Research Article

Constructing Fraud Risk Indicators Using Unsupervised Learning Models, ESG, and Firm Value: The Moderating Role of Corporate Governance

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ABSTRACT

This study investigates the impact of anomalous activities and environmental, social, and governance (ESG) performance on the firm value of companies listed on the Stock Exchange of Thailand. Anomalous organizational behavior may indicate the potential for future fraud, which is often only revealed upon detection——sometimes delayed——by which time the damage to stakeholders or the public may have already occurred. To prevent such fraud, this study employs four unsupervised learning models to construct indicators of anomalous behavior, despite the absence of confirmed fraudulent cases in the sample firms. In other words, actual fraud has not yet been detected in the organizations under study.

The results suggest that the market possesses a certain degree of ability to perceive anomalous behavior. However, when such behavior occurs within an ESG context, it becomes more difficult for the market to distinguish between financial anomalies and legitimate ESG-driven activities. Additionally, corporate governance mechanisms play a critical moderating role in the relationship between anomalous behavior, ESG performance, and firm value. This research highlights that unsupervised learning models can effectively identify anomalous patterns and may serve as an early-warning tool for financial risk assessment by policymakers. Furthermore, ESG can play a dual role——either enhancing corporate reputation and regulatory compliance, or conversely, being used to obscure financial irregularities.

Keywords: Corporate Governance, ESG, Fraud, Firm Value, Machine Learning, Sustainable Industries

บทความวิจัย

การสร้างตัวชี้วัดความเสี่ยงจากการทุจริตโดยใช้ตัวแบบการเรียนรู้แบบไร้การกำกับ ESG และมูลค่ากิจการ : บทบาทกำกับของการกำกับดูแลกิจการ

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บทคัดย่อ

งานวิจัยนี้ศึกษาผลกระทบของกิจกรรมที่เกี่ยวข้องกับกิจกรรมผิดปกติและผลการดำเนินงานด้านสิ่งแวดล้อม สังคม และการกำกับดูแล (ESG) ที่มีต่อมูลค่าของบริษัทจดทะเบียนในตลาดหลักทรัพย์แห่งประเทศไทย กิจกรรมผิดปกติที่เกิดขึ้นในองค์กรอาจก่อให้เกิดการทุจริตตามมาในภายหลัง ซึ่งการทุจริตที่เกิดขึ้นในองค์กรจะถูกเปิดเผยเมื่อมีการตรวจพบซึ่งบางครั้งการตรวจพบการทุจริตมีความล่าช้าและผลเสียหายที่มีต่อสาธารณะได้เกิดขึ้นแล้ว เพื่อเป็นการป้องกันการทุจริตที่อาจจะเกิดขึ้น งานวิจัยนี้ใช้แบบจำลองการเรียนรู้แบบไร้การกำกับจำนวน 4 ตัวแบบ เพื่อสร้างตัวชี้วัดพฤติกรรมผิดปกติของกลุ่มตัวอย่างโดยยังไม่มีข้อมูลจริงเกี่ยวกับพฤติกรรมผิดปกติของกลุ่มตัวอย่างแต่อย่างใด หรืออาจกล่าวอีกนัยหนึ่งได้ว่า ยังไม่พบการทุจริตที่เกิดขึ้นจริงในองค์กร

ผลการศึกษาแสดงให้เห็นว่า ตลาดมีความสามารถระดับหนึ่งในการรับรู้พฤติกรรมผิดปกติ อย่างไรก็ตาม เมื่อพฤติกรรมผิดปกติเกิดขึ้นในบริบทของ ESG ตลาดจะมีความยากลำบากในการแยกแยะว่าพฤติกรรมนั้นเกิดจากความผิดปกติทางการเงินหรือเป็นความพยายามในการดำเนินงานด้าน ESG นอกจากนี้ กลไกของธรรมาภิบาลองค์กรยังมีบทบาทสำคัญในการปรับความสัมพันธ์ระหว่างการมีพฤติกรรมผิดปกติ ESG และมูลค่าบริษัท งานวิจัยนี้ชี้ให้เห็นว่าตัวแบบจำลองการเรียนรู้แบบไร้การกำกับสามารถถูกนำมาใช้ในการประเมินหรือตรวจจับพฤติกรรมผิดปกติได้อย่างมีนัยสำคัญ ซึ่งสามารถนำไปประยุกต์ใช้เป็นเครื่องมือตรวจจับล่วงหน้าเกี่ยวกับความเสี่ยงทางการเงินสำหรับผู้กำหนดนโยบายได้ และ ESG อาจมีบทบาทสองด้านคือ ช่วยส่งเสริมชื่อเสียงและการปฏิบัติตามข้อกำหนดทางกฎหมาย หรือในทางกลับกันอาจถูกใช้เป็นเครื่องมือในการปกปิดพฤติกรรมทางการเงินที่ผิดปกติ

คำสำคัญ: การกำกับดูแลกิจการ สิ่งแวดล้อม สังคม และการกำกับดูแลกิจการ การฉ้อโกง มูลค่ากิจการ การเรียนรู้ของเครื่อง อุตสาหกรรมที่ยั่งยืน

INTRODUCTION

In recent years, Environmental, Social and Governance (ESG) issues have become important factors in assessing business performance and investment decisions. Currently, the Stock Exchange of Thailand (SET) has organized a group of ESG-focused securities called the SET ESG index– a group of stocks that investors are interested in according to its relatively high trading value. However, in a recent case in the Thai stock market, the SET removed Energy Absolute PCL from the SET ESG Index due to a scandal involving one of its top executives. This incident highlights that, although ESG is often seen as a strategy to enhance reputation and ensure compliance with legal requirements (Li et al., 2024a; Wang & Liu, 2025), there is ongoing debate about whether ESG can also be misused as a tool to conceal fraudulent behavior and increase financial risks (Park, 2023).

According to Park (2023), ESG-related fraud is more complex than business failure risks, as it encompasses a broader range of risks and is more difficult to predict. Expectations for a company's ability to manage these risks are still evolving, and expanding legal liability in this area could increase legal costs and impact a company's core business operations. This dual role of ESG (Hossain, 2025; Kumashiro, 2025) raises important questions about whether the market assesses the fraud risk and ESG performance of businesses, especially in emerging markets like Thailand. In cases where ESG is used as a channel for anomalous behavior, corporate governance processes are necessary to help ensure that ESG initiatives are carried out according to their intended goals (Sastroredjo and Suganda, 2025; Wang et al., 2024). Therefore, it also raises the issue that corporate governance mechanisms also play an important role in controlling business activities and may serve as a variable that influences the relationship between fraud risk, ESG performance, and firm value.

Unlike prior studies that measure fraud using labeled data (Li et al., 2024a; Wang & Liu, 2025) or interviews and case analyses (Hossain, 2025), the research constructs indicators of anomalous activities using four unsupervised learning models that can detect linear and non-linear behaviors without the need for explicit data (Islam & Rahman, 2025; Kennedy et al., 2025; Walauskis & Khoshgoftaar, 2025). This method enables the prediction of hidden anomalies that traditional methods may not be able to detect. In addition, the research analyzes how the Thai capital market is able to assess the value of fraud risk by taking ESG variables into account, since ESG operations may have unclear profit implications. As suggested by Del Sarto (2025), ineffective ESG management increases firm's financial risks. We also conduct a test on the moderating role of corporate governance on the effect of fraud and ESG on firm value. Existing research has not integrated anomalous activities, ESG performance, and corporate governance into a unified analysis of firm value. Instead, prior studies tend to examine the relationship between firm value and either fraud (Wang et al., 2025b), ESG (Narula et al., 2025),

or corporate governance (Farooq et al., 2023), separately. Or the prior study explores the moderating effect of corporate governance on the relationship between corporate social responsibility (CSR) and firm value (Farooq et al., 2023). Previous studies have left the combined effect of fraud, ESG and corporate governance on firm value unexplored. This area remains a significant gap in the literature, particularly within the context of Thailand.

According to this analysis, we find that the market is able to recognize abnormal behaviors to some extent. However, the market will be limited when it comes to distinguishing whether those abnormal behaviors are actually caused by fraudulent behaviors or are the result of ESG operations. In addition, corporate governance mechanisms play an important role in helping the market detect and adjust the value of the business more accurately (Hussain & Haileslasie, 2025).

This research contributes to theoretical knowledge in three main aspects: (1) it promotes the use of unsupervised learning models to detect complex anomaly behaviors, supporting the application of advanced analytical tools in fraud detection; (2) it enhances the understanding of ESG roles - as a financial risk factor and as a potential channel for unfavorable practices. This supports the fraud triangle theory, particularly the opportunity and rationalization components, where ESG may be misused to justify or conceal misconduct; and (3) it highlights the role of corporate governance mechanisms in balancing stakeholder power and reducing financial risk. This aligns with agency theory, emphasizing the need for effective oversight to ensure management acts in the best interest of shareholders. In terms of practical implications, the results of the study indicate that ESG practices play a dual role, both in terms of enhancing reputation and regulatory compliance, and as a channel that may be used to conceal financial problems. Therefore, the use of effective governance mechanisms is essential to monitor and control such behaviors. In addition, the unsupervised learning models used in this research can act as an early warning system to detect anomaly behaviors, supporting effective governance and policy.

The following section reviews the literature related to the core research question: To what extent do fraud risk and ESG performance affect firm valuation, and how does corporate governance moderate these relationships in the Thai setting? Section 3 describes the data used and the research methodology for predicting anomaly behaviors and conducting regression analysis. The research results are explained in Section 4, and the final section concludes.

LITERATURE REVIEW AND RESEARCH QUESTION

Fraud

Fraud in private sectors is a problem that has profound and widespread impacts on the operations, financial stability and credibility of an organization. Fraud not only causes direct financial losses but also results in damage to reputation, relationships with stakeholders, and the market competitiveness. The Association of Certified Fraud Examiners (ACFE, 2024) suggests that organizations worldwide suffer from fraud losses of more than 5 percent of their annual revenue. It is probably due to the lack of appropriate internal controls and insufficient risk management. Such problems not only affect the financial position but also weaken the confidence of stakeholders. In a financial perspective, fraud can be achieved in the form of earnings management or financial information distortion to create false performances (Dechow et al., 1996). This affects accounting information quality and weakens the credibility of financial reports. Fraud reflects the weakness of an effective internal control system, which is a concern addressed by agency theory (Jensen and Meckling, 1976). The theory emphasizes the importance of mechanisms that help balance stakeholder interests in order to prevent undesirable events that could harm the organization, such as various forms of financial risk.

In addition, the main factors leading to fraud are pressure, opportunity, and rationalization as described by fraud triangle theory (Cressey, 1953; Oseifuah, 2025). For example, firms may feel pressured to meet high expectations to attract investors or maintain market credibility. Firms' weak system create opportunities for reporting falsify information. At the same time, firm's executives may rationalize such actions by believing that enhancing the firm's image ultimately serves the greater good.Thus, robust governance, transparent assurance processes, and good mindsets are needed. Understanding these three factors helps organizations develop appropriate control strategies and measures, such as enhancing the effectiveness of internal control systems. Studying fraud helps organizations design effective governance mechanism such as establishing an independent audit committee (Beasley et al., 2000). This should reduce the chances of fraud involvement and enhances transparency in financial reporting. In addition, the corporate governance promotes a firm culture that is committed to ethics and responsibility. This is an important factor in preventing fraudulent behavior in the long run (Coates, 2007).

ESG and Fraud-Related Activities

ESG has become an important factor for investors and managers to assess the sustainability and long-term viability of a business. In particular, Thai stock market requires listed firms to disclose sustainability information related to the financial value of the firm. ESG emphasizes responsible

environmental, social, and governance practices within an organization. According to stakeholder theory (Freeman & McVea, 2001), the foundation of ESG practices is not solely to meet the expectations of investors, but also to address the interests of various stakeholder groups such as employees, customers, society, and the environment. In practice, ESG may not only be a tool for creating transparency and credibility but also a channel for some organizations to disguise information about unfavorable behaviour. The organized hypocrisy concept explains that some organizations may actively express their commitment to ESG in their reports and communicate with stakeholders (Cho et al., 2015). Nevertheless, they in practice may contradict such claims, creating a good reputation but hiding false behaviour. This inconsistency is a major concern that requires ESG disclosure to be closely examined to prevent it from becoming a tool to divert attention from inappropriate actions (Kathan et al., 2024). In addition, Wang et al. (2025a) evidence the increasing of financial crime risks associated with ESG, particularly in the form of greenwashing (Hossain, 2025). Such practices not only harm a corporation's long-term credibility but increase legal risks and potential financial damages as well. Prior et al. (2008) find that organizations with high levels of corporate social responsibility (CSR) may be more likely to engage in earnings management. Furthermore, Sastroredjo and Suganda (2025) indicate that in environments with low fraud level, a firm’s ESG initiative does not significantly affect its financial distress. This finding suggests an inverse interpretation of the relationship under such conditions. In contrast, Wang and Liu (2025) repost a negative association between ESG and financial fraud. The existing research highlights the complexity of interpreting ESG information because even though ESG reporting may seem like a signal of transparency and responsibility, it cannot be used as a confirmation that the firm does not have any hidden fraudulent behaviour. Therefore, for a firm to truly and transparently implement ESG, it needs to have strong and effective corporate governance mechanisms to balance the behaviour of executives and various parties within the organization. These mechanisms reduce the risk of using ESG as a tool to cover fraud and increase credibility in the view of stakeholders (Coates, 2007; Hossain, 2025; Park, 2023).

In summary, although ESG is a useful and necessary approach for sustainable corporate development, there is a risk that ESG may be misused, such as to disguise financial fraud. Therefore, investors, regulators, and researchers should carefully consider ESG data and thoroughly assess governance mechanisms and financial data to prevent and reduce the risk of fraudulent behaviour that may be hidden under ESG initiatives.

ESG and Corporate Governance

In the current era where sustainability has become an important issue for business and society, the relationship between ESG and corporate governance has been widely studied. However, results are mixed (Prior et al., 2008; Samsudin et al, 2025; Wang et al., 2025a). Both ESG and corporate governance focus on promoting transparency, responsibility, and effective risk management within an organization. It should affect the sustainability of the organization in the long run. ESG consists of three main dimensions: environmental, social, and governance. In this third dimension, corporate governance is considered the core that helps create a framework and audit mechanism that allows organizations to effectively carry out ESG activities. As suggested by the agency theory, the effective governance promotes transparent and sustainable management of environmental and social risks. For example, the relationship between ESG and corporate governance is the CSR activity –a part of the social dimension of ESG. The implementation of CSR by an organization with good governance mechanisms, such as having a committee that is clearly responsible for overseeing CSR, will help these activities be designed and implemented transparently, effectively, and in line with the organization's sustainability goals (Samsudin et al., 2025).

Prior studies have found that organizations with strong governance are more likely to conduct genuine CSR activities and create positive social and environmental impacts (Agnese et al., 2022), while organizations that lack governance may use CSR as a marketing tool to create a good image without actual practices (Cho et al., 2015), which distracts from important ESG issues. In addition, corporate governance helps to enhance the credibility of publicly disclosed ESG information, especially in terms of sustainability reports, which require review and certification by an independent and expert board to ensure that the information presented is accurate and transparent, which is a key factor in building confidence among investors and stakeholders.

In summary, ESG and corporate governance have a positive relationship and promote each other. Good governance enables ESG operations to be efficient and transparent, while ESG is a framework that helps measure and reflect the quality of an organization's governance in terms of social and environmental responsibility. Therefore, organizations that want to create long-term sustainability should focus on both developing ESG in its entirety and building strong governance mechanisms at the same time.

Fraud, ESG, and Firm Value

Prior studies have evidenced the relationship between fraud and firm value. For instance, Junus et al. (2025) investigate the relationship between fraud and firm value by constructing fraud scores based on accounting accruals. They reveal the positive association between fraud scores and firm value measured by Tobin's Q. Similarly, Aditya (2025) reports a positive relationship between fraud scores measured using the Beneish M-Score and firm values. Khan et al. (2023) also observe the positive link between Dechow's fraud scores and the firm values of companies in Malaysia and Indonesia. In contrast, Wang et al. (2025b) argue that corporate fraud negatively affects firm performance of companies in China

Narula et al. (2025) note that the association between ESG and firm performance has been extensively examined across different settings. For instance, Attia & Almoneef (2025) report a positive association between ESG and firm performance. In contrast, Chen et al. (2025) argue that ESG performance negatively impacts the performance of firms in Taiwan. Narula et al. (2025) propose that the inconsistent findings across studies may derive from the use of unique ESG measurements in different settings.

The aforementioned empirical studies have primarily examined the impact of fraud and ESG performance on firm value separately, and their findings are mixed. However, research investigating the interactive effect of fraud and ESG on firm value remains limited. Based on the findings of Sastroredjo and Suganda (2025), both fraud and ESG factors play a significant role in influencing financial distress, as measured by the Altman Z-score. Supporting this, Christian and Mardianto (2025) report a positive relationship between fraud and the Altman Z-score. Çek (2025) provides a more focused examination on the issue and finds a negative relation between the interactive effect of accounting controversies measured by earnings manipulation, fraudulent financial statements or misrepresentation of financial data and ESG on firm value.

To summarize, previous studies have reported mixed findings regarding the association between fraud, ESG and firm values. The study about the interactive effect of fraud and ESG on firm value remains scarce. Furthermore, the findings are inconclusive.

The Moderating Role of Corporate Governance in the Effects of Fraud and ESG on Firm Value

The recent research examines the moderating role of corporate governance in different dimensions. For instance, Wang et al. (2025b) report that director turnover induces the negative effect of fraud on firm performance. Aditya (2025) suggests that the change in director encourages financial fraud. Attia and Almoneef (2025) report that high audit quality enhances the effectiveness of ESG initiatives,

which in turn leads to improved corporate performance. However, the moderate role of corporate governance in the effects of fraud and ESG on firm value has not been directly explored in previous studies, especially in Thai settings.

From the existing empirical studies, ESG has become an important tool for investors to assess the firm risk. However, a firm with a high ESG score or reporting a large number of ESG projects does not always guarantee that the company is free from financial anomalous behaviours. This study views that some companies may use ESG as a marketing tool to create a good image but their internal operating behaviour may not be properly performed. Greenwashing may be a common example that firm invests in clean energy projects or social activities, but falsifies data, distorts impact reports, or uses accounting mechanisms to hide the true costs. These actions can easily occur if a company's governance mechanism is weak. The strong corporate governance system offers the systematic verification of data accuracy including both financial and non-financial perspectives. Performing ESG along with the strong corporate governance system is very important. It should reduce a firm's chance to hide potential financial risk or ethical fraud. This study views that a firm may use ESG communication to mislead information. The recent study finds that weak ESG management leads to increased financial risk, and corporate governance plays a crucial role in moderating this effect. The strong corporate governance mitigates the financial risks associated with ESG (Del Sarto, 2025). Buchetti et al. (2025) suggest that corporate governance has positive impact on ESG performance. Additionally, the capital market may not be able to accurately assess this potential risk without reliable data and effective monitoring system. The stock price of high ESG score firms may be increased because of the market response to the positive news of ESG. This also probably allows high ESG score firms to issue bonds at a low cost. However, the actual behaviour may be hidden, probably leading to a huge damage to the public at the end. Therefore, integrating ESG and corporate governance is the key to encourage a transparent, sustainable, and responsible organization in the long run. As confirmed by Farooq et al. (2023), they examine the moderating role of corporate governance on the relationship between CSR and Tobin's Q. Their findings reveal that effective corporate governance enhances CSR activities and positively impacts firm value. Moreover, strong corporate governance itself also has a positive effect on firm value.

Building on the existing literature, this study extends prior research by exploring the relationship between fraud, ESG performance, and firm valuation within the Thai context. Additionally, it examines the moderating effect of corporate governance on the influence of fraud and ESG on firm value. Given that previous studies have reported inconclusive findings, this study does not assign an expected sign for the relationship. Accordingly, we formulate the following hypotheses.

H_1: The corporate fraud has a significant effect on firm value.

H_2: ESG performance has a significant effect on firm value.

H_3: The interaction between corporate fraud and ESG performance has a significant effect on firm value.

H_4: The effect of the interaction between fraud and ESG performance on firm value is moderated by the level of corporate governance.

DATA AND RESEARCH METHOD

Data

Data are obtained from SETSMART database system developed by SET. All the available data during 2018–2023 are included in analysis. We construct the fraud index (FI) using unsupervised machine learning models. Then, we draw out important insights about the relationship between fraud and ESG in the Thai setting.

Research Method

Fraud index

According to prior studies, fraud score has been constructed using different measures. For example, Khan et al. (2023) compute the fraud score based on Dechow et al., 2011. Aditya (2025) uses Beneish M-Score to formulate fraud score. These indicators utilize linear estimation method. In addition, fraud index has been constructed using labeled data, such as company's scandal related to financial reporting (Çek, K. (2025) or bribery and corruption (Sastroredjo and Suganda, 2025). To address the limitations of linear estimation and the absence of labeled data, this study utilizes unsupervised machine learning models (Rajaprkash et al., 2025). They offer techniques for constructing a fraud score when the explicit fraudulent activities are unavailable. For instance, Shanaa & Abdallah (2025) use credit card transactions to construct fraud index. They utilize Isolation Forest and Autoencoder to analyze the transactions and compute fraud index. Walauskis & Khoshgoftaar (2025) employ K-Means clustering (Xu et al., 2025), Spectral Clustering, and Gaussian Mixture Model to compute credit card fraud. Van et al. (2025) use Isolation Forest, One-Class Support Vector Machine, Autoencoder, Selforganising Map, Local Outlier Factor, and Hierarchical Density Based Spatial Clustering of Applications with Noise to detect fraud in insurance industry. The existing studies suggest that unsupervised learning models are powerful to detect fraud activities when the explicit fraud data are not available (Shanaa & Abdallah, 2025).

In this study, since fraud activities cannot be explicitly observed, we employ four unsupervised learning models to detect potential anomalies –the indicative of fraudulent activities. The models include Local Outlier Factor (LOF), Isolation Forest (ISF), Autoencoder (AUTO), and K-means clustering (K-means). These models leverage different methodologies to identify anomaly patterns within the data. LOF and ISF are employed to capture nonlinear structure, while AUTO and K-means are for linear activations. Therefore, the calculations using these four methods construct four different fraud score indexes, each derived from a different approach, which will be used for the analysis. By combining these four approaches, we aim to capture different facets of fraud risk inherent in the dataset. Following prior studies (Hassanniakalager et al., 2025; Bao et al., 2020; Dechow et al., 2011 and Cecchini et al., 2010), we employ ten financial ratios to construct the fraud score. Table 1 presents variable description.

Table 1 Variable Description

Variable	Description
For fraud index construction (Hassanniakalager et al., 2025)	
AR	Accounts receivable turnover = Net sales/Average accounts and notes receivable
AST	Asset turnover = Total revenue/Average total asset
CR	Current ratio = Total current asset/Total current liability
DE	Debt to equity ratio = Total liability/Total equity
ETX	Taxable income ÷ Total revenue
GP	Gross profit margin = (Sales – Cost of goods sold)/Sales
INV	Inventory turnover = Cost of goods sold/Average inventory
NP	Net profit margin = Net income/Total revenue
QR	Quick ratio = (Cash and cash equivalent + Short-term investment + Accounts and Notes receivable)/Total current liability
ROA	Return on asset = Earnings before tax/Average total asset

Table 1 Variable Description (Cont.)

Variable	Description
For regression analysis	
Dependent variable	
Tobin's Q	Firm value = Market capitalization ÷ Total asset
Independent variable	
FI	Fraud index constructed from 4 separate unsupervised models.
ESG	Indicator variable equal to 1 if the firm is listed in SET ESG Index.
CG	Indicator variable equal to 1 if the firm has a corporate governance score.
Control variables	
DEP	Depreciation and amortization expenses (Obiedallah & El Mahdy, 2025)
INT	Interest coverage ratio = Earnings before interest and tax/Interest expenses (Deshmukh & Goel, 2025)
POST	Pre- and Post-COVID-19 Periods: 2018–2020 and 2021–2023
SIZE	Natural logarithm of total revenue (Frances & Nworie, 2025)
SPR	Offer share price – Bid share price (Behrmann et al., 2025; Satt et al., 2023)

1. LOF measures the deviation of a given data point with respect to its neighbors (Breunig et al., 2000). It identifies observations that have significantly lower density than their nearby points, thus flagging them as potential anomalies. The fraud index (FI) for firm i at time t based on LOF is defined as:

$$FI_{i,t}^{LOF} = LOF(AR_{it}, AST_{it}, CR_{it}, DE_{it}, ETX_{it}, GP_{it}, INV_{it}, NP_{it}, QR_{it}, ROA_{it})$$

We construct FI using k nearest neighbors = 30 (Breunig et al., 2000).

2. ISF will isolate anomalies by randomly partitioning the data space. Since anomalies are few and different, they require fewer splits to isolate, making the average path length in the isolation tree shorter for anomalous points compared to normal points (Liu et al., 2008). Let the input feature vector for firm i at time t be:

$$x_i = (AR_{it}, AST_{it}, CR_{it}, DE_{it}, ETX_{it}, GP_{it}, INV_{it}, NP_{it}, QR_{it}, ROA_{it})$$

FI on ISF is defined as:

$$s(x_i) = 2^{-\frac{E(h(x_i))}{c(n)}}$$

3. AUTO is a type of neural network designed to reconstruct its input (Hinton and Salakhutdinov, 2006). By training on normal data patterns, it learns a compressed representation and can detect anomalies based on reconstruction errors — observations that are poorly reconstructed are flagged as potential anomalies. Let the input feature vector for firm i at time t be:

$$X_i = (AR_{it}, AST_{it}, CR_{it}, DE_{it}, ETX_{it}, GP_{it}, INV_{it}, NP_{it}, QR_{it}, ROA_{it})$$

The reconstruction function is:

$$\hat{X}_i = f_\theta(X_i)$$

f_θ is the autoencoder function parameterized by θ

$\hat{X}_i$ is the reconstructed vector (or FI).

4. K-means clustering partitions the data into clusters based on similarity (Jain, 2010). Data points that fall far from the centroids of their assigned clusters or in small, sparse clusters can be considered anomalous, potentially indicating fraudulent activity.

Given $X_i = (AR_{it}, AST_{it}, CR_{it}, DE_{it}, ETX_{it}, GP_{it}, INV_{it}, NP_{it}, QR_{it}, ROA_{it}) \in R^p$ represents a vector of standardized financial ratios for a firm, the K-means algorithm partitions the data into K clusters by minimizing the total within-cluster variance:

$$\arg\min_{c} \sum_{k=1}^{K} \sum_{x_i \in C_k} \| x_i - \mu_k \|^2$$

Where C_k is the set of points assigned to cluster k, and μ_k is the mean vector of cluster k. $\| \bullet \|^2$ is Euclidean distance. The algorithm iteratively assigns observations to the nearest cluster centroid and updates centroids until convergence. Silhouette method is applied to choose the most appropriate number of clusters k by measuring how well each point fits within its cluster compared to others.

Firm value analysis

To investigate the effects of fraud and ESG activities on firm value, we estimate the following equation using the fixed effect with robust standard error clustering at the firm level. Our dependent variable is firm value measured by Tobin's Q. This analysis focuses on two primary variables: FI and ESG. We add several control variables. First, we include information asymmetry (SPR). According to Behrmann et al. (2025) and Satt et al. (2023), firm value decreases as information asymmetry rises.

Obiedallah and El Mahdy (2025) suggest that non-current assets are utilized to increase taxable expenses through depreciation and amortization, which in turn contributes to enhanced firm value. Therefore, our second control variable is depreciation and amortization expenses (DEP). Deshmukh and Goel (2025) suggest that interest expense can influence investors' expectations regarding future net cash flows, which impacts firm value. Accordingly, this analysis includes the interest coverage ratio (INT) as an additional control variable. INT is intended to capture a firm's ability to manage its debt obligations, which in turn affects its overall value. Frances & Nworie (2025) suggest that firm size measured by revenue significantly influence a firm's capacity to generate firm value. Thus, we include revenue (SIZE) as an additional control variable. This study uses the fixed effects method, with firm and year fixed effects included to control for unobserved heterogeneity across firms and over time. The model is operationalized as follows.

$$\text{Tobin's Q} = f(FI_{it}, ESG_{it}, \text{Multiplicative variables}_{it}, \text{Controls}_{it})$$

RESULTS

We investigate multicollinearity of variables used for fraud index construction. Table 2 shows no severe problem about multicollinearity in variables. In addition, Variance Inflation Factor as shown in Table 3 support the results from the Pearson correlation analysis. Fraud indices based on four detection anomaly methods are summarized in Table 4. They have differences in anomaly score distribution and sensitivity to outliers. LOF and AUTO scores have the highest skewness and kurtosis, indicating strong right-skewed distributions with extreme outliers, suggesting they are highly sensitive to severe anomalies. AUTO, in particular, shows the widest spread and most extreme values. In contrast, ISF constructs a slim clustered score range with lower skewness and kurtosis, indicating lower sensitivity to extreme outliers. By testing different k values from 2 to 10 and selecting the one with the highest average Silhouette score, the most appropriate number of clusters for K-means is 2. K-means offers a middle ground, with moderate skewness and kurtosis, capturing outliers more conservatively than LOF and AUTO but more broadly than ISF.

Table 2 Pearson Correlation

	AR	CR	DE	ETX	GP	INV	NP	QR	ROA
CR	–0.0021								
DE	–0.0045	–0.1429*							
ETX	–0.0051	0.1730*	–0.0171						
GP	0.0136	0.0102	–0.0182	–0.0474*					
INV	–0.0017	–0.0111	0.0287	–0.0035	0.0232				
NP	0.0001	0.1383*	–0.0192	–0.4107*	0.1365*	0.0005			
QR	–0.0244	0.5704*	–0.2117*	0.0401*	0.0418*	–0.0133	0.3554*		
ROA	–0.0028	–0.0031	–0.1825*	–0.0747*	0.2441*	0.0034	0.1108*	0.0734*	
AST	–0.0206	–0.0515*	–0.0775*	–0.0597*	–0.1570*	–0.0159	–0.0118	–0.0484*	0.1660*

* denotes statistical significance at the 5% level.

Table 3 Variance Inflation Factor (VIF)

Variable	VIF
AR	1.00172
INV	1.0023
DE	1.09118
NP	1.2529
ETX	1.25503
AST	1.26792
GP	1.37941
ROA	1.40141
CR	1.47129
QR	1.48322

Table 4 Fraud Index from Four Models

Fraud Index (FI)	Mean	SD	Min.	Max.	Median	Skewness	Kurtosis
LOF	1.27	1.71	0.96	47.20	1.07	21.39	514.68
ISF	0.32	0.04	0.30	0.80	0.31	6.18	58.01
AUTO	0.31	3.99	0.00	118.51	0.03	25.28	692.60
K-means	1.90	2.35	0.37	46.65	1.40	10.10	145.44

Table 5 presents main results. The regression results indicate that fraud risk (FI) has a positive and marginally significant effect on firm value in ISF and K-means models. This suggests that higher fraud risk is likely associated with increased firm valuation in these cases. Nevertheless, this effect is weaker or not significant in the LOF and AUTO models. Therefore, it cannot be conclusively determined whether the market consistently values or disregards a firm's anomalous activities. ESG shows a consistent negative and significant impact on firm value across all models. Importantly, the multiplicative term (FI × ESG) is positive and statistically significant in all models. These results reveal that the market probably devalues the strong ESG practices. However, ESG helps buffer the impact of fraud risk on firm value. These results suggest a complex relationship where ESG performance plays a critical moderating role between fraud risk and firm value. Consistent with prior studies, Lin et al., (2023) and Li et al. (2024b) highlight that the market positively prices in ESG-greenwashing performance but the market recognition is not sustainable (Li et al., 2024b).

Table 5 ESG and Fraud

$$\text{Tobin's Q} = f(FI_{it}, ESG_{it}, FI \times ESG_{it}, Controls_{it})$$

Variable	LOF	t-value	ISF	t-value	AUTO	t-value	K-means	t-value
Intercept	−2961.49	−0.88	−4187.92	−1.04	−2988.91	−0.89	−3271.84	−0.94
FI	2.53	0.96	2482.05	1.61*	1.02	0.88	19.86	1.65*
ESG	−225.15	−2.32**	−1280.82	−1.88*	−144	−1.65*	−227.32	−2.28**
FI × ESG	**71.91**	**2.76*** **	**3610.99**	**1.73***	**33.15**	**3.17*** **	**52.74**	**2.81*** **
Control variables added; firm and year fixed effects with robust standard errors clustered at the firm level								
Adj. R^2	0.5824		0.5836		0.5825		0.583	
F-statistic	4.94***		2.8**		350.95***		9.33***	
Observations	2,449		2,449		2,449		2,449	

*** , **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6 presents the updated results reinforce and extend the main findings. ESG alone now remains strongly negative effect on the firm value, particularly significant in LOF and ISF models. The positive and significance of FI × ESG remains across all models. This supports that ESG continues to play a vital moderating role in how fraud risk relates to firm valuation. When integrating CG, the multiplicative term (FI × ESG × CG) is significantly negative in most models. This indicates that corporate governance further complicates this relationship by reducing the positive buffering effect of ESG on fraud risk's impact. Meanwhile, the interactions involving CG alone with FI or ESG are weaker or mostly insignificant. This suggests that while ESG mitigates the influence of fraud risk, strong corporate governance may diminish this mitigation effect. Overall findings are consistent with prior studies (Prior and Tribó, 2008; Hussain & Haileslasie, 2025; Ngo et al., 2025; Wang et al., 2025).

Based on the overall analysis, the impact of fraud-related factors on firm value remains inconclusive; therefore, we cannot definitively confirm Hypothesis 1 that fraud has a significant effect on firm value. However, the market appears to perceive that ESG activities do not contribute positively to firm value, as evidenced by the consistently negative relationship across all models. Thus, for Hypothesis 2, we conclude that ESG performance has a negative effect on firm value. Regarding Hypothesis 3, which posits that the interaction between corporate fraud and ESG performance has a significant effect on firm value, the results show a consistently positive relationship across all models. These findings suggest that the market cannot clearly distinguish between fraud and ESG activities.

Regarding Hypothesis 4, which discusses the moderating role of corporate governance on the effect of fraud and ESG on firm value, we find that corporate governance does play a moderating role in this relationship.

Table 6 ESG and Fraud Index with Corporate Governance Integration

$$\text{Tobin's Q} = f(FI_{it}, ESG_{it}, FI \times ESG_{it}, FI \times CG_{it}, ESG \times CG_{it}, FI \times ESG \times CG_{it}, Controls_{it})$$

Variable	LOF	t-value	ISF	t-value	AUTO	t-value	K-means	t-value
Intercept	−3735.51	−0.97	−5352.72	−1.17	−3753.27	−1.00	−3998.62	−1.04
FI	12.00	0.20	1624.343	1.06	2.885	0.20	8.638	0.58
ESG	−740.049	−5.09***	−1115.83	−3.51***	−27.739	−0.3	−136.239	−1.2
FI × ESG	709.733	10.6***	3670.365	4.5***	702.772	8.38***	94.94	6.05***
FI × CG	−8.749	−0.15	2802.491	1.33	−1.526	−0.11	30.884	1.33
ESG × CG	517.095	3.39***	269.491	0.32	−108.967	−0.86	−58.821	−0.41
FI × ESG × CG	**−633.33**	**−12.5*** **	**−1430.65**	**−0.56**	**−667.666**	**−8.92*** **	**−56.985**	**−2.44** **
Control variables added; firm and year fixed effects with robust standard errors clustered at the firm level								
Adj. R^2	0.5706		0.5727		0.5707		0.5717	
F-statistic	54.50***		36.03***		381.01***		38.19***	
Observations	2,288		2,288		2,288		2,288	

*** , **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

In terms of theoretical implications, the results of this study suggest that the analytical method used to determine fraud score may influence the outcomes of the analysis. The use of ESG as a strategy to support operations may not be well-captured by the market or investors. Furthermore, the market may perceive ESG efforts as ambiguous, seeing them more as a means to create a positive organizational image rather than reflecting genuine operations. According to the fraud triangle theory, our results reflect the opportunity-seeking and mindset of executives who probably prioritize image-building over improving actual performance. In addition, the results involve stakeholder theory, which suggests that firms must engage in various activities to meet the diverse interests of different stakeholders. However, a single action may not satisfy all stakeholder groups simultaneously. As a result, certain initiatives may be perceived by the market as not generating favorable returns

for investors, even though they may benefit other stakeholder groups. However, strong corporate governance can help the market better understand the firm's operations and improve its perception. These findings support the notion of agency theory.

In practice, these findings imply that the market undervalues ESG activities in terms of profitability and is slow to recognize the implications of anomalous firm behavior. However, the market appears more likely to value anomalous activities when they are associated with ESG performance compared to non-ESG performance because the market may not be able to immediately detect anomalous activities. That is, firms might use ESG initiatives as a channel to mask such behavior or it might simply be used to distract from other deceitful activities. When corporate governance becomes part of the mechanism, the market begins to perceive the ESG-related anomalies and responds by reducing firm value.

For managers, this suggests that communicating robust ESG practices could help mitigate the financial consequences of fraud-related concerns, but the market strongly relies on corporate governance mechanisms as tools to detect anomalous firm behaviors. However, firms with strong ESG practices can better buffer the adverse valuation impacts of fraud risk. Effective governance can influence how ESG strategies affect investor perceptions and risk management. Firms should integrate governance reforms with ESG initiatives to optimize their value, especially in environments with fraud risk concerns. In the long run, fraud-related activities carried out through ESG projects will damage financial performance and eventually be exposed and priced in by the market.

For policymakers, caution should be exercised regarding ESG activities. A monitoring mechanism is needed to ensure that ESG initiatives genuinely serve the public interest—particularly in delivering environmental and social benefits. Such a mechanism should be implemented through an effective corporate governance system that helps balance stakeholder power. The policymaker should enhance the relevant regulations to respond and monitor the increasing ESG projects.

ADDITIONAL TESTS

To support our main findings, we perform serval additional analyses. First, we exclude all controls variables from the analysis. The untabulated results are qualitatively consistent with the main findings. Second, we construct a fraud index specifically for ESG firms. The results, presented in Table 7 are consistent with the main analysis. The market strongly recognizes anomalous activities performed by ESG firms as evidenced by the positive and significant relationship between FI and firm value across all models. After incorporating CG into the analysis, the results show that the multiplicative term (FI × CG) is found to be negative and statistically significant. These additional results reinforce the main

findings, highlighting the important role that corporate governance mechanisms play in shaping the influence of ESG and fraud-related activities. Finally, we further control for pre- and post-COVID-19 periods to investigate whether the pandemic affects the relationship. The results, presented in Table 8, are qualitatively consistent with the main analysis. The multiplicative term (FI × ESG) remains positive and statistically significant across all models. Additionally, corporate governance appears to weaken the influence of fraud and ESG on firm value, as indicated by the negative and significant interaction term (FI × ESG × CG). These relationships hold steady both before and after the COVID-19. In summary, our additional findings strongly reinforce the main analysis, emphasizing the complex relationship among fraud-related activities, ESG, and corporate governance. It should be noted that when analyzing periods before and after COVID-19, as the use of fixed effects in model estimation may lead to collinearity with the pre- and post-COVID indicator variable (POST). In such cases, the collinear variable will be excluded from the estimation. Nevertheless, the obtained results remain valid (Azevedo et al., 2025).

Table 7 ESG Sock Only

$$\text{Tobin's Q} = f(FI_{it}, FI \times CG_{it})$$

Variable	LOF	t-value	ISF	t-value	AUTO	t-value	K-means	t-value
Intercept	954.89	21.32***	214.46	0.34	1098.93	318.64***	1018.54	73.48***
FI	908.88	2.72**	8541.7	2.07*	323.94	3.41***	234.49	3.09***
FI × CG	**–818.82**	**–2.47****	**–6332.51**	**–1.43**	**–262.78**	**–2.77*****	**–187.81**	**–2.58****
Firm and year fixed effects with robust standard errors clustered at the firm level								
Adj. R^2	0.7058		0.7015		0.7071		0.7099	
F-statistic	7.08***		2.87*		15.87***		55.62***	
Observations	296		296		296		296	

*** , **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 8 Pre-Post Years: Dependent Variable = Tobin's Q

Variable	LOF	t-value	ISF	t-value	AUTO	t-value	K-means	t-value
Intercept	−3916.86	−0.99	−3878.9	−1.00	−4185.44	−1.06	−5488.73	−1.17
FI	−3.8913	−0.08	−2.1823	−0.24	5.0718	0.43	1429.009	0.97
ESG	−590.728	−4.58***	110.7357	1.43	−27.4935	−0.3	−1553.06	−3.53**
FI × ESG	690.7988	10.62***	654.4246	9.53***	102.8904	5.79***	5417.664	4.36***
FI × CG	9.0967	0.19	3.3526	0.4	47.5509	1.52	2448.208	1.07
ESG × CG	544.4533	2.57**	−159.043	−0.83	−16.2175	−0.06	2041.062	1.57
FI × ESG × CG	−692.953	−11.59***	−654.27	−10.82***	−110.064	−1.39	−7209.66	−1.92
FI × POST	29.1044	0.78	35.0932	0.67	16.0765	0.75	549.6174	0.42
ESG × POST	252.0544	1.05	−304.854	−2.50*	−176.604	−1.57	1119.987	2.50*
FI × ESG × POST	−538.499	−3.67***	−464.233	−2.87**	−83.5254	−4.26***	−4558.92	−3.36***
CG × POST	136.6561	1.07	102.5061	0.97	155.9283	1.10	−56.5279	−0.08
FI × CG × POST	−32.9659	−0.8	−34.6658	−0.65	−36.0427	−0.86	468.6678	0.21
ESG × CG × POST	−483.508	−2.70**	174.2087	1.16	−33.9083	−0.14	−2593.68	−2.18*
FI × ESG × CG × POST	**629.2383**	**5.18*** **	**500.193**	**3.30*** **	**138.886**	**1.79**	**8929.745**	**2.47***
Control variables added; firm and year fixed effects with robust standard errors clustered at the firm level								
Adj. R^2	0.5694		0.5694		0.5704		0.5717	
F-statistic	262.41***		1318.29***		63.54***		52.92***	
Observations	2,288		2,288		2,288		2,288	

*** , **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

CONCLUSION

This study constructs measures of anomalous activities using four different unsupervised learning models. These models are employed to capture both linear and nonlinear potential anomalous behaviors in firms without requiring labeled data. Next, we examine whether the market values fraud-related activities. We include ESG performance in the analysis because ESG initiatives may be perceived as non-profitable. Additionally, ESG investment projects could potentially induce fraudulent behavior and increase financial risk. Our robust results provide evidence that the Thai market is relatively rational in recognizing anomalous activities. However, when such activities occur within an ESG context, the market finds it more difficult to distinguish whether they stem from fraud or genuine ESG efforts. Corporate governance plays a significant moderating role in the relationship between fraud-related activities, ESG, and firm valuation, suggesting that the market begins to detect anomalies once corporate governance mechanisms are factored into the analysis.

This research provides insightful information about the complex relationship between fraud risk, ESG, and corporate governance. Theoretical implications from this research consist of the following: First, it employs four different unsupervised learning models to capture unobserved behavior. The anomaly scores across all models provide relatively consistent results, which supports the notion that using unsupervised learning models as a tool to detect anomalous behavior is promising. Second, this research extends existing studies by highlighting the complexity of ESG performance, which may induce financial risks such as fraud or other anomalous financial behaviors, and suggests that ESG may also be used as a tool for financial misbehavior. Finally, this study contributes to the literature by reinforcing the role of corporate governance mechanisms as effective tools for balancing stakeholder power.

In terms of practical contributions, ESG performance has a twofold role. First, it is used to enhance reputation and comply with relevant regulations. Second, it may serve as a channel to exploit a firm's resources and to disguise fraud-related financial issues. This study provides policymakers with tools—through unsupervised learning models—to serve as an early warning system for detecting financial misbehavior within firms. Managers should recognize that using ESG to mask anomalous activities is not sustainable, as it ultimately harms financial performance. Implementing an effective corporate governance mechanism has a significant impact on both fraud-related activities and ESG performance.

Some limitations of this study should be acknowledged and may offer useful directions for future research. Additional variables could be incorporated to enhance the analysis, such as labeled data or disaggregated ESG scores, to better assess the effect of each ESG dimension. Alternative theoretical

approaches, such as supervised machine learning models, may also be employed to produce more robust fraud-related scores. Furthermore, using a longer time series for analysis could be explored to provide more data for model training and improve predictive accuracy.

REFERENCES

Aditya, G. N. I. A. (2025). New fraud diamond and financial statement fraud: A case study in emerging country. *East Asian Journal of Multidisciplinary Research, 4*(5), 2211–2226. https://doi.org/10.55927/eajmr.v4i5.199

Agnese, P., Battaglia, F., Busato, F., & Taddeo, S. (2022). ESG controversies and governance: Evidence from the banking industry. *Finance Research Letters, 49*, 103397. https://doi.org/10.1016/j.frl.2022.103397

Association of Certified Fraud Examiners. (2024). Occupational Fraud 2024: A Report to The Nations. https://www.acfe.com/-/media/files/acfe/pdfs/rttn/2024/2024-report-to-the-nations.pdf

Attia, E. F., & Almoneef, A. (2025). Impact of ESG on Firm Performance in the MENAT Region: Does Audit Quality Matter? *Sustainability, 17*(13), 6151. https://doi.org/10.3390/su17136151

Azevedo, G., Oliveira, J., Almeida, T., Borges, M. F. R., Tavares, M. C., & Vale, J. (2025). Determinants of Financial Risks Pre- and Post-COVID-19 in Companies Listed on Euronext Lisbon. *Journal of Risk and Financial Management, 18*(3), 135. https://doi.org/10.3390/jrfm18030135

Bao, Y., Ke, B., Li, B., Yu, Y.J. & Zhang, J. (2020). Detecting accounting fraud in publicly traded US firms using a machine learning approach. *Journal of Accounting Research, 58*(1), 199–235. https://doi.org/10.1111/1475-679X.12292

Beasley, M. S., Carcello, J. V., Hermanson, D. R., & Lapides, P. D. (2000). Fraudulent financial reporting: Consideration of industry traits and corporate governance mechanisms. *Accounting Horizons, 14*(4), 441–454. https://doi.org/10.2308/acch.2000.14.4.441

Behrmann, V., Hornuf, L., Vrankar, D., & Zimmermann, J. (2025). The deregulation of quarterly reporting and its effects on information asymmetry and firm value. *Review of Quantitative Finance and Accounting, 64*, 1221–1259. https://doi.org/10.1007/s11156-024-01338-5

Breunig, M. M., Kriegel, H.-P., Ng, R. T., & Sander, J. (2000). LOF: Identifying density-based local outliers. *ACM SIGMOD Record, 29*(2), 93–104. https://doi.org/10.1145/335191.335388

Buchetti, B., Arduino, F. R., & Perdichizzi, S. (2025). A literature review on corporate governance and ESG research: Emerging trends and future directions. *International Review of Financial Analysis, 97*, 103759. https://doi.org/10.1016/j.irfa.2024.103759

Cecchini, M., Aytug, H., Koehler, G.J. & Pathak, P. (2010). Detecting management fraud in public companies. *Management Science, 56*(7), 1146–1160. https://doi.org/10.1287/mnsc.1100.1174

Çek, K. (2025). Effect of accounting and ESG controversies on financial performance: Moderating effect of ESG. *Fiscaoeconomia, 9*(2), 1213–1224. https://doi.org/10.25295/fsecon.1556525

Chen, K. H., Zhang, Y., Elston, J. A., & others. (2025). Environmental, social, and governance (ESG) initiative scores and firm performance: The importance and role of firm size. *Small Business Economics*. https://doi.org/10.1007/s11187-025-01096-1

Christian, N., & Mardianto. (2025, April). Does financial distress lead to corporate fraud?. *Global Financial Accounting Journal, 9*(1), 90–99. https://doi.org/10.37253/gfa.v9i1.10448

Coates, J. C. (2007). The goals and promise of the Sarbanes-Oxley Act. *Journal of Economic Perspectives, 21*(1), 91–116. https://doi.org/10.1257/jep.21.1.91

Cressey, D. R. (1953). *Other people's money: A study in the social psychology of embezzlement*. Free Press.

Dechow, P. M., Ge, W., Larson, C.R. & Sloan, R.G. (2011). Predicting material accounting misstatements. *Contemporary Accounting Research, 28*(1), 17–82. https://doi.org/10.1111/j.1911-3846.2010.01041.x

Dechow, P. M., Sloan, R. G., & Sweeney, A. P. (1996). Causes and consequences of earnings manipulation: An analysis of firms subject to enforcement actions by the SEC. *Contemporary Accounting Research, 13*(1), 1–36. https://doi.org/10.1111/j.1911-3846.1996.tb00489.x

Deshmukh, S., & Goel, A. (2025). When do optimistic CEOs enhance firm value?. *European Financial Management*. https://doi.org/10.1111/eufm.12544

Del Sarto, N. (2025). Corporate governance and ESG controversies: Navigating risk-taking in banks. *Business Strategy and the Environment, 34*(4), 4541–4560. https://doi.org/10.1002/bse.4214

Farooq, M., Khan, I., Kainat, M., & Mumtaz, A. (2023). Corporate social responsibility and firm value: The role of enterprise risk management and corporate governance. *Corporate Governance: The International Journal of Business in Society*. Advance online publication. https://doi.org/10.1108/CG-08-2023-0341

Frances, C. C., & Nworie, G. O. (2025). Firm size: A strategic booster of shareholder wealth maximisation among listed agricultural firms in Nigeria. *International Journal of Academic Accounting, Finance & Management Research, 9*(4), 47–57.

Freeman, R. E., & McVea, J. (2001). A stakeholder approach to strategic management. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.263511

Hassanniakalager, A., Ji, X., Perotti, P., & Tsoligkas, F. (2025). A machine learning approach to detect accounting fraud. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4117764

Hinton, G. E., & Salakhutdinov, R. R. (2006). *Reducing the dimensionality of data with neural networks. Science, 313*(5786), 504–507. https://doi.org/10.1126/science.1127647

Hossain, M. Z. (2025). Forensic auditing in environmental and social governance (ESG): Detecting fraud and ensuring compliance. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.5255556

Hussain M., & Haileslasie, T. (2025). Corporate governance and ESG controversies: A quantile regression approach. *Corporate Governance*. https://doi.org/10.1108/CG-11-2024-0616

Islam, M. S., & Rahman, N. (2025). AI-driven fraud detections in financial institutions: A comprehensive study. *Journal of Computer Science and Technology Studies, 7*(1), 100–112. . https://doi.org/10.32996/jcsts.2025.7

Jain, A. K. (2010). Data clustering: 50 years beyond K-means. *Pattern Recognition Letters, 31*(8), 651–666. https://doi.org/10.1016/j.patrec.2009.09.011

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics, 3*(4), 305–360. https://doi.org/10.1016/0304-405X(76)90026-X

Junus, A., Sundari, S., & Azzahra, S. Z. (2025). Fraudulent financial reporting and firm value: An empirical analysis from the fraud hexagon perspective. *Investment Management and Financial Innovations, 22*(1), 339–350. https://doi.org/10.21511/imfi.22(1).2025.26

Kathan, M. C., Utz, S., Dorfleitner, G., Eckberg, J., & Chmel, L. (2024). What you see is not what you get: ESG scores and greenwashing risk. *Finance Research Letters, 65*, 106710. https://doi.org/10.1016/j.frl.2024.106710

Kennedy, R. K. L., Villanustre, F., & Khoshgoftaar, T. M. (2025). Unsupervised feature selection and class labeling for credit card fraud. *Journal of Big Data, 12*, Article 111. https://doi.org/10.1186/s40537-025-01154-1

Khan, A. S., Nejad, M. Y., & Kassim, A. A. M. (2023). The effect of audit quality on fraud reduction: A moderating role of International Financial Reporting Standards (IFRS) adoption in Malaysia and Indonesia. *International Journal of Professional Business Review, 8*(6), 1–21. https://doi.org/10.26668/businessreview/2023.v8i6.2181

Kumashiro, T. (2025). *Guardians of truth: How to ensure the accuracy of ESG information* (European Corporate Governance Institute - Law Working Paper No. 862/2025). https://doi.org/10.2139/ssrn.5359350

Li, D., Ma, C., Yang, J., & Li, H. (2024a). ESG performance and corporate fraud. *Finance Research Letters, 62*(Part B), 105212. https://doi.org/10.1016/j.frl.2024.105212

Li, T., Shu, X., & Liao, G. (2024b). Does corporate greenwashing affect investors' decisions?. *Finance Research Letters, 63*, 105877. https://doi.org/10.1016/j.frl.2024.105877

Lin, X., Zhu, H., & Meng, Y. (2023). ESG greenwashing and equity mispricing: Evidence from China. *Finance Research Letters, 52*, 104606. https://doi.org/10.1016/j.frl.2023.104606

Liu, F. T., Ting, K., & Zhou, Z.-H. (2008). Isolation forest. In *2008 Eighth IEEE International Conference on Data Mining*, 413–422. https://doi.org/10.1109/ICDM.2008.17

Narula, R., Rao, P., Kumar, S., & Paltrinieri, A. (2025). ESG investing & firm performance: Retrospections of past & reflections of future. *Corporate Social Responsibility and Environmental Management, 32*(1), 1096–1121. https://doi.org/10.1002/csr.2982

Ngo, N.-Q.-N., Pham, T.-H., Pham, H., & Truong, M. T. (2025). Green finance and anti-money laundering effectiveness: Evidence from Asian countries. *SSRN Electronic Journal*. https://ssrn.com/abstract=5179815

Obiedallah, Y. R., & El Mahdy, A. H. A.M. (2025). Accounting conservatism and firm value in Egypt: The mediating role of tax avoidance. *Future Business Journal, 11*, Article 177. https://doi.org/10.1186/s43093-025-00600-z

Oseifuah, E. K. (2025). Application of the fraud triangle model in mitigating tax evasion in developing countries: a conceptual framework. *International Journal of Business Ecosystem & Strategy (2687–2293), 7*(2), 297–306. https://doi.org/10.36096/ijbes.v7i2.782

Park, J. J. (2023). ESG securities fraud. Wake Forest Law Review, 58, 1149–1182. UCLA School of Law, Law-Econ Research Paper No. 23-02. *SSRN Electronic Journal*. https://ssrn.com/abstract=4428212

Prior, D., Surroca, J., & Tribó, J. A. (2008). Are socially responsible managers really ethical? Exploring the relationship between earnings management and corporate social responsibility. *Corporate Governance: An International Review, 16*(3), 160–177. https://doi.org/10.1111/j.1467-8683.2008.00678.x

Rajaprkash, S., A. K. V, M. D., Reddy, G. S. K., Reddy, A. S., & Lokesh, B. (2025). Supervised and unsupervised learning for fraud detection in banking transactions. In *2025 International Conference on Emerging Technologies in Engineering Applications (ICETEA)*, 1–4. https://doi.org/10.1109/ICETEA64585.2025.11099764

Samsudin, Z. A., Sahu, M., Alahdal, W. M., Abd Majid, N., & Muhmad, S. N. (2025). The moderating effect of ESG controversies on the relationship between CSR committee and ESG performance: Malaysian evidence. *Business Strategy & Development*. https://doi.org/10.1002/bsd2.70158

Satt, H., Chetioui, Y., Ouahidi, O., Bodolica, V., & Lamiri, D. (2023). Capital expenditure and firm value in the MENA region: The role of market competition and information asymmetry. *Macroeconomics and Finance in Emerging Market Economies, 18*(1), 138–157. https://doi.org/10.1080/17520843.2022.2163564

Sastroredjo, P. E., & Suganda, T. R. (2025). ESG and financial distress: The role of bribery, corruption, and fraud in FTSE All-Share companies. *Risks, 13*(3), 41. https://doi.org/10.3390/risks13030041

Shanaa, M., & Abdallah, S. (2025). A hybrid anomaly detection framework combining supervised and unsupervised learning for credit card fraud detection. *F1000Research, 14*, 664. https://doi.org/10.12688/f1000research.166350.1

Van Rensburg, W. A. J., Van Staden, C., & Prinsloo, L. (2025). Fraud, waste, and abuse detection in medical claims using an ensemble of unsupervised machine learning models. In *2025 IEEE 38th International Symposium on Computer-Based Medical Systems (CBMS)*, 1–6. https://doi.org/10.1109/CBMS65348.2025.00181

Walauskis, M. A., & Khoshgoftaar, T. M. (2025). Unsupervised label generation for severely imbalanced fraud data. *Journal of Big Data, 12*, Article 63. https://doi.org/10.1186/s40537-025-01120-x

Wang, J., Chen, Y., & Wang, S. (2024). Exploring the relationship between corporate ESG performance and corporate violation: Based on the fraud triangle theory. *Corporate Social Responsibility and Environmental Management, 31*(6), 5606–5626. https://doi.org/10.1002/csr.2882

Wang, Y., & Liu, S. (2025). Managerial short-termism, ESG performance, and corporate financial fraud: A heterogeneity analysis based on corporate ownership. *International Review of Economics & Finance, 102*, 104385. https://doi.org/10.1016/j.iref.2025.104385

Wang, L., Tang, R., & Zhou, X. (2025a). Financial crime risks in environmental, social, and governance (ESG) investment: Perspectives on greenwashing and false disclosure. *Finance Research Letters, 85*(Part A), 107856. https://doi.org/10.1016/j.frl.2025.107856

Wang, R., Hu, Y., Teng, Y., Liu, Y., Liu, L., & Li, X. (2025b). Corporate fraud, director turnover, and corporate performance in the Chinese construction industry. In *ICCREM 2024: Proceedings of the International Conference on Construction and Real Estate Management*, 233–243. https://doi.org/10.1061/9780784485910.024

Xu, S., Cao, Y., Wang, Z., & Tian, Y. (2025, June). Fraud Detection in Online Transactions: Toward Hybrid Supervised–Unsupervised Learning Pipelines. In *Proceedings of the 2025 6th International Conference on Electronic Communication and Artificial Intelligence (ICECAI 2025), Chengdu, China*, 20–22. https://doi.org/10.20944/preprints202505.1101.v1