rather than as separate hypotheses.

Table 2

Variables in the hypothesis model

Construct	Symbol / measure	Operational meaning	Hypothesis role
Market integrity risk	MIR_it	Bounded research index from 0 to 100; higher values indicate higher assessed market-integrity risk. The replication specification must identify every component, risk direction, transformation, normalisation rule, weight and missing-data rule.	Dependent outcome
Board independence	BIND_it	Percentage of independent directors on the board.	H1: governance-monitoring channel
Ownership concentration	OWN_it; LBHO_it	Controlling ownership percentage and low-board/high-owner condition.	H2: ownership-control channel.
ESG disclosure quality	ESG_it	ESG disclosure score measuring the extent and/or quality of environmental, social and governance reporting according to the study's documented scoring protocol. Higher values indicate stronger disclosure quality.	H3: disclosure-quality channel
Trading anomalies	TA_it = {ACAVT_it, LIQ_it, VOL_it, DTI_it, NTONE_it, SFLAG_it}	Trading-information feature set covering abnormal volume, liquidity, volatility, digital trading intensity, news tone and a suspicious market-integrity flag; statistical anomalies are treated as risk signals rather than legal findings.	H4: trading-information channel
Controls	lnMCAP_it, BIG4_it, INST_it, FOR_it, RSI_it	The factors include firm size, audit quality, institutional ownership, foreign ownership, and the intensity of regulatory surveillance.	Control and robustness variables

Note. ACAVT = abnormal cumulative adjusted volume turnover; ESG = environmental, social and governance; LBHO = low-board/high-owner condition; SFLAG = suspicious market-integrity flag. Criterion separation is mandatory: an anomaly variable used as an explanatory predictor or SFLAG used as a predictive target should not be mechanically duplicated inside the contemporaneous MIR outcome used for the corresponding analysis. Exact construct definitions, cut points and coding rules belong in the replication specification.

Measurement transparency and construct separation

The study's principal measurement challenge is construct auditability rather than model complexity. MIR, ESG, DTI, LBHO and SFLAG are research constructs whose interpretation depends on transparent coding. Four safeguards are therefore required. First, each construct should have a documented data source, scale, direction and transformation rule. Second,

LBHO must be defined by explicit board-independence and ownership cut points rather than by a descriptive label alone. Third, SFLAG must have a transparent threshold or coding rule. Fourth, any variable used as an explanatory predictor or predictive target must remain mechanically distinct from the contemporaneous MIR outcome used in that analysis. Because the supplied manuscript does not contain the underlying component-level workbook definitions, this revision does not infer or fabricate them; the exact construct dictionary is specified as a mandatory replication supplement. This approach prioritises auditability and avoids false precision.

Model specification

Let MIR_{it} denote market integrity risk for firm i in year t . The primary explanatory specification is the two-way fixed-effects model:

$$MIR_{it} = \alpha + \beta_1 BIND_{it} + \beta_2 OWN_{it} + \beta_3 ESG_{it} + \beta_4 TA_{it} + \theta Z_{it} + \mu_i + \lambda_t + \varepsilon_{it}.$$

where $BIND_{it}$ represents board independence, OWN_{it} ownership concentration, ESG_{it} ESG disclosure quality, TA_{it} the retained trading-information signal set, Z_{it} the control vector, μ_i firm fixed effects, λ_t year fixed effects and ε_{it} the disturbance term. Firm fixed effects absorb time-invariant firm characteristics, while year effects absorb market-wide annual shocks. Robust standard errors are clustered by firm to address within-firm serial dependence and heteroskedasticity (Petersen, 2009; Wooldridge, 2010). The coefficients are interpreted as conditional within-panel associations, not as causal effects.

Dynamic and upper-tail models are used as sensitivity analyses rather than as stronger causal estimators. The dynamic specification adds lagged MIR within the fixed-effects framework to examine persistence. Because the time dimension is short ($T = 10$), lagged-outcome fixed-effects estimates may exhibit finite- T bias and are interpreted only as corroborative evidence. Arellano-Bond and Blundell-Bond are therefore cited as alternative dynamic-panel frameworks for further robustness, not as estimators used to generate the reported dynamic coefficients (Arellano & Bond, 1991; Blundell & Bond, 1998). Quantile regression at $\tau = 0.75$ evaluates whether associations differ among higher-risk observations; the replication specification should state the exact quantile estimator, treatment of firm/year effects and standard-error procedure used for that model (Koenker & Bassett, 1978; Koenker, 2005).

With 40 firm clusters, firm-clustered standard errors remain the primary variance estimator, but finite-cluster inference deserves caution. Cluster bootstrap procedures can improve inference when asymptotic cluster approximations are weak (Cameron et al., 2008). The study therefore gives greatest weight to findings that are directionally consistent, statistically supported and substantively coherent across the primary fixed-effects and sensitivity specifications, rather than relying on isolated p-values.

The four hypotheses are expressed as directional association and prediction propositions:

H1: $\beta_1 < 0$. Greater board independence is associated with lower market integrity risk.

H2: $\beta_2 > 0$, with a positive upper-tail LBHO condition. Greater ownership concentration is associated with higher market integrity risk, particularly when board independence is low.

H3: $\beta_3 < 0$. Higher ESG disclosure quality is associated with lower market integrity risk.

H4: retained anomaly-related coefficients are expected to be positive, and the trading-information feature set is expected to provide useful early-warning classification. Predictive

performance complements the regression evidence; it does not establish causality or misconduct.

As illustrated in Figure 2, the analytical sequence separates explanation from prediction. The workflow moves from sample construction and variable definition to descriptive diagnostics, two-way fixed-effects estimation, dynamic and upper-tail sensitivity analysis, machine-learning classification, feature-importance interpretation and conditional scenario projection. This separation prevents predictive accuracy from being presented as econometric identification and prevents scenario analysis from being presented as a probabilistic forecast.

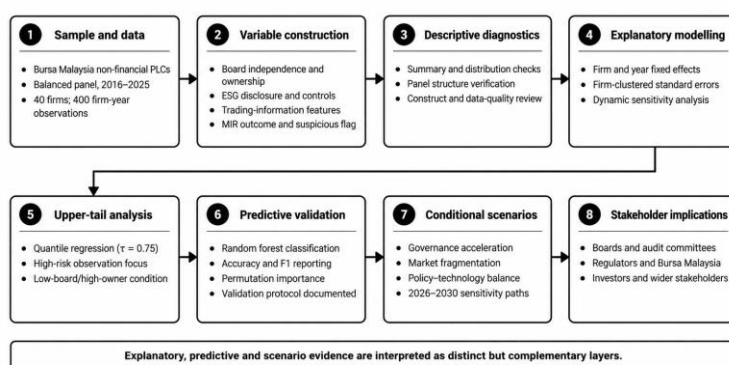


Figure 2 Empirical and predictive analytical pipeline

Note. Source: Analytical structure developed from panel modelling, dynamic-panel and quantile-regression literature (Arellano & Bond, 1991; Blundell & Bond, 1998; Koenker & Bassett, 1978; Koenker, 2005; Petersen, 2009; Wooldridge, 2010) and predictive-analytics literature (Breiman, 2001; Friedman, 2001; Hastie et al., 2009; Pedregosa et al., 2011; Lundberg & Lee, 2017; Molnar, 2022). Explanatory coefficients, predictive metrics and scenario paths are interpreted according to their distinct evidential roles.

Identification, validation and scenario discipline

The inferential hierarchy is intentionally conservative. The two-way fixed-effects model is the primary explanatory specification because it absorbs time-invariant firm heterogeneity and common year shocks, while firm-clustered standard errors address within-firm dependence. These controls strengthen inference but do not identify causal effects. Dynamic fixed-effects and upper-tail quantile results are therefore used to test persistence and high-risk sensitivity rather than to claim stronger identification. Coefficient signs, statistical significance, cross-model consistency and economic interpretation are considered jointly when assessing H1–H4.

Prediction and scenario analysis follow a separate evidential logic. The reported random-forest accuracy, F1 score and permutation importance are treated as sample-specific early-warning evidence whose external validity depends on the validation design. For panel data, the preferred protocol holds out entire firms or uses forward-chaining across time so that the same firm's future observations are not indirectly learned from related observations. The replication specification should report class balance, training/validation split, cross-validation design, random seed, hyperparameters, decision threshold, confusion matrix, precision,

recall, ROC AUC, precision-recall AUC, F1 and Brier score. Scenario paths for 2026-2030 remain conditional sensitivity exercises rather than probabilistic forecasts. A critical safeguard throughout is criterion separation: no predictor or predictive target should be mechanically duplicated in the contemporaneous MIR outcome used for that model. These distinctions improve auditability and prevent explanatory, predictive and scenario evidence from being interpreted as interchangeable.

Scenario construction and auditability

Scenario paths are deterministic sensitivity exercises whose credibility depends on transparent input assumptions rather than on forecast accuracy. The accompanying scenario specification should report, for each year from 2026 to 2030 and for each scenario, the assumed values or changes for board independence, ownership concentration, ESG disclosure, volatility, digital trading intensity and any other variable entering the projection equation, together with the rule used to translate those inputs into MIR. The governance-acceleration, policy-technology balanced and market-fragmentation paths are therefore interpreted only within their stated assumptions and are not assigned probabilities.

Results

Descriptive and diagnostic profile

Before testing the four hypotheses, Table 3 reports the core descriptive profile. Market integrity risk averages 16.468 on a 0-100 scale and reaches the upper bound in at least one observation, supporting examination of both average and upper-tail behaviour. Board independence averages 53.282%, ownership concentration 38.633%, and ESG disclosure 77.839%. The dispersion across these measures provides sufficient within-sample variation for the hypothesis tests, while the wide MIR distribution cautions against relying only on average effects.

Table 3

Core descriptive and diagnostic evidence

Variable	Mean	Std. Dev.	Min	Max	Interpretation
Market integrity risk	16.468	23.966	0.000	100.000	The wide range supports both average-effect and upper-tail analysis.
Ownership concentration	38.633	17.820	8.000	80.486	Concentrated ownership remains a central governance feature.
Board independence	53.282	9.817	28.215	78.734	Variation enables testing of the monitoring hypothesis.
ESG disclosure score	77.839	10.078	46.621	95.000	Disclosure maturity is uneven across firms and years.
Volatility	0.103	0.043	0.027	0.280	Trading-environment risk differs substantially across observations.
Digital trading intensity	0.579	0.141	0.256	0.885	Digital market exposure provides the main trading complexity indicator.
ACAVT	0.016	0.032	-0.064	0.123	Abnormal volume pressure supports the trading-anomaly construct.

Note. Statistics are based on 400 firm-year observations, except for lagged variables, where the first year of each firm is excluded. ACAVT = abnormal cumulative adjusted volume turnover.

Hypothesis testing

Table 4 consolidates the hypothesis evidence. H1 is supported because board independence is negative and statistically significant in the fixed-effects model and remains negative in the dynamic and upper-tail specifications. H2 is supported because ownership concentration is positive and significant, while the low-board/high-owner condition is strongly positive in the upper tail. H3 is supported because ESG disclosure quality is consistently negative and significant. H4 is supported by the positive volatility and digital-trading coefficients together with the reported random-forest classification metrics. These decisions indicate empirical support for the prespecified directions; they do not convert the observational design into causal identification.

Table 4

Four-hypothesis evidence and support decisions

Hypothesis	Main variable(s)	Key evidence	Decision	Interpretation
H1: Board independence is associated with lower MIR.	BIND_it	FE: -0.755***; dynamic: -0.719***; Q0.75: -0.674***	Supported	Board independence is consistently associated with lower average and upper-tail market-integrity risk.
H2: Ownership concentration is associated with higher MIR.	OWN_it; LBHO_it	OWN FE: 0.623***; OWN Dynamic: 0.685***; OWN Q0.75: 0.576***; LBHO Q0.75: 39.945***	Supported	Ownership concentration is associated with higher MIR, with a particularly large upper-tail low-board/high-owner condition.
H3: ESG disclosure quality is associated with lower MIR.	ESG_it	FE: -0.249***; dynamic: -0.237***; Q0.75: -0.275***	Supported	Higher ESG disclosure quality is consistently associated with lower market-integrity risk.
H4: Trading anomalies are associated with higher MIR and predictive risk signals.	VOL_it; DTI_it; ML evidence	VOL FE: 80.015***; DTI FE: 26.879**; RF accuracy: 0.917; RF F1: 0.750	Supported	Volatility and digital trading intensity are positively associated with MIR; random-forest metrics provide complementary early-warning evidence.

Note. MIR = market integrity risk; FE = firm and year fixed-effects model; Q0.75 = upper-tail quantile regression at $\tau = 0.75$; RF = random forest. ***, ** and * indicate significance at 1%, 5% and 10%, respectively. "Supported" means that the reported evidence is consistent with the prespecified directional proposition; it does not imply causal proof. Machine-learning

evidence is treated as complementary early-warning evidence supporting H4, not as a separate hypothesis or a legal classification of misconduct.

Predictive evidence and conditional scenario projections

The predictive analysis complements the four-hypothesis interpretation by showing which variables contribute most to suspicious market-integrity classification within the fitted random-forest model. Figure 3 shows that ownership concentration produces the largest decrease in ROC AUC when permuted, making it the strongest permutation-importance signal in this model and sample. This result reinforces H2 as a predictive warning signal, but permutation importance should not be interpreted as a causal ranking or as proof that ownership concentration alone creates suspicious trading outcomes.

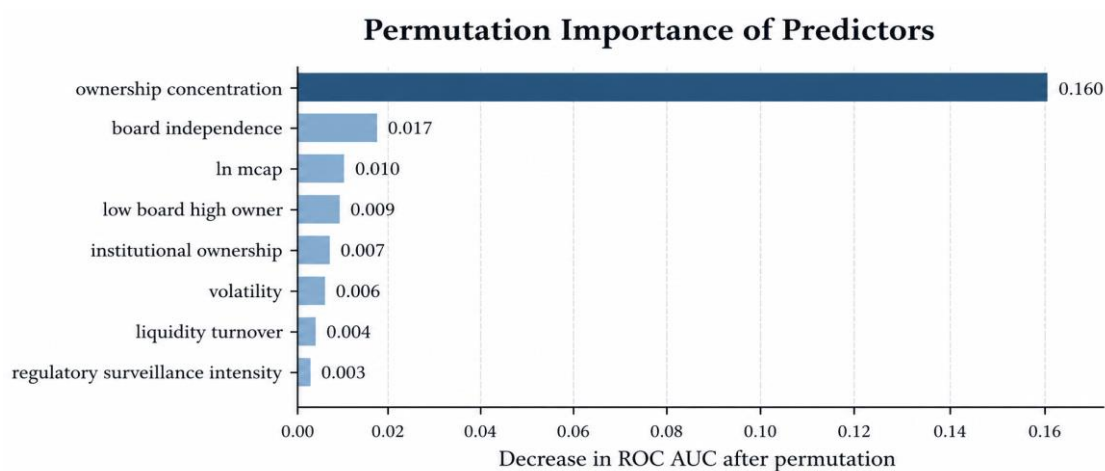


Figure 3. Most influential predictors of suspicious market-integrity flags

Note. Source: Random-forest estimation and permutation-importance analysis, interpreted using random-forest and explainable-machine-learning principles (Breiman, 2001; Lundberg & Lee, 2017; Molnar, 2022). Importance values describe deterioration in fitted predictive performance after permutation and are model- and sample-dependent.

Figure 4 presents conditional 2026-2030 scenario paths rather than a deterministic forecast. Under the governance-acceleration path, mean market integrity risk declines from 7.321 in 2026 to 3.624 in 2030; under the market-fragmentation path, it rises from 10.696 to 15.436. The policy-technology balanced path lies between these cases. These trajectories illustrate how alternative governance, disclosure and market conditions map into the estimated governance-intelligence framework. They should be read as structured sensitivity scenarios, not as probabilities or predictions of what will occur.

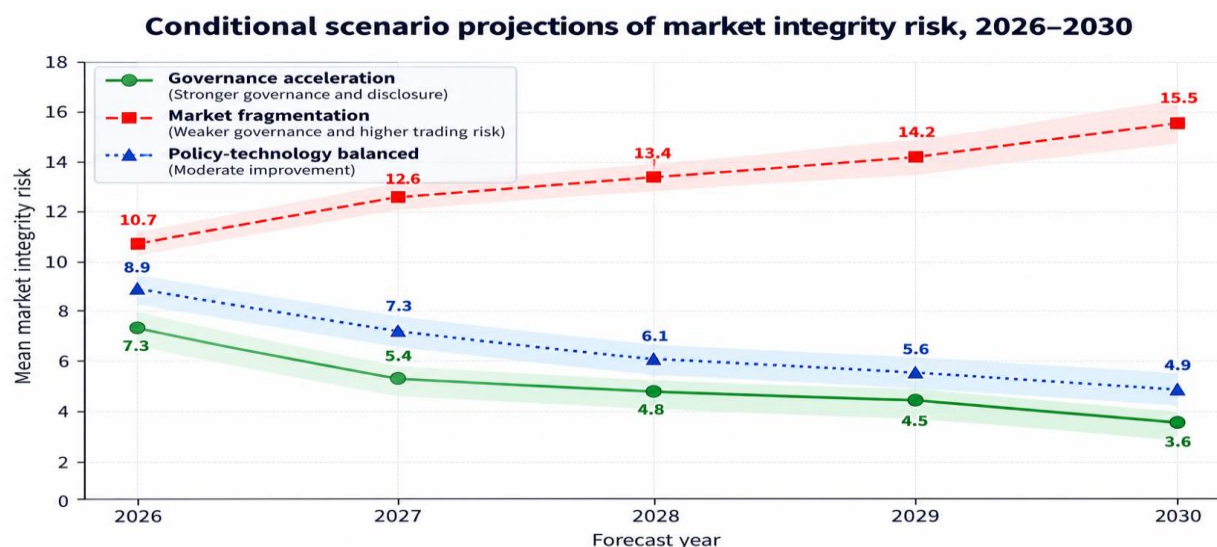


Figure 4. Conditional scenario projections of market integrity risk, 2026-2030

Note. Source: Conditional scenarios constructed from the estimated governance-intelligence framework and Malaysia's governance and sustainability-reporting direction (Securities Commission Malaysia, 2021, 2024; Bursa Malaysia, 2022, 2024; IFRS Foundation, 2023a, 2023b, 2025; OECD, 2025). The paths are illustrative scenario projections and should not be interpreted as probabilistic forecasts.

Economic magnitude and evidence triangulation

The fixed-effects coefficients also have substantive meaning when read in the units used by the study. Holding the remaining model structure constant, a 10-percentage-point increase in board independence corresponds to a 7.55-point lower fitted MIR (10×-0.755), while a 10-percentage-point increase in ownership concentration corresponds to a 6.23-point higher fitted MIR. A 10-point increase in the ESG disclosure score corresponds to a 2.49-point lower fitted MIR. For the trading environment, a 0.10 increase in digital trading intensity corresponds to about a 2.69-point higher fitted MIR, and a 0.01 increase in volatility corresponds to about a 0.80-point higher fitted MIR. These are model-implied conditional differences, not causal treatment effects. Their value is interpretive: the signs and magnitudes are economically meaningful and align with the upper-tail and predictive evidence.

Discussion

The findings provide a coherent four-channel account of market integrity risk in the sampled Malaysian non-financial listed companies. The evidence is strongest when interpreted through an explicit hierarchy: two-way fixed effects provide the primary conditional associations; dynamic and quantile specifications test persistence and upper-tail sensitivity; machine learning evaluates early-warning discrimination; and scenarios illustrate conditional futures. The economic-magnitude calculations further show that the estimated associations are not merely statistically detectable but material on the 0-100 MIR scale. Keeping these evidential roles separate strengthens theoretical interpretation and avoids overstating what an observational panel can establish.

H1: Board independence is associated with lower market integrity risk.

H1 is supported because the board-independence coefficient is negative and statistically significant in the fixed-effects model ($\beta = -0.755$) and remains negative in the dynamic ($\beta = -0.719$) and 0.75-quantile ($\beta = -0.674$) specifications. The consistency across average and upper-tail models is compatible with the agency-theoretic prediction that independent monitoring constrains information advantages and strengthens challenge of market-sensitive decisions. Independent directors may improve disclosure discipline, related-party scrutiny and minority-shareholder protection, but the observational estimates should be read as conditional associations rather than causal effects (Jensen & Meckling, 1976; Hasan et al., 2022; Miao et al., 2023; Salleh, 2024).

H2: Ownership concentration is associated with higher market integrity risk.

H2 is supported because ownership concentration is positive and statistically significant in the fixed-effects model ($\beta = 0.623$), dynamic model ($\beta = 0.685$) and upper-tail model ($\beta = 0.576$). The low-board/high-owner condition is also large and positive at the upper tail ($\beta = 39.945$), indicating that concentrated ownership warrants particular attention when independent board oversight is weak. Concentrated ownership can provide commitment and monitoring benefits, so the result should not be read as a universal condemnation of blockholding. Rather, the joint pattern is consistent with heightened information and minority-shareholder risk when control concentration coincides with weaker independent monitoring (Bagh et al., 2025; Natto & Mokoaleli-Mokoteli, 2025).

H3: ESG disclosure quality is associated with lower market integrity risk.

H3 is supported because the ESG coefficient is negative in the fixed-effects model ($\beta = -0.249$), dynamic model ($\beta = -0.237$) and upper-tail model ($\beta = -0.275$). The result is consistent with an information-quality mechanism: more decision-useful sustainability disclosure can reduce uncertainty, improve comparability and signal stronger risk-governance routines. ESG disclosure should therefore be interpreted as part of the wider corporate information architecture rather than as a stand-alone sustainability exercise. This interpretation aligns with the integrated-reporting and sustainability-disclosure literature and with Malaysia's movement toward IFRS S1/S2-aligned reporting (AlHares, 2025; Anyigbah et al., 2023; Appiagyei & Donkor, 2023; Cooray et al., 2020; Najaf et al., 2025; Veeravel et al., 2024; Bursa Malaysia, 2022, 2024; IFRS Foundation, 2023a, 2023b, 2025; Securities Commission Malaysia, 2024).

H4: Trading-information anomalies are associated with higher market integrity risk and provide early-warning signals.

H4 is supported by positive fixed-effects coefficients for volatility ($\beta = 80.015$) and digital trading intensity ($\beta = 26.879$), together with the reported random-forest accuracy of 0.917 and F1 score of 0.750. The econometric and predictive results answer different questions: the coefficients describe conditional associations with MIR, whereas the classifier evaluates discrimination of suspicious flags. High volatility or digital trading intensity can arise for legitimate reasons, so neither measure should be treated as evidence of wrongdoing.

Predictive outputs are most appropriate for prioritising review, especially when combined with governance and ownership signals (Breiman, 2001; Friedman, 2001; Hastie et al., 2009; Li, 2025; Loughran & McDonald, 2011; Pedregosa et al., 2011; Shaban, 2025; Svanberg et al., 2022).

Overall interpretation

The four hypotheses converge on a governance-intelligence interpretation of market integrity. Lower-risk observations are associated with stronger independent monitoring and more credible disclosure, whereas higher-risk observations are associated with concentrated ownership and more intense trading-information pressure. This pattern integrates agency theory's monitoring mechanism, disclosure theory's information mechanism and stakeholder theory's value-protection mechanism. The practical contribution is not a misconduct detector but a layered early-warning architecture that helps boards and regulators combine governance, disclosure and market signals before deciding whether deeper review is warranted.

Practical and Policy Implications

For regulators, the evidence supports risk-based surveillance that combines governance, ownership, ESG disclosure and market-signal information rather than relying on a single trigger. Firms with overlapping warning signals may warrant greater analytical attention, but statistical flags should initiate review rather than substitute for investigation. This distinction is particularly important when predictive tools are used in enforcement-adjacent settings.

For boards and audit committees, market integrity should be treated as a governance and information-quality risk. Independent directors can scrutinise disclosure timeliness, related-party exposure, ownership influence, market-sensitive announcements and ESG reporting quality. Audit committees and external auditors may use abnormal trading indicators as contextual inputs to risk assessment, especially where concentrated ownership or weak disclosure discipline is also present, while preserving professional judgement and evidential safeguards.

For investors, employees, creditors and communities, the value of governance intelligence lies in confidence protection. More credible disclosure and stronger oversight can improve the information environment on which capital allocation depends. Figure 1 therefore links market-integrity monitoring to stakeholder value, while Figure 4 illustrates how alternative governance and market conditions can be translated into conditional risk scenarios rather than deterministic forecasts.

Limitations and Future Research

Several limitations qualify the findings. First, the balanced panel contains 40 non-financial Bursa Malaysia companies over 2016-2025 and is not a probability sample of the entire market; the final replication file should document the screening flow and sector composition. Second, market integrity risk is a constructed research index, so full reproducibility requires disclosure of its components, directionality, transformations, normalisation, weights and missing-data rules. Third, the primary fixed-effects estimates reduce bias from time-invariant firm heterogeneity and common year shocks but cannot eliminate reverse causality or time-varying omitted variables. The dynamic fixed-effects model may also face finite-T bias

because $T = 10$, and the quantile model is best treated as upper-tail sensitivity evidence rather than causal identification. Fourth, 40 firm clusters warrant caution in asymptotic inference, particularly for coefficients close to conventional significance thresholds. Fifth, predictive metrics are sample- and validation-design dependent; external validity requires firm-separated or time-ordered validation, full class-balance reporting and leakage controls. Sixth, MIR and SFLAG are research constructs rather than regulatory determinations, and the predictive model has not been validated against enforcement outcomes. Finally, any trading feature used as a predictor must remain demonstrably distinct from contemporaneous MIR components; otherwise, criterion contamination could mechanically inflate H4.

Future research can expand the firm coverage, use higher-frequency market data, estimate dynamic panel models designed specifically for short- T settings, and test sector heterogeneity. Predictive validation could be strengthened through firm-separated or forward-chaining evaluation, alternative classification thresholds, SHAP-based explanation and external validation against enforcement outcomes or independently coded surveillance events. Further work could also examine sustainability assurance, IFRS S1/S2 readiness, analyst coverage, cost of capital and investor sentiment. Malaysia's evolving sustainability-reporting architecture provides a useful setting for testing whether improvements in disclosure maturity are followed by more stable market-integrity outcomes over time.

Conclusion

This study develops a governance-intelligence framework for market integrity in Malaysia using a 2016-2025 analytical panel of 40 non-financial Bursa Malaysia companies. The evidence supports all four prespecified directional propositions: greater board independence and stronger ESG disclosure are associated with lower market integrity risk, while ownership concentration and selected trading-information pressures are associated with higher risk. Upper-tail analysis indicates that concentrated ownership is particularly consequential when board independence is weak, and the random-forest results show that ownership concentration carries the largest permutation-importance signal within the fitted classification model. The model-implied effect magnitudes further indicate economically meaningful differences on the 0-100 MIR scale, while remaining conditional rather than causal.

The contribution is both theoretical and practical. Theoretically, the paper integrates agency, disclosure and stakeholder mechanisms into a single market-integrity architecture. Empirically, it separates average association, upper-tail sensitivity and predictive evidence rather than treating them as interchangeable. Practically, it offers a risk-based governance dashboard that can support surveillance prioritisation, board oversight, audit planning and investor analysis without treating anomalies as proof of misconduct. Conditional scenario projections further show how governance, disclosure and market conditions can be translated into forward-looking sensitivity analysis. For Malaysia, the central implication is that credible governance and decision-useful disclosure are not merely compliance outcomes; they are part of the information infrastructure that sustains market confidence and stakeholder value.

Data Availability Statement

The firm-year panel dataset, variable dictionary and analysis workbook supporting the reported results are retained as research files and may be made available by the corresponding author upon reasonable academic request, subject to publication, confidentiality and data-use requirements. For journal-level reproducibility, the submission package should include the firm-screening flow, complete MIR construct dictionary, LBHO/ESG/DTI/SFLAG coding rules, model specifications, predictive-validation settings, anti-leakage checks and year-by-year scenario assumptions. No unverified formula or threshold has been introduced in this manuscript revision.

Ethical Statement

The study uses company-level secondary data and does not involve human participants, private personal information or experimental intervention.

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Conflict Of Interest Statement

The authors declare no conflict of interest in relation to this manuscript.

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