

A computational approach to transparency in corporate governance across borders

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Abstract:

This article delves into the intricate relationship between information asymmetry and financial reporting comparability, with a particular emphasis on earnings management (EM) in cross-border corporate governance settings. Utilising data from 2,475 non-financial firms across 19 frontier markets from 2003 to 2019, the study employs pooled OLS, fixed effects, and between-effects models to scrutinise the impact of factors like financial comparability, reputable auditing, analyst coverage, and legal systems on earnings management. The findings reveal that enhanced financial comparability, facilitated by strong governance mechanisms such as reputable auditors and analyst coverage, leads to a reduction in earnings management and information asymmetry. Interestingly, leverage does not serve as a constraining factor as commonly believed. The results contribute to the growing body of literature on the application of data science, and challenge the pecking order theory (POT), while lending support to the knowledge-based view (KBV) and convergence theories, thereby offering valuable insights into the role of corporate governance in mitigating information asymmetry.

Keywords: accounting comparability, accruals earnings management, frontier markets, information asymmetry.

Classification number: 2.2

1. Introduction

With the global business transactions, ensuring transparency in corporate governance has become a critical factor. In this context, addressing the issue of asymmetric information is of the greatest concern, given it can lead to higher financing and transaction costs and market failure if market participants make poor financial decisions. Enhancing comparability, a key qualitative characteristic of financial statements, helps mitigate the negative effects of asymmetric information by enabling users to evaluate financial performance across firms. This approach assists shareholders in making rational decisions, promotes accurate analysis of economic indicators [1], guides policy responses and improves information quality [2].

To understand how information asymmetry affects markets, it is necessary to analyse the issue in the context of various economic challenges. Analysing asymmetric information within the context of various economic challenges provides valuable insights into the efficiency of markets. This is because asymmetric information allows certain market participants to access private knowledge [3, 4]. The KBV theory posits that private information is the

most significant source of competitive advantage [3-5]. To retain their competitive advantage, managers can either gather or suppress negative data and may also employ EM methods as proposed by [6]. The negative consequences of EM are similar to those of asymmetric knowledge, as it can compromise the decision-making process and result in long-term declines in value [7] if funding providers become hesitant. Furthermore, EM also suppresses relevant information, thereby reducing the information content of financial reports and causing reductions in economic efficiency [8]. Reduced financial reporting volume negatively impacts the quality of accounting information and raises doubts about a firm's sustainability [9].

Despite existing research, the role of accruals-based EM (AEM) in exacerbating information asymmetry remains poorly understood, particularly in under-researched frontier markets. Addressing this gap, the central research question of this study is: How do governance mechanisms and financial comparability influence information asymmetry and EM? This overarching question is further dissected into five sub-questions focusing on specific governance and firm factors that could constrain EM.

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Our initial findings indicate that high financial comparability is inversely related to accrual earnings management (AEM) and, consequently, to information asymmetry. This relationship is further strengthened by governance mechanisms such as audit quality, analyst following, and firm leverage, which act as constraining factors on EM. These mechanisms enhance the quality of information disseminated, aiding investors in more accurately assessing a firm's financial performance¹.

Building on this, the study shows that firms with robust comparability metrics are less likely to engage in AEM, thereby reducing information asymmetry. Effective corporate governance practices, including high-quality audits and increased analyst following, serve as additional constraints on EM. These practices not only improve the quality of disseminated information but also simplify the task for investors in evaluating a firm's relative financial performance¹.

Conclusively, this research illuminates how the interplay between financial comparability and governance mechanisms, such as BigN auditors and analyst following, effectively mitigates information asymmetry. Interestingly, leverage does not deter opportunistic EM behaviour, challenging conventional wisdom. The theoretical implications include a critique of the pecking order theory (POT) and a reinforcement of the knowledge-based perspective. From a practical standpoint, the study underscores the importance of enhanced comparability and governance in emerging markets. It also cautions against the universal applicability of findings from other markets. In addressing the challenges posed by these frontier markets, particularly the inconsistent data presentation from the 2,475 companies investigated, the study navigated these complexities with rigorous and systematic analysis. Overall, this study, using a methodological approach of comparative regression analysis, significantly enriches the literature on information asymmetry and comparability, offering a nuanced understanding that can guide more efficient markets and better financial decision-making.

The progression of this study is as follows. A review of prior literature and the development of hypotheses are presented in Section 2. The research designs and data are described in Section 3, followed by a presentation of the theoretical framework in Section 4. Empirical results are presented and discussed in Section 5, and the study concludes with practical and theoretical implications in Section 6.

¹The difference due to accounting effects or firm fundamentals.

2. Background, related literature, and research question

2.1. Characteristics and challenges of frontier markets and their firms

Frontier markets are characterised by moderate market openness to foreign ownership, limited capital movement, and modest operating efficiency, rendering them less economically mature than developed markets [10]. In these markets, information asymmetry, exacerbated by herding—an evolving market feature—impairs the dissemination of fundamental information [11]. Asymmetric markers lead to price formation based on limited information, supporting the argument that frontier markets lack depth. Despite comprising over 20 percent of the world's population, the aggregate value of frontier markets is less than 0.3 percent of global markets [12]. The characteristics of frontier markets and firms include: (1) A lack of strong inter- and intra-market correlation in frontier firms, often due to the practice of cross markers, where companies list shares on multiple stock exchanges in different countries [13]; (2) Higher ownership concentration and lower investor protection levels in frontier market equities; (3) The effectiveness of diversifying into frontier equity markets, as evidenced by strong hedging, high portfolio returns, and minimal investment losses [14]; and (4) The role of financial statements in enabling investors to gain a better understanding of a company's performance and management activities across various stages of country development, thereby increasing the volume of available information [10].

2.2. Financial comparability

Market policies and monitoring pressure drive firms toward high-fidelity practices, causing decreased information asymmetry and acquisition costs. Pressure, as a result of monitoring and increases in financial statement comparability, brings about increases in the quantity and quality of information available to corporate outsiders. Financial comparability is the extent to which transactions similar in content and form are treated alike. The Financial Accounting Standards Board's (FASB) conceptual framework prescribes comparability as a crucial quality of financial statements that help investors compare information between firms and evaluate alternative opportunities [15]. Comparability facilitates the detection of opportunistic managerial behaviour and reduces information processing costs for investors and monitoring agents.

Various factors drive comparabilities, such as effective audit committee attributes, auditor quality, competition, and product differentiation. Additionally, accounting standards and regulations such as IFRS affect comparabilities.

Understanding what factors influence comparability is crucial because it improves the quality of available information and reduces the costs associated with acquiring that information.

When comparability increases, the information quality and quantity of a firm's financial report are more readily interpreted. Empirical studies have confirmed that the benefits of comparability in financial report interpretation include more efficient capital allocation, reduced information asymmetry, reduced risk-taking, economised cash holdings, improved forecast accuracy, and a decreased managerial incentive to hoard bad news [16].

S. Franco (2021) [17], W. Martens, et al. (2023) [18] argue that managers try to gain legitimacy for their strategic imperatives by mimicking the strategies and policies of larger and more established peers in the industry. Particularly, companies' financial statements are more comparable to those of their industry counterparts in the same metropolitan region than those elsewhere. This is because competition acts as a corrective mechanism, enhancing comparability and decreasing agency costs. E. Delbufalo, et al. (2018) [19], J.P. Martin, et al. (2001) [20] back up this conclusion.

When a firm's information environment and accounting comparability are higher, opportunistic AEM behaviour decreases [21]. Research on the linkages between comparability and information asymmetry in frontier markets is sparse because the concentrated firm ownership structure in emerging Asia and Latin American markets hampers performance comparison. Despite noted issues with a concentrated ownership structure, comparability helps resolve principal-ownership issues [22]. M. Bjornsen, et al. (2022) [23] stated it is imperative to consider the associated consequences, namely EM, when conducting a comparability analysis.

2.3. Earnings management

EM is a practice that enables insiders to obtain private benefits by presenting misleading financial data. However, such opportunistic behaviour can negatively affect the company's value and ultimately ruin the interests of creditors and minority shareholders. Accounting comparability is a factor that can reduce the agency cost associated with the incentives to hold negative information and conceal the company's poor performance. Better accounting comparability also increases labour investment efficiency and reduces the costs of monitoring and governing for various stakeholders. While the adoption of IFRS has resulted in enhanced information environments and less manipulated earnings in some jurisdictions, many economies still adhere to national standards. AEM, which develops when financial information is creatively managed to influence decision-making, is distinct from fraud and is not regarded as fraudulent if set by accounting standards [24]. Individual characteristics

such as gender, age, professional experience, educational qualifications, and training area influence the perception of how simple it is to implement and detect AEM practices in financial statements [25].

Due to the failures of economic enterprises and the credibility concerns surrounding accounting as an authentication system, AEM has generated many studies. The relationship between accounting standards and practices and economic crises has been established, and financial controversies have occurred in the United States, Europe, and elsewhere. The findings underscore the need to limit unethical behaviour and instil ethical values in the next generation of accounting, management, and auditing professionals.

Increases in financial disclosure quality are crucial in minimising information asymmetry; however, information asymmetry is heightened when a corporation participates in EM. EM is a process through which a company's performance is manipulated for short-term gain. Managers may manage earnings to avoid losses, achieve predetermined profit levels, meet previous management earnings forecasts, or influence stock returns [26]. A consequence of EM is that reported financial results may not truly reflect the economic and financial realities [27]. While not all EM is opportunistic, companies in less-developed markets have a greater propensity to manage earnings than those in developed economies [28], thereby increasing information asymmetry. A firm's accruals are increasingly seen as a measure of its performance and a technique for managing earnings. However, the reversible nature of accruals limits a manager's ability to make biased estimates continually. Because managers can choose accrual techniques to enhance accounting's information value, a compelling case can be made that managers may also engage in reporting processes in their best interest. Advanced AEM monitoring systems have increased the detection of AEM activity, aided in uncovering financial reporting irregularities, and decreased information asymmetry [29]. Furthermore, corporate governance practices that promote transparency and accountability in financial reporting and effective internal controls can significantly reduce information asymmetry and encourage ethical behaviour [30].

2.4. Firm leverage

A positive association exists between informational asymmetry and leverage. M.Z. Frank, et al. (2003) [31] suggested that debt is favoured over equity when external financing is required due to its lower information costs and ability to avoid equity-associated agency costs. Debt financing imposes disciplinary constraints on management by reducing cash for non-optimal expenses, as cash is needed for debt repayment. Additionally, highly leveraged companies face increased monitoring by bankers and

creditors [32]. Although a positive association exists between information availability and leverage, leveraged firms are more likely to engage in EM activities. A levered firm may adopt accounting policies that increase income to comply with the lender-imposed debt covenants. Information asymmetries due to EM are less severe for firms with large loans as borrowing information costs are less of a barrier. M.L. DeFond, et al. (1994) [33] found that managers often engage in EM to prevent adverse lending effects. It was also found that firms experiencing financial distress and those with failed agreements have an increased likelihood to manage earnings [34]. Conversely, Y. Li, et al. (2016) [35] found that increased leverage is associated with decreased EM, a relationship influenced by firm growth. As robust institutional environments reduce the negative association between information asymmetry and the adverse consequences of leverage, the association between leverage and comparability is a logical extension of this study.

2.5. External audit quality

External audit firms must have knowledge of industry-specific regulations and standards, as well as the ability to audit complex financial instruments and determine the fair value of assets and liabilities, to conduct high-quality audits of the financial statements of publicly traded companies. If an audit firm lacks this knowledge or proficiency, it can result in a loss of confidence among stakeholders in the financial statements, leading to adverse outcomes such as a decline in stock prices or difficulty securing financing. In addition, external audit firms play a vital role in assuring investor protection and enhancing the quality and distribution of reported information.

In all levels of country development, increased audit quality is affiliated with greater investor protection, legal enforcement, and earnings quality. The findings imply that auditors act as a management constraint mechanism [36] and increase the quality and distribution of reported information. Conventional thinking suggests that Big-N auditors² will ensure greater caution in client financial accounts. BigN's enforcement and prudence fare well in response to investor protection establishments' need for rigor, such as stakeholders' power to bring legal action against auditors for negligence or regulatory bodies disciplining auditors for delinquency [37]. C.L. Becker, et al. (1998) [38] found that non-Big-N auditors' clients are more engaged in revenue-enhancing EM than the clients of non-Big-N auditors. More recently, however, M. Tsipouridou, et al. (2012) [39] found no statistically significant association between EM activities

of firms audited by BigN and those that were not. In an investigation on the external auditor's role in EM following IFRS adoption by a firm, B.V. Tendeloo, et al. (2005) [40] found that, although EM practices generally increased, EM decreased significantly when audited by a BigN audit firm. The authors acknowledge that external auditors may not adequately explain the observed phenomenon, implying that other corporate governance factors may also play a role. Consequently, the relationship between corporate governance practices and auditors' effectiveness in controlling management behaviour and assuring the quality of financial reporting is essential for fostering investor confidence and protecting their interests.

2.6. Analyst following

The relationship between analysts and publicly available information is critical to corporate governance. Analysts play a crucial role in disseminating information to the public, bridging the knowledge gap between firms and market participants. Previous research has demonstrated the significance of analysts in providing information to market participants by investigating the relationship between analyst following and various measures of market liquidity (e.g., see [41]). Analyst following is a proxy for the amount of publicly available information, as determined by the prediction dispersion findings. Greater volumes of publicly available information bolster the notion that analysts help disseminate information to the general public, bridging knowledge gaps between firms and market participants. The extent to which consistent financial reporting reduces an analyst's informational expenses may indicate the value of consistent financial reporting, resulting in reduced information asymmetry. The relationship between analysts and publicly available information may depend on how analysts disseminate information to market participants. If analyst information is rapidly communicated to many market players, a large number of analysts following and concentrated analyst projections combine to create an excellent information environment for uninformed or partially informed market participants. While the role of analysts in bringing information to the public provides numerous advantages, research has also shown that firms increased EM activities when facing increased pressure to meet or exceed analysts' and investors' expectations [42], thereby reducing information transparency. Further, W. Martens, et al. (2021) [43] also found an inverse relationship between EM and analysts following. The inverse relationship is rationalised to result from outsized media and analyst coverage, factors often present around large companies. An analyst's role in restricting EM is inconclusive, yet, when financial statement users are presented with analyst-organised information, users make better decisions [44]. From the above, analysts' influence is inconclusive in their ability to reduce asymmetric information.

²In 1997, the accounting world experienced a major upheaval with the mergers of four of the Big Six accounting firms, forming what is now known as the Big-4 or Big-N.

2.7. Research questions

Based on the arguments presented above, it is anticipated that mitigation of information asymmetry can be achieved through increased comparability of financial statements. Furthermore, it is expected that the quality of financial statement information can be enhanced through governance mechanisms such as improved audit quality and constraints imposed by lenders. These mechanisms are likely to lead to a reduction in earnings manipulation. Additionally, good corporate governance practices, such as transparency and accountability in financial reporting, can play a crucial role in reducing information asymmetry and promoting ethical behaviour. In light of current literature discussions, the research questions (RQs) are formalised as follows:

RQ1: Managerial constraint through financial comparability reduces information asymmetry.

RQ2: Managerial constraint through increased firm leverage results in reduced information asymmetry.

RQ3: Managerial constraint through greater audit quality (as proxied by BigN) results in reduced information asymmetry.

RQ4: Managerial constraint through a greater number of analysts following a firm results in reduced information asymmetry.

RQ5: Information asymmetry lessens managerial constraints and encourages EM.

These questions will illuminate conceptual and empirical discussions on the role of comparability on information asymmetry in frontier markets. The examination of this relationship will provide a deeper understanding of the conceptual and empirical discourses surrounding the topic. The findings of this study will contribute to the ongoing discussion on governance mechanisms and provide additional insights into frontier markets.

3. Theoretical framework

This study is grounded in multiple theoretical frameworks that focus on enhancing decision-making and reducing asymmetric information. Foremost among these is the Symbolic Convergence Theory, as proposed by E.G. Bormann (1985) [45]. This theory is advantageous as it suggests that mass action occurs when individuals with similar wants, values, and goals come together. The concept is further extended by the argument that homogeneity results when individuals face comparable limitations. While this may be perceived as disadvantageous, it is proposed that when managers are constrained in their self-interest, the reliability of available information increases with mass participation.

The modified POT, proposed by S.C. Myers (1984) [46], serves as the second theoretical foundation of this research. According to POT, firms do not maintain a specific target capital structure, but they do prefer internal financing

over external financing. External financing is viewed as a means to increase the informativeness of earnings since it restricts managers from acting solely in their self-interest. In particular, external debt reduces free cash flow, thereby limiting managerial control over fund flows. However, these restrictions and limitations decrease the managerial capacity to conceal inefficiencies, leading to reduced asymmetric information, which is advantageous.

Knowledge is a crucial element that enables firms to sustain competitive advantages and outperform competitors. Thus, the KBV theory, proposed by R.M. Grant (1996) [47], serves as the third theoretical foundation for this research. According to this theory, the asymmetry of information between firm insiders and outsiders represents a strategic disadvantage for the latter. The theory is utilised to argue that increasing knowledge through improved comparability in reporting expands strategic resources, reduces gaps in asymmetric information, and optimises decision-making [48].

Furthermore, it can be argued that sound corporate governance practices, such as transparency and accountability in financial reporting, play a crucial and advantageous role in reducing information asymmetry between insiders and outsiders, aligning with a key aspect of the KBV theory. This aligns with the assertions of R.M. Grant (1996) [47], who emphasises the importance of access to information and knowledge as essential resources for organizations to sustain competitive advantages.

Drawing from the distinct tenets of the Symbolic Convergence Theory, the POT, and the KBV, emerge a unified academic perspective that underscores the collective endeavour of these theories to mitigate information asymmetry. Although each theory originates from its unique vantage point, its confluence highlights the pivotal role of alignment, oversight, and transparency in bridging informational divides. This interplay reinforces the imperative for structured constraints, diligent oversight, and transparent reporting, enhancing the integrity and accessibility of information crucial for informed decision-making. The interplay is illustrated in Fig. 1.

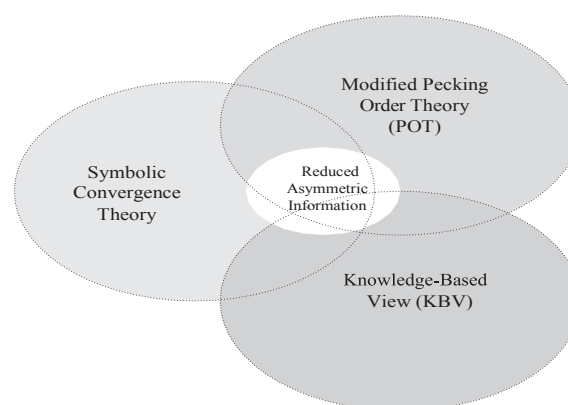


Fig. 1. Convergence of theoretical frameworks.

4. Research design

4.1. Comparability measures

In financial accounting literature, the research on comparability by G.D. Franco, et al. (2011) [49] using quarterly US stock data is considered a seminal study. M.E. Barth, et al. (2012) [50] subsequently modified the comparability method proposed by G.D. Franco, et al. (2011) [49] to evaluate firms using multiple accounting standards (US GAAP and IFRS) in cross-sectoral settings. Given the difficulty of obtaining quarterly data from listed frontier market firms, W. Martens, et al. (2020) [51]'s adaptation of earlier comparability methods using annual data adds robustness, for it produces multiple counter-samples based on specific country-industry factors, despite differing accounting standard regimes.

Using a five-step procedure, our analysis examines the financial comparability of companies across various countries and industries. It estimates a company's fitted stock return, the fitted stock return under each counter-sample model, the absolute value of the difference between the within-sample and counter-sample fitted stock prices, and the comparability score by multiplying the median absolute difference between the fitted stock prices by the negative natural logarithm. The model employs time-series regression to account for cross-national accounting comparability between firms. Greater values indicate greater comparability. Fig. 2 depicts the method for determining comparability, and a thorough breakdown of the entire procedure is available in Appendix A.

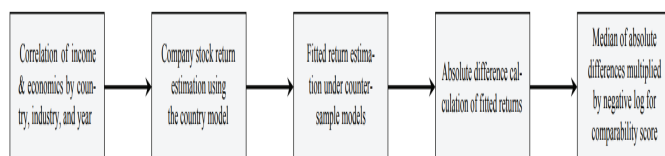


Fig. 2. Comparability model.

4.2. Accruals manipulation

According to S.P. Kothari, et al. (2005) [52], the examination of discretionary accruals through commonly used proxies is incorrectly specified when samples include firms with extraordinary performance. Given that the firms under examination exhibit a significant standard deviation of returns, the method proposed by C. Leuz, et al. (2003) [53] for detecting EM through accruals (AEM) is utilised. Specifically, a composite measure of AEM is calculated to indicate the extent of revenue management through accruals. The calculation of accruals is outlined in Appendix B.

4.3. Regression composition

When information asymmetry is high, shareholders lack the necessary information to supervise management's actions. In environments of considerable information asymmetry between management and shareholders, management can manipulate earnings to a greater extent than in minimal asymmetry environments. As a result, it is predicted that there is a positive relationship between the level of information asymmetry and the extent of EM.

The empirical model used to examine Hypothesis H1-H5 is presented in Equation 11. The study follows the approach of B.C. Sohn (2016) [54] and uses the mean value of the firm-specific comparability scores for target firm i 's to their peers with the same 2-digit SIC code. This process tends to be a benchmark of comparable firms used by acquisition analysts to evaluate a target firm's accounting information.

$$EM_{it} = \gamma + \gamma_1 CmpreScore_{it} + \gamma_2 Analyst_{it} + \gamma_3 BigN_{it} + \gamma_4 Leverage_{it} + \sum \gamma_5 Control Variables_{it} + \sum_i \delta IND + \sum_i \delta YEAR_t + \epsilon_{it} \quad (11)$$

where EM_{it} represents the accruals EM variable of firm i at time t .

4.4. Control variables

Firm-specific control variables are included to isolate the relationship between this study's hypotheses and confounders. The first control variable included is the book-to-market ratio (B/M) to control for firm size. Return-on-assets (ROA) and its absolute value (ROA) control for resource efficiency. Cash flow from operations (CFO) is a function of the accrual adjustment process that transforms cash into earnings and provides additional insight into accruals; we, therefore, include CFO scaled by total assets (CFO/A), and its absolute value (CFO/A). Share return (Return) controls for 'rent efficiencies' and market concentration (as suggested by industrial organization theory [55]). Also included in the model dichotomous

Table 1. Variable definition and predicted relationship with EM.

Variable	Definition	Predicted Relation
EM	The accruals earnings management score is computed using the model developed by C. Leuz, et al. (2003) [58]	
CmpreScore	Comparability for company i and other companies in the same two-digit SIC in a particular year [56].	-
Analyst	Calculated as one's natural log plus the sum of analysts following an entity. Source: Datastream.	-
BigN	BigN, calculated as the number of firms audited by Big 4 or 5 auditors divided by the number of firms by country. Source: Datastream	-
Leverage	Leverage is calculated as total liabilities scaled by total assets. Source: Datastream	-

Source: Authors.

Table 2. Sample distribution.

Panel A			Panel B				Panel C				
By year			By Country				By industry				
Year	N	%	Country	N	Freq.	%	Law	IFRS	Industry	N	%
2003	568.0	23.0	Argentina	92.0	692.0	2.0	††		Oil & Gas	1297	4.7
2004	90.0	3.6	Bangladesh	25.0	1286.0	7.0	†		Food Products	1825	6.6
2005	122.0	4.9	Bulgaria	235.0	2488.0	8.7	††	▲	Paper and paper products	2926	10.6
2006	48.0	1.9	Croatia	305.0	1033.0	3.9	††	▲	Chemical Products	1280	4.7
2007	67.0	2.7	Jordan	134.0	1489.0	4.4	††	▲	Manufacturing	13,413	48.7
2008	124.0	5.0	Kazakhstan	15.0	174.0	1.5	††	▲	Transportation	314	1.1
2009	290.0	11.7	Kenya	150.0	166.0	0.4	†	▲	Scientific instruments	181	0.7
2010	395.0	16.0	Kuwait	91.0	1229.0	3.9	†	▲	Communications	1080	3.9
2011	180.0	7.3	Mauritius	38.0	387.0	1.5	††	▲	Durable goods	1248	4.5
2012	101.0	4.1	Morocco	143.0	281.0	0.9	††		Eating and drinking establishments	3883	14.1
2013	135.0	5.5	Nigeria	5.0	1221.0	3.7	†		Health	102	0.4
2014	76.0	3.1	Oman	18.0	940.0	2.6	††	▲			
2015	54.0	2.2	Pakistan	82.0	3510.0	9.2	†				
2016	40.0	1.6	Romania	57.0	3241.0	11.9	††	▲			
2017	53.0	2.1	Serbia	158.0	4221.0	18.7	††	▲			
2018	81.0	3.3	Slovenia	92.0	115.0	0.4	††	▲			
2019	51.0	2.1	Sri Lanka	271.0	2840.0	7.9	††	▲			
			Tunisia	370.0	78.0	0.4	††	▲			
			Vietnam	608.0	2158.0	11.1	††				
Total	2,475	100		2,475	27,549		100			27,549	100

The sample is divided into firms using IFRS (44.29%), US Generally Accepted Accounting Principles (US GAPP) (0.03%), and local standards (55.68%). Following the 2001 market correction and the 2008 financial crisis, several firms were delisted due to bankruptcy or failure to meet the index's requirements. † denotes civil law countries, †† denotes common law adhering countries. IFRS-adhering countries at the time of the study are denoted by ▲. Source: Authors's summary.

variables for loss (*Loss*) if the company incurred a loss, and a dichotomous variable for both industry (*IND*) and year (*YEAR*) effects. Table 1 describes key variables and their predicted relation to EM. Of note, the variables in the table are anticipated to exhibit an inverse relationship with EM.

5. Key descriptive statistics and discussion on empirical findings

5.1. Sample description

The financial data for this study, collected from Refinitiv Datastream, includes listed companies from 19 frontier countries, excluding financial and insurance firms

due to their unique characteristics and regulations³. The sample omits companies with non-standard fiscal year-ends to prevent bias and comprises 2,475 companies with 27,549 firm-year observations across 11 industries. The characteristics of these firms are detailed in Table 2, which is organised into three panels: Panel A shows the yearly count of included firms, Panel B contains company and country data, and Panel C presents industry data along with two-digit SIC codes. Descriptive statistics for key variables like EM, Comparability Score (*CmpreScore*),

³Robust methodologies were used to ensure the study's validity over time.

Leverage, BigN, and Analysts are presented in Table 3. This table not only provides measures of central tendency and variability, such as mean and standard deviation, but also quartile values (Q1, median, and Q3) for each variable. For instance, *EM* has a Q1 of 0.023 and a Q3 of 0.115, *Leverage* has a Q1 of 0.246 and a Q3 of 0.661, *BigN* ranges from 0.000 to 1.000, and *Analysts* has a Q1 of 0.941 and a Q3 of 2.660. These tables collectively lay the groundwork for subsequent analysis.

Table 3. Descriptive statistics of key variables.

	N	Mean	Std Dev	Q1	Median	Q3
EM	27,549	0.089	0.110	0.023	0.055	0.115
CmpreScore	27,549	0.632	1.116	-0.142	0.394	1.637
Leverage	27,549	0.482	0.428	0.246	0.455	0.661
BigN	27,549	0.328	0.506	0.000	0.000	1.000
Analysts	27,549	1.777	1.086	0.941	1.279	2.660

Source: Authors.

In line with W. Martens, et al. (2020) [51], *CmpreScore* shows mean and median values of 0.632 and 0.394. The standard deviation of 1.116 suggests scores are reasonably distributed. The mean for *EM* (0.089) is quantitatively similar to those reported by B.C. Sohn (2016) [54] and suggests widely varying *EM* practices. The mean value for other variables examined shows concordance and disagreement from B.C. Sohn (2016) [54]'s US-based. The mean values showing similarities are *Leverage*, and *Analyst*, with the following respective scores: 0.482 and 1.77. *BigN*, with a score of 0.328, is notably lower than the value found in the US-based study.

Table 4 shows the Pearson correlation between the primary variables utilised in Eq. (1). *CmpreScore* has a significant and positive correlation with *AEM* (coefficient of 0.015). *Leverage*, *Analysts*, and *BigN* were all statistically significant and inversely correlated with *CmpreScore*. The significance of these variables validates their subsequent use in the analysis. Following this, Table 5 provides further validation by showing that multicollinearity is not a significant concern as all VIF values are well below the commonly used threshold of 10.

Table 4. Pearson correlation coefficients of key variables.

	AEM	CmpreScore	Leverage	Analyst	Big4
AEM	1.000				
CmpreScore	0.015	1.000			
Leverage	-0.111	-0.073	1.000		
Analyst	-0.018	0.475	-0.022	1.000	
Big4	-0.004	-0.310	0.017	-0.271	1

Source: Authors.

Significance is identified at three levels, 0.05, 0.01, and 0.001, respectively, by using *italics*, **bold** typeface, and **bold italics** typeface.

Table 5. Variance inflation factor (VIF) analysis.

Variable	VIF	1/VIF
ROA	4.52	0.221007
ROA	4.36	0.229586
CFO	3.03	0.330376
CFO	2.75	0.363884
Industry	1.35	0.739802
Loss	1.34	0.746231
Analyst	1.33	0.752461
Leverage	1.10	0.907648
CmpreScore	1.03	0.967094
BigN	1.03	0.968521
Year	1.01	0.990281
B/M	1.01	0.990304
Return	1.00	0.999651
Mean VIF	1.91	

Source: Authors.

1/VIF represents the tolerance of a variable in a regression model. It is the inverse of the VIF.

5.2. Main regression results

To examine the interdependence of comparability and *AEM*, we apply three regression methods: Pooled OLS (Model 1), Fixed effects (Model 2), and Between Effects (Model 3)⁴. The fixed effects model is helpful for it rules out the contemporaneous correlation of regressors and idiosyncratic errors and the assumption of stable characteristics and regressors is not required. In contrast, the random effects model enables the estimation of

Table 6. Regression analysis of key variables on EM.

Variable	Model 1	Std Err	Model 2	Std Err	Model 3	Std Err
CmpreScore	-0.023***	-0.66	-0.019**	0.05	-0.012**	0.11
Analyst	-0.032***	-3.36	-0.001***	-2.89	-0.004***	-3.75
BigN	-0.045***	-2.81	-0.044***	-2.81	-0.044***	-2.82
Leverage	0.019***	4.14	0.018*	2.16	0.010	1.35
Intercept	0.230***	13.62	1.120***	13.85	0.232***	13.21
Control Variables	yes		yes		yes	
Year	yes		yes		yes	
Industry	yes		yes		yes	
Observations	12026		12026		12026	
Adj R ²	0.188		0.065		0.399	

Source: Authors.

The Table presents coefficient estimates and standard errors. Significance is identified at three levels: 0.05 *, 0.01 **, and 0.001 ***. Year and industry are set as the fixed effects. As suggested by C. Cinelli, et al. (2020) [57], the interpretation of control variables may be limited as they may not have a structural interpretation; therefore, they are presented collectively in this output.

⁴The Hausman test provides a χ^2 of 51.87, significant at 0.01%, signifying that the fixed-effect model is reliable.

Table 7. Regression analysis of AEM on lag comparison score.

	Model 1	Std Err	Model 2	Std Err	Model 3	Std Err
L.CmpreScore	-0.001*	-2.22	0.003*	-1.62	-0.002*	-2.47
Leverage	0.019***	-4.07	0.015	-1.75	0.012	-1.68
BigN	-0.024***	-5.06	-0.200	-4.16	-0.024***	-3.61
Analyst	-0.003***	-3.76	-0.005*	-2.11	-0.004**	-3.15
B/M	0.000	-0.18	0.001*	-2.05	0.000	-0.08
ROA	-0.262***	-16.57	-0.223***	-12.55	-0.347***	-11.70
ROA	0.294***	-18.55	0.25***	-18.55	0.373***	-18.55
CFO/A	0.052***	-8.55	0.050***	-7.11	0.043**	-3.18
Return Intercept	0.083***	-12.66	0.076***	-12.66	0.134***	-12.66
Industry Dummies Year	-0.025*** 0.002**	-6.11	-0.021*** 0.003**	-4.41	-0.041*** 0.002**	-5.27
Dummies	12.681**	-2.95	15.442	-2.94	10.240	-1.13
	yes yes	-0.52	yes yes	-0.77	yes yes	0.72
Obs	10960		10960		10960	
adj.R ²	0.179		0.103		0.276	

The Table presents estimates and standard errors at three significance levels: 0.05 *, 0.01 **, and 0.001 ***. The fixed effects are set as year and industry. The Wooldridge autocorrelation test results in an F-statistic of 1786.826, which is significant at the 0.01% level for the lag comparable score value. The heteroskedasticity score in the Breusch–Pagan/Cook–Weisberg test is 96.46, which is significant at the 0.01 percent level. This implies that the homoscedastic assumption is not accepted.

β with lower sample-to-sample variability by partially pooling information across units. Using between-effects regression illuminates the inference of marginal effects in small samples. Regression results are displayed in Table 6.

EM is inversely related to *CmpreScore*, suggesting that greater comparability decreases EM and thus increases information asymmetry. Leverage reveals a significant and positive association with EM, which is contrary to the expected hypothesis, yet consistent with [58]. Analyst coverage and the use of Big Four auditors are both found to be inversely associated with EM. The results suggest that firms with greater leverage engage in increased EM activity, whereas a greater presence of analysts following a firm inhibits it. Additionally, the use of Big Four auditors attenuates EM activity, which aligns with prior studies such as [59] in emerging markets. Having controlled for factors such as resource efficiency, firm size, cash flow, losses, and returns, the main variables of this study point to areas that restrict EM activity and those that do not. When EM is not restricted, the precision and quality of public information provided to an investor decreases, causing an increase in the investor's level of uncertainty [60].

5.3. Examination of endogeneity

The potential for endogeneity biases to occur in the application of EM is acknowledged due to the discretion of management. Companies facing losses or attempting to avoid losses may engage in EM to mitigate negative market repercussions. These actions can significantly impact a firm's reported financial performance. To address the possibility of a simultaneous determination of EM and *CmpreScore*, B.C. Sohn's (2016) [54] method of including a one-period lag of the comparison score (denoted as *L.CmpreScore*)⁵ was employed in the re-examination of Eq. 1. This approach aims to alleviate causality concerns and exogenise the variable, as proposed in [61]. Results of this analysis can be found in Table 7.

In support of previous findings, the comparability score is statistically significant and remains negative using Method 1. Results weakly support past results' validity in that increasing comparability is inversely associated with AEM and exogenous from management behaviour. Leverage continues to show a positive association with AEM. In contrast, *BigN* and *Analysts* exhibit a negative association suggesting that firms with greater leverage

⁵Replacing *xt* with *xt-1*.

have a greater reason to obscure earnings. Firms audited by BigN audit firms and those with increased analysts following show constraints in the attempt to conceal reported earnings, thereby decreasing asymmetric information.

An examination of control variable coefficients reveals that size was not a factor in the level of EM activity, as proxied by *B/M*. The results of the resource allocations measured by *ROA* and *ROA* indicate that more efficient firms employ less EM. Countries with weaker investor protection tend to hold more liquid assets to conceal EM from discretionary fund use when examining cash flow. The positive coefficients for *CFO/A* and *CFO/A* in this study of frontier markets lead to a similar conclusion. The findings are consistent with previous research [62] that suggests firms with losses are likely to engage in EM to avoid reporting losses. The association between EM and stock return as measured by *Return* is positive, indicating that increased EM in the current period may polish earnings and be reflected in increased stock returns.

Endogeneity checks suggest an exogenous relationship between financial statement comparability and management within a firm. Further examination is conducted to investigate the influence of information asymmetry on corporate and individual decision-making,

with a focus on instances where a firm has reported diminished earnings or losses and adopted IFRS. The impact of the country's legal system on AEM is also considered.

5.4. Decreased earnings and losses

The POT provides a theoretical framework in which managers are incentivised to manage earnings downward to avoid dividend payouts and retain earnings. Previous research by A.W. Bartik, et al. (2020) [63] also suggests that management actively manages earnings to avoid losses, as evidenced by the volume of firms with an unusually low frequency of small earnings decreases and small losses. This regularity increases as reported earnings remain positive. The intuition here suggests that the signalling of non-negative earnings information outweighs the effects of information asymmetry. A review of decreased earnings and slight increases was conducted, with firms with small profits defined as net income (scaled by lagged total assets) between 0 and 0.01 and small earnings increases defined as annual net income changes in the interval >0 and <0.01, following the definitions of K.A. Gunny (2010) [64]. The results of this review, as reported in Panel A of Table 8, indicate that both firms with small profits and small earnings increases show a positive association between AEM and greater comparability. The motivation

Table 8. Supplementary tests.

Panel A framework					Panel B			Panel B Earnings			IFRS Adoption	
Variable	Small Profit	Std Err	Small Increase	Std Err	2005-2006	Std Err	2007- 2009	Std Err	Civil	Std Err	Common	Std Err
CmpreScore	0.054*	2.06	0.043*	2.30	0.001	-0.41	-0.002*	-2.45	-0.001	-1.45	-0.200*	-2.45
Leverage	0.025	1.06	0.098***	3.340	-0.196**	2.94	0.018*	2.16	0.018*	2.16	0.018*	2.16
Big4	-0.295***	0.11	-0.152***	-0.07	-0.655***	-0.19	-0.275***	-0.04	-0.847*	-0.49	-0.475*	-0.09
Analyst	-0.001***	-5.05	-0.017**	-3.13	0.000	-0.01	-0.006**	-2.62	-0.006**	-2.62	-0.006**	-2.62
B/M	0.001	1.67	-0.001	-1.73	-0.001	-1.21	0.001**	2.91	0.001**	2.91	0.001**	2.91
ROA	1.073	1.240	0.522	1.750	-0.146	1.60	-0.222***	13.05	-0.222***	13.05	-0.222***	13.05
ROA	0.000		-0.037		0.505***		0.257***		0.257***		0.257***	
CFO/A	-0.077	0.00	-0.243***	-0.13	-0.131**	5.43	0.055***	15.00	0.055***	15.00	0.055***	15.00
CFO/A	0.854***	2.60	0.623***	-9.50	0.357***	-2.70	0.82***	-8.29	0.082***	-8.29	0.82***	-8.29
CFO/A Loss Return	0.004	21.90	0.012	19.90	0.002	5.38	0.021***	1.66	-0.021***	11.66	0.021***	11.66
Intercept	-0.002	0.12	0.000	0.66	0.004	0.07	-0.021 *** 0.200*	-4.46	-0.021***	-4.46	0.002*	-4.46
Year Dummies Industry	24.728	-0.87	-46.596	-0.15	13.768	-0.73	-18.989	-2.30	-18.989	-2.30	-18.989	-2.30
Dummie	yes	1.18	yes	1.90	yes	0.66	yes	18.0	yes	1.52	yes	-1.52
	yes		yes		yes		yes		yes		yes	
Obs	1333		1785		1029		2506		9214		2862	
Adj R sq	0.323		0.073		0.994		0.623		0.384		0.454	

The Table presents the results of a fixed-effects panel data regression analysis, with standard errors corrected for firm-level clustering. The coefficients of the independent variables are reported in the first line, with the corresponding standard errors presented in parentheses. Significance levels are identified at three levels: 0.05 *, 0.01 **, and 0.001 ***. Each column of the table displays the results for a different dependent variable, as specified at the top of the respective columns.

to manage earnings is stronger in these cases as it may help the firm evade external monitoring. The increased EM would also imply that the accounting data is less informative despite increased comparability. Additionally, results reveal that a BigN auditor or firms with a greater number of analysts following are less likely to engage in EM, thereby increasing the integrity of the data.

5.5. European adoption of IFRS

In 2005, the European Union (EU) implemented IFRS, fundamentally altering the EU's economic landscape by enhancing global market integration and reducing information asymmetry [65]. This study investigates the impact of IFRS adoption on financial comparability by examining data from 2005-2006 (pre-EU IFRS adoption) and 2007-2009 (post-adoption), focusing on changes in AEM (see Table 8, Panel B). Additionally, the study differentiates between IFRS and non-IFRS-adhering countries for 2007-2009. The results reveal that IFRS adoption significantly reduced AEM in IFRS-adhering countries, as evidenced by a shift in the *CmpreScore* coefficient from positive to negative (-0.005 at $p < 0.001$). This indicates that IFRS adoption enhances financial comparability and restricts AEM, thus mitigating information asymmetry globally. It also aligns with the interest convergence theory, which states that reform is brought about by aligned interests.

5.6. Civil versus common law legal systems

Emerging evidence suggests that market integrity, culture, and institutional context, including a country's legal system, significantly influence EM [66]. Studies indicate that common law countries provide better investor protection and quicker recognition of bad news, leading to stricter financial disclosure and enforcement [61]. To assess the impact of legal systems on EM and financial comparability, Eq. 4 is re-evaluated using a binary variable for common and civil law countries. Panel C of Table 8 reveals an inverse relationship between AEM and *CmpreScore* in both legal systems, but statistical significance is only observed in common law countries (α of 0.05), affirming their stronger investor protection mechanisms.

6. Conclusions

This analysis examines the impact of financial reporting comparability on information asymmetry. Firstly, it was demonstrated that the constraint of EM increases with increased financial comparability, the presence of BigN

auditors, and an increased number of analysts following the firm. Secondly, it was found that contrary to expectations, restrictions of debt payments due to leverage did not impede management from opportunistic EM behaviour. Thirdly, the use of BigN auditors and the greater number of analysts following a firm were negatively associated with discretionary accruals. The results of this research have narrowed gaps in comparability literature and highlighted that information asymmetry could be reduced through increased financial reporting comparability in the 19 frontier market countries. Theoretical underpinnings and practical implications resulting from this research follow.

6.1. Theoretical implications

The theoretical contributions of this study are threefold. First, the findings challenge the POT by revealing that higher leverage in firms exacerbates information asymmetry and reduces the quality of investor information, thereby increasing EM. Second, the study lends credence to the KBV theory, as evidenced by the global reduction in EM following the adoption of IFRS and enhanced oversight by BigN audit firms and analyst coverage. Lastly, the results support the convergence theory, indicating that the harmonization of accounting standards reduces principal-agent conflicts. This is further corroborated by the correlation between increased financial comparability and a growing number of analysts following a firm, suggesting that standardization leads to more accurate financial data interpretation. Consequently, the study's results support the objectives mentioned in the Introduction regarding the relationship between financial comparability and governance mechanisms.

6.2. Practical implications

The practical implications of this study can be divided into four aspects. *Firstly*, improved comparability provides valuable information for regulators in emerging markets and similar institutional contexts. In situations with a high degree of information asymmetry, greater comparability—such as audits and forms of monitoring—can equip external stakeholders with the necessary information to monitor managers' actions. Adopting and expediting a common accounting reporting standard is a crucial step toward achieving this goal. *Secondly*, corporate governance, reinforced by legal frameworks like those provided by common law legal systems, standard boards, and professional associations, and their effective enforcement,

can positively impact EM practices and reduce information asymmetry. This allows investors to better understand the quantity and quality of disclosures within a country's legal framework. *Thirdly*, although asymmetric information is detrimental, large firms did not exhibit a greater tendency to manage earnings compared to smaller firms, contrary to the pattern observed in loss-reporting firms. This finding underscores that corporate governance initiatives should be uniformly applied across firms of all sizes and earnings levels. *Fourthly*, firms in emerging markets have distinct operating characteristics, and the variation in behaviour from mature markets suggests that different values and standards exist. Therefore, conclusions drawn from other markets cannot be universally applied.

APPENDICES

Appendix A

According to W. Martens, et al. (2020) [51], the process of calculating comparability involves the following stages:

Stage 1: In the first stage of the comparability calculation process, as outlined in Equation 1, a correlation between economic results and income is established for each country-industry year using all the data available for a company. It is important to note that a minimum of ten firms must be included in each country-industry-year in order for the estimate to be valid.

$$R_{it}^{Cj} = \gamma_0^{Cj} + \gamma_1^{Cj} \left[\frac{NI_{it}}{P_{it-1}} \right] + \gamma_2^{Cj} \left[\frac{\Delta NI_{it}}{P_{it-1}} \right] + \gamma_3^{Cj} L_{it} + \gamma_4^{Cj} L_{it} \left[\frac{NI_{it}}{P_{it-1}} \right] + \gamma_5^{Cj} L_{it} \left[\frac{\Delta NI_{it}}{P_{it-1}} \right] + \varepsilon_{it} \quad (1)$$

where the symbol Cj denotes the price multiples associated with the accounting system for country C in industry j . Thus, each γ coefficient varies among the sample's countries, industries, and years. The variable Δ serves as the change agent, NI represents earnings per share before unusual items, while letters i and t denote the firm and year, respectively, ε is the error term. The term P refers to share price, and R represents the buy-and-hold return on investment. Additionally, L is a dummy variable assigned a value of one if NI is below zero, and zero otherwise. It is important to note that all data used in this study was collected in US dollars.

Stage 2: As outlined in Equation 2, the second stage of the comparability calculation process involves estimating a company's fitted stock return utilizing the country model.

$$\hat{R}_{it}^{Cj,Cj} = \gamma_0^{Cj} + \gamma_1^{Cj} \left[\frac{NI_{it}}{P_{it-1}} \right] + \gamma_2^{Cj} \left[\frac{\Delta NI_{it}}{P_{it-1}} \right] + \gamma_3^{Cj} L_{it} + \gamma_4^{Cj} L_{it} \left[\frac{NI_{it}}{P_{it-1}} \right] + \gamma_5^{Cj} L_{it} \left[\frac{\Delta NI_{it}}{P_{it-1}} \right] + \varepsilon_{it} \quad (2)$$

Stage 3: As detailed in Equation 3, the third stage of the comparability calculation process involves estimating the fitted stock return under each counter-sample model for each company, as at least two nations with sufficient firms in each industry-year are required. Specifically, this step involves estimating the fitted stock return for each company under each counter-sample model for each industry-year.

$$\hat{R}_{it}^{Cj,Cj^n} = \gamma_0^{Cj^n} + \gamma_1^{Cj^n} \left[\frac{NI_{it}}{P_{it-1}} \right] + \gamma_2^{Cj^n} \left[\frac{\Delta NI_{it}}{P_{it-1}} \right] + \gamma_3^{Cj^n} L_{it} + \gamma_4^{Cj^n} L_{it} \left[\frac{NI_{it}}{P_{it-1}} \right] + \gamma_5^{Cj^n} L_{it} \left[\frac{\Delta NI_{it}}{P_{it-1}} \right] + \varepsilon_{it} \quad (3)$$

Stage 4: In the fourth stage of the comparability calculation process, as outlined in Equation 4, the absolute value of the difference between the within-sample and counter-sample fitted stock prices for each company is calculated and represented as *DIFF*. This step is intended to quantify the variation in the estimated stock return between the within-sample and counter-sample models for each company.

$$DIFFERENCE_{i,t}^{Cj,Cj^n} = \left| \hat{R}_{i,t}^{Cj,Cj} - \hat{R}_{i,t}^{Cj,Cj^n} \right| \quad (4)$$

Stage 5: As detailed in Equation 5, the fifth stage of the comparability calculation process involves calculating the median absolute difference between the fitted stock prices of the within-sample and counter-samples, multiplied by the negative natural logarithm. This computed value serves as an indicator of the firm's assessment of comparability with the counter-sample, with larger values indicating a higher degree of comparability. This step is intended to provide a comprehensive measure of the overall comparability of the results between the within-sample and counter-sample models.

$$CmpreScore_{it} = -\ln[\text{Median}(DIFFERENCE_{i,t}^{Cj,Cj^n})] \quad (5)$$

It is important to note that while companies i and k may originate from different countries, they may share the same two-digit Standard Industrial Classification (SIC) industry code. To explain for accounting comparability between firms across national boundaries, the variable *CmpreScore* is estimated utilizing time-series regression. This approach enables capturing the accounting comparability between firms, despite the differences in their national origins.

Appendix B

The study C. Leuz, et al. (2003) [53] employs four metrics for EM: EM1 and EM2, which focus on income smoothing, and EM3 and EM4, which are discretionary income measures. Notably, the “small-loss avoidance” observed in EM4 allows for both AEM and Real EM strategies, diverging from the exclusive use of AEM. This study adopts the first three metrics, aligning with prior research such as [67].

To commence the analysis, accruals are initially calculated utilizing the equation represented in Equation 6.

$$\text{Accruals}_{it} = (\Delta CA_{it} - \Delta \text{Cash}_{it}) - (\Delta CL_{it} - \Delta STD_{it} - \Delta TP_{it}) - \text{Dep}_{it} \quad (6)$$

where CA_{it} represents the overall total of current assets, Cash_{it} represents cash and cash equivalents, CL_{it} represents the total of current liabilities, STD_{it} represents short-term debt, TP_{it} represents taxes payable, and Dep_{it} denotes depreciation and amortization expenses. The three measures of AEM are denoted as Equation 8 to Equation 10.

$$EM1 = \sigma(\text{Operating Earnings}) / \sigma(\text{Cash flow from operations}) \quad (7)$$

The measure of EM ($EM1$) is determined by dividing the standard deviation of operating earnings net of interest and taxes by the standard deviation of net operating cash flows. The smaller the value of this metric, the greater the likelihood that management is utilizing accruals to mitigate the variance of operating cash flows.

$$EM2 = \rho(\Delta \text{Accruals}, \Delta \text{Cash flow from operations}) \quad (8)$$

The measure of EM ($EM2$) is calculated as the correlation between changes in accruals and changes in net operating cash flow. Notably, net cash flow from operations is obtained by subtracting accruals from operating earnings.

$$EM3 = |\text{Accruals}| / |\text{Cash flow from operations}| \quad (9)$$

The measure of EM ($EM3$) is computed by dividing the absolute values of accruals by the absolute value of operational cash flow.

The firm-level EM index in this study is formulated based on methodologies from C. Leuz, et al. (2003) [53] and C.H. Sheu, et al. (2007) [68], incorporating three individual measures: EM1, EM2, and EM3. These measures are ranked, and to maintain consistency, particularly for EM3, the rankings for EM1 and EM2 are inverted as per Equation 10. A composite firm-level EM score is then calculated by averaging the scaled rankings of these three measures for each firm (i), with higher scores indicating a greater propensity for EM.

$$EM_{it} = \frac{(\text{Rank}(EM1_{it})^{-1} + \text{Rank}(EM2_{it})^{-1} + \text{Rank}(EM3_{it}))}{3} \quad (10)$$

CRediT author statement

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COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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