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Investment Efficiency and Stock Price Crash Risk: Unveiling Board Governance amidst Informative Asymmetry

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Abstract

With the increasing concern regarding distortions related to corporate investments and the fact of stock price collapses, it has become an ultimate interest for finance scholars and practitioners to understand the relationship between firm-level investment decisions and market stability. After the realization of previously concealed information, stock price crash risk exists where negative information holds a level of exposure within information environments. This research examines the connection between investment efficiency and the danger associated with stock price crashes and seeks to investigate information asymmetry as a mediating variable and board governance quality as a moderating variable. The study provides a quantitative study of panel data of non-financial firms classified on the Pakistan stock exchange, across an interval of years, and utilizes mediation and moderation methods through regression analysis to establish that such relationships exist to the degree outlined. The findings reveal that investment efficiency has a negative and significant effect on stock price crash risk, indicating that efficient investment decisions reduce the likelihood of extreme negative stock returns. Information asymmetry negatively affects investment efficiency and mediates the relationship between investment efficiency and crash risk, suggesting that efficient investment reduces crash risk partly through enhancing transparency. Board effectiveness directly reduces information asymmetry and strengthens the negative relationship between investment efficiency and information asymmetry. Leverage shows protective effects against crash risk while constraining investment efficiency, highlighting capital structure trade-offs. The findings contribute to agency theory by demonstrating how investment efficiency, information asymmetry, and board governance interact to influence stock price stability. For practitioners, improving investment efficiency and strengthening board effectiveness can enhance transparency and reduce crash risk. For policymakers, the study underscores the importance of governance reforms that promote board independence and monitoring capability to enhance corporate accountability and financial market stability.

Keywords: Efficient Market, Investment, Stock Price, Crash Market, Board Governance, Corporate Governance, Information Asymmetry, Crash Risk, Investment Efficiency

Introduction

A stock price crash is when some negative news for a company comes to light, news that has otherwise been withheld, resulting in an immediate and rapid decline in a company's stock price. It is not only a confidence killer and wealth-reducing event for shareholders, it also presents fundamental issues regarding the efficiency of the market and the duty of

management to perform its oversight duties (Shelih and Wang, 2024). Given the well-known financial crises that have occurred in recent decades, such as Enron and Lehman Brothers, which illustrate how periods of delayed release of bad news can add to systematic risk (Andreou et al., 2016). When firms waste capital through excessive risk-taking, empire-building or failure to invest, they increase the risk of a crash for their shareholders through withholding deteriorating economic performance (Chebbi 2024). As soon as the conditions of bad news are detected, their stock price can rapidly collapse. Given the discussion, the efficiency of investment, or how effectively a firm invests in their significant projects, is an important indicator of a firm's stock price crash risk (SPCR). An important factor explaining how investment efficiency contributes to crash risk is information asymmetry, which is the basic problem of financial markets. Information asymmetry exists when managers have information about a firm's business and prospects that is better than that which can be acquired by investors on the outside (Ullah, Zeb et al. 2020). When this mismatch exists, managers can control the information that investors receive; they can provide "good" news and hold or delay "bad" news (Aldhamari et al., 2023). In firms where information asymmetry is significant, investors cannot fully value the true value of the firm, and stock prices will be overpriced. As bad information builds up over time, and the market absorbs the new information, it can produce an abrupt shift in the market, resulting in a price crash (Zhang et al., 2022). A firm with low information asymmetry means that the investor receives the transmission of firm value with better timing and transparency; therefore, prices can adjust slowly and will exhibit a lower likelihood of collapse. Therefore, information asymmetry is a mediating variable that explains how inefficient investment decisions become a crash risk; this links the behavioral aspect of management with the market information side. Through an examination of that mediating role, researchers come to know more about the transmission channel through which the inefficiencies of firms exhibit themselves as instability in the market. Essentially, investment inefficiency determines the level of information asymmetry in the firm, which will, in turn, define the readiness of the firm to collapse into a crash as the information asymmetry diminishes (Arab et al., 2020). If the impact of information asymmetry is about how information flows internally, a board that is led by quality governance defines how much asymmetry will be tolerated and how much will be minimized (Zaigham et al., 2019). Quality governance measures of boards include independence, gender diversity, financial acumen, and active governance. Superior board governance ensures that managers make divergent investment decisions based on the pursuit of long-term value over personal interests (Saleeb, 2024). A vigilant board with strong governance attributes and oversight enforces accountability from management and demands timely, accurate, and intelligible financial information put forth by management to minimize management efforts to conceal bad news (Menshawy et al., 2023). Weak governance plans, including a dominance of the CEO that disallows independent oversight of management performance and manipulation of the information asymmetry issue, allow for manipulation of information and opportunistic behavior in which managers can disguise inefficiencies by manipulating investments that produce inefficient and inflated stock performance, until holding out a long-term collapse of the firm's stock price (Zhao et al., 2023). Thus, board governance mediates the relationship between information asymmetry and stock price crash risk, modifying the efficacy of transparency mechanisms to offset possible managerial discretion. Effective boards can obviate the harmful mediating process or effect of information asymmetry, and ineffective board governance will perpetuate it (Bilyay-Erdogan et al., 2024). This demonstrates how corporate governance should not only be an oversight mechanism but also an anticipatory, active, and strategic risk management tactic to mitigate the risk of a market collapse.

The aim of the current research is to use empirical data to witness the relationship between investment efficiency and stock price crash risk, while testing the mediating effect of information asymmetry and the moderating effect of board governance. Precisely, the

research seeks to witness if more investment efficiency firms have lower crash risk, and if the same is induced by differences in information asymmetry and transparency (Khan et al., 2025). In addition, the research will establish to what extent the structure of governance (such as board independence, diversity, and ability) reinforces or weakens the role of information asymmetry and transparency towards stock price crash risk. Research that combines these variables under one model might be able to gain a better understanding of how managerial discretion, corporate governance, and information environments can influence market outcomes (Habib et al., 2018). They can, together, assist us in enhancing our knowledge of how stocks fall, either through the worst or best effects of stock price crash risk in emerging and developed markets.

This research is significant not just to us out of pure intellectual interest, but also to corporate managers, investors, and policymakers. At an academic level, the research bridges a gap in theory in the literature by relating investment efficiency, information asymmetry, and mechanisms of governance to the risk of stock price crash (Habib & Hasan, 2017). While previous research has evaluated these relationships in isolation, without considering the interdependence between the managerial inefficiency, transparency of information, and oversight of boards of directors, the research contributes to the literature on risk determinants at the firm and market level (Erkip & Cover, 2002). On a practitioner level, the study will identify points of action for corporate managers to improve the quality of investment decisions and to reduce potential crash risk going forward (Dow & Gorton 1997). For investors, the understanding related to the relationship between weak governance and investment inefficiency will provide additional information to inform investment portfolios, and for regulators/policymakers, evidence-based recommendations to improve disclosure standards and strengthen codes of governance to ensure market integrity (Chen et al., 2017).
Last but not least, the implications of the study are multi-dimensional. One implication for corporate managers is the correlation of poor investment practices with the risk of disclosing business practices that jeopardize increasingly fragile levels of trust in the market (Ben-Nasr & Alshwer, 2016). Highlighting the reasons for investments, and having transparency in reporting, would assist, if anything, in the firm managers maintaining (or achieving) trust and market stability (Basu, 1977). The result may shift the thinking of boards of directors for the need to create governance that promotes diversity and independence, and monitoring to offset the information asymmetry and support the mitigation of a crash (Zhang et al., 2022). For investors, these outcomes will help to detect (or not) whether firms are at risk of crashing based on visible governance and investment behavior. For (public sector) policy makers, the study will help with their work to advance policy reform in corporate disclosures and accountability (Shelih & Wang, 2024). Overall, and finally, through responsible investment, governance, and disclosures, the study seeks to support a framework of more transparent, accountable, and resilient business culture that collectively protects individual investors in their exposures to market collapse and stock price crashes of business structures.

Literature Review

Investment Efficiency and Stock Price Crash Risk

Efficiency of investment is the capacity to use firm resources in the most effective way that produces the greatest return, reflects both rational manager choice and manager discipline in using firm resources (Biddle et al., 2009). Efficient investment decisions yield resource allocation toward projects with the highest value for the firm while reducing uncertainty in operations and increasing trust in equity investors. Conversely, the two forms of inefficiency, overinvestment or underinvestment, are often associated with managers acting in a self-interested manner and/or behavioral biases. Overinvestment could occur when managers acting on inherent empire-building motives make investments in negative-NPV projects to

increase their control and compensation (Richardson, 2006). Furthermore, underinvestment can develop from excessive risk aversion about incurring losses, or managers would hoard cash even if it increases the uncertainty in the environment, neither of which is a sign of effective capital utilization. The connection of inefficient investment to stock price crash risk primarily relates to the manager's predisposition to conceal negative performance. For example, managers will not relay bad investment performances immediately and instead try to maintain optimism in the market and/or increase stickiness in their bonuses and/or avoid the scrutiny from stakeholders (Jin & Myers, 2006). Managers conceal bad news, equating to a reservoir of bad news that, at some point, explodes to reveal the information. Kim et al. (2011) showed empirically that firms with low investment efficiency are at a higher risk of crash due to earnings manipulation and less transparent disclosures. An and Zhang (2013) empirically found that overinvesting is strongly correlated with increased volatility and crash-prone behavior in stock returns. Similarly, inefficient investment has also been shown to be associated with low accounting quality, as managers often manipulate earnings in order to justify investing in misallocated resources (Francis et al., 2004). Accordingly, inefficient investment not only undermines firm fundamentals but also creates unintended risk associated with investor uncertainty - thereby creating greater crash risk. From the perspective of behavioral finance, inefficient investment acts as a signal about management's overconfidence or opportunism, which, in turn, undermines market trust. Spurred by panic, when eventually investors understand the difference between reported performance and economic reality, they can sell quickly, creating a market panic and possible correction in short order (Basu, 1977). Decreasing investment efficiency leads to increased transparency within the firm, less potential for hidden financial risk, and creates a calming of expectations in the market.

H1: *Investment efficiency is negatively associated with stock price crash risk*

Investment Efficiency and Information Asymmetry

Investment efficiency has an important influence on the information asymmetry that exists between managers and other stakeholders. Managers hold more detailed knowledge about how well a business operates than external stakeholders, including shareholders; therefore, this detail creates more of an imbalance in terms of access to accurate information about a business. Efficient investment decisions are made with the use of objective evaluation criteria, transparent governance processes, and reliable reporting practices. All three of these aspects contribute to better decision-making processes, which then lead to improvements in the quality of information disclosed, thereby reducing the information gap between inside and outside parties (Bushman & Smith, 2001; Healy & Palepu, 2001). Another consequence of making efficient investments is that they are a signal or indication of managerial discipline and rationality in capital allocation, which assists investors in more accurately assessing the timing, risks, and expected returns of projects; therefore, much of the time that investors expect from businesses is aligned with how those businesses operate and reduce the level of information asymmetry (Ben-Nasr & Alshwer, 2016). Inefficient investment behavior can be attributed to poor governance structures, inadequate disclosure, or ineffective monitoring environments that open the door to managers more likely pursuing individual gain (e.g., empire-building, tunneling, or related-party transactions) on their projects rather than increasing shareholder value, obfuscating the real economic performance of a company and furthering the gap in information asymmetry (Chen et al., 2011). Additionally, empirical research demonstrates that significant levels of inefficient investment are correlated with earnings-management activities, which suggests that managers may manipulate accounting data to hide the results of suboptimal capital allocation decisions (McNichols & Stubben, 2008). Consequently, lower levels of investment efficiency will reduce transparency in financial reporting and, consequently, diminish the credibility of the reports presented to the

investing community, further increasing the differences in information between a firm and the marketplace. Furthermore, it can be concluded that an increasingly prevalent misallocation of capital is likely to occur in situations where investment decisions do not have any form of discipline, thus restricting investors' capacity to monitor or appropriately price management's performance (Firth et al., 2011). The ability of a firm to obtain external funding is contingent on its utilization of its capital. Efficient utilization of capital enhances the perception of the investor in the company and decreases the uncertainty about the future cash flow. When there is a decrease in perceived risk of the company's investment, it decreases the necessary return for investors on the investment in companies. Firms without efficient utilization of capital will have a tougher time attracting investors because of the riskier nature of the company (Chen et al., 2017). Efficiently utilized investments convey information to the investor on the effectiveness of the company in utilizing its resources. The elements that improve perceptions are improved transparency, increased investor confidence in the financial markets, and increased communication between the investor and the company, that reduce the levels of information asymmetry between firms and their investors. Efficiently utilized investments may also result in improved corporate governance and increased capital market participation (Dow & Gorton, 1997).

H2: *Investment efficiency is inversely related to the degree of information asymmetry.*

Information Asymmetry and Stock Price Crash Risk

In environments with high information asymmetry, managers can withhold or misrepresent bad news information disclosures. This can result in a disconnect between real and perceived firm performance (Jin & Myers, 2006). More specifically, the bad news hoarding hypothesis posits that managers hoard undisclosed negative information during good times to serve their self-interests, such as bonuses or job security. In contrast, the accumulated information will be released through external shocks, a financial audit, and/or decreasing performance, which then yields a rapid and large-scale correction in stock prices (He et al., 2022). This mechanism has been reported in several empirical studies. Hutton, Marcus, and Tehranian's (2009) study on the consequences of poor transparency and high opacity to those information asymmetries suggests that firms had significantly higher crash risk. Additionally, Bleck and Liu (2007) find that imperfect information environments encourage admixtures of speculative trading with herd behavior. In Callen and Fang's (2015) findings, they go on to confirm that weak financial reporting quality signals higher crash probability due to the enabled hoarding of bad news. Extreme degrees of information asymmetry reduce market quality when investors do not fairly value firms, resulting in overvaluation until bad news reveals the adverse reality and prices adjust downward (Saleem & Usman, 2021). From an investor's psychological perspective, information asymmetry creates uncertainty, and investors exhibit larger reactions to bad relative to good news announcements. The skewing of responses, magnifying the downward movement, emerges, creating behavior similar to a crash (Xie et al., 2020). Therefore, keeping the sudden changes in a firm's value to a minimum, by having lower information asymmetry, is a protection for investors and creates a more stable financial system in the aggregate.

H3: *Information asymmetry is positively related to stock price crash risk*

Mediating Role of Information Asymmetry

Information asymmetry is the unequal distribution of information between an organization’s internal people and the external market. For example, Company M's managers possess information that is not available to the external market (investors). Therefore, because the managers of Company M have greater access to information about the company than the external investors, there is a potential for agency problems (Jensen & Meckling, 1976; Healy

& Palepu, 2001). As described in the literature by Healy and Palepu (2001), because of agency problems, the market has an increased level of uncertainty associated with determining the performance of the company and the risk associated with that performance. Previous research has indicated that when there is a high degree of information asymmetry between internal and external sources of information, there will be less transparency in the market, weaker monitoring of management by outside sources of information, and more opportunities for management to act opportunistically, hence causing a misalignment of the valuation of a company in the marketplace and creating or amplifying adverse events. Information asymmetry also serves as a critical transmission channel for external investors to respond to inefficient internal investment decisions. The more transparent the investment decisions made by management through a company's financial reporting system, the better capable investors will be in determining Company M's true valuation; therefore, reducing uncertainty. Consequently, using the financial reporting system, inefficient investments made by management (either by over-investing or under-investing) will generally be associated with an opaque financial reporting system. The less transparent (less reliable) the financial reporting system, the more likely it is that external investors will not be able to determine if the investment decision made by management will either add value to the company or decrease value to the company, and, in turn, misprice the company's shares in the marketplace. Additionally, the literature on stock price crash risk identifies a mediation function for information asymmetry. Jin and Myers (2006) assert that when firms operate in an environment of information asymmetry, managers will tend to withhold bad news, leading to a buildup of negative information that is then disclosed all at once, resulting in a significant stock price decline. Evidence from empirical research indicates that companies experiencing high levels of information asymmetry are more likely to experience price crash risk (Hutton et al., 2009; Kim et al., 2011). Consequently, information asymmetry serves as an important intermediary between investing behaviour and crash result, where poorly informed investors make inefficient investment decisions, resulting in a greater stock price crash risk.

H4: *The information Asymmetry mediates the relationship between Investment efficiency and stock price crash risk.*

Role of Moderating Board Governance

An organization’s board of directors plays an important role in the management of the organization by acting as a monitoring mechanism to help reduce the opportunity for managerial opportunism, while also improving the transparency of corporate decision-making. From an investment perspective, an effective board (independent, diverse, has a financial expertise and provides active oversight of management) has a positive impact on the quality of an organization’s investment decisions by enabling more efficient allocation of capital to different projects as well as ensuring that major strategic projects receive a thorough evaluation before proceeding with investment (Fama & Jensen, 1983). The presence of an active board of directors provides a monitoring function that reduces the risk of over- or under-investing or personal self-serving acts and improves the timeliness and accuracy of management’s disclosure to investors and other stakeholders, thus reducing the level of information asymmetry between the organization and its investors. Previous work has shown that strong corporate governance mechanisms improve the quality and transparency of an organization’s financial reporting, thereby decreasing the amount of information asymmetry resulting from poor investment decisions (Bushman & Smith, 2001; Xie et al., 2003). Thus, board governance serves to lessen the positive relationship between low-quality investments and information asymmetry because it makes management’s actions visible, accountable, and aligned with the interests of the organization’s shareholders. The governance structure of boards of directors also acts as a moderator for any changes that occur due to an uneven

distribution of information in capital markets, including the probability of having a significant amount of risk associated with a rapid decrease in stock prices. In environments where there is a lack of transparency, managers may withhold unfavorable information about the company, leading to an accumulation of unfavorable information and eventually culminating in a sudden and catastrophic decline in the company's stock price (Jin & Myers, 2006). A board that is independent and functions efficiently increases the effectiveness of internal controls, enhances the effectiveness of the company's audit function, and mandates full disclosure, which ultimately limits the ability to delay the release of unfavorable information. As a result of increased investor confidence and reduced discretion of managers due to effective governance, the relationship between information asymmetry and extreme negative stock returns is lessened. Board governance acts as a buffer to reduce the extent to which information transmission results in negative crash risk outcomes.

H4: *Effective corporate governance moderates the relationship between investment inefficiency and information asymmetry*
H5: *Effective corporate governance moderates the relationship between information asymmetry and stock price crash risk*

Theoretical Background

Investment performance, information asymmetry, board oversight, and stock price crash risk are all interconnected concepts based on a broad breadth of theoretical foundations, primarily agency theory (Jensen & Meckling, 1976), information asymmetry theory, and signaling theory. Agency theory explains that interest conflicts arise when managers (agents) pursue goals for themselves, which are contrary to those of shareholders (principals) (Agah et al., 2017). Interests' clashes where shareholders suffer from disadvantages in information, discouraging their ability to keep managerial influence under control, are more serious (Nugroho et al., 2018). Managers will then be able to manipulate information disclosure, manage earnings, or make inefficient investments to increase their private benefits (Habib et al., 2018). Managerial opportunism and poor governance give rise to inefficiencies, value erosion, and eroded confidence in the firm. Information asymmetry theory adds greater insight to this notion by explaining how varying access to information by outsiders and insiders leads to deceptive capital allocation and market valuations (Healy & Palepu, 2001). In situations where investors cannot accurately evaluate the quality of managerial decisions, they can overreact or underreact to new information and establish market inefficiencies and price volatility. Signaling theory (Spence, 1973) extends this view by indicating that managers send private information about firm quality through observable behavior such as investment choices, dividend payouts, and financial disclosures. Board investment efficiency is therefore a vital signal to the market--efficient investment processes reflect managerial quality and integrity while inefficient investment processes convey opportunism, manipulation, or hiding of adverse firm information. Last but not least, the hypothesis of bad news hoarding (Jin & Myers, 2006) synthesizes these theories and adds to the knowledge of how, in the case of vastly high information conditions, managers stockpile bad information that results in a sharp negative stock-price reduction when revealing cumulative bad news. In this theoretical structure, board governance is the primary moderation mechanism that allows managerial choice consistently creating value or creating systemic risk.

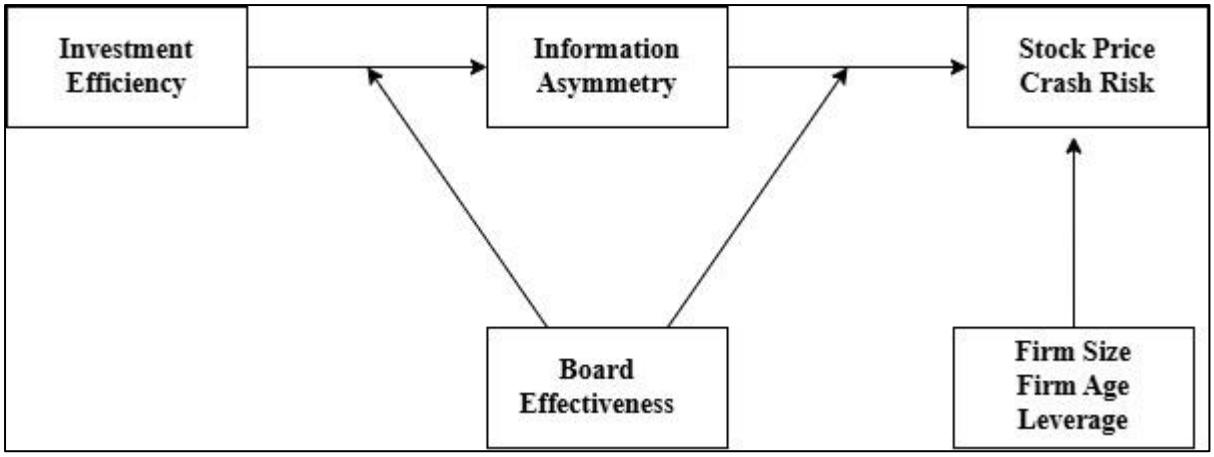

Figure 2.1: Theoretical Framework

Proposed Methodology

Research Design

This study employs a quantitative, explanatory research design to quantitatively examine the effect of investment efficiency on stock price crash risk, with information asymmetry as a mediator variable and board governance as a moderator variable. The study will ascertain the degree to which an efficient decision-making process on the part of managers can be associated with a higher risk of a stock price crash, and the degree to which the use of good corporate governance principles can negate that relationship. The research framework is grounded in agency theory and information asymmetry theory as the primary theoretical framework, and stresses the nexus between managerial choice and investment, firm disclosure, and market behavior (Zaigham et al., 2019). To account for cross-section and time-series variation across competing firms, panel data methods will be applied to provide stronger causal inference and estimation of the heterogeneity at the firm level while considering the efficiency of investment and governance quality. The population focus for this research study is all non-bank publicly listed firms on the Pakistan Stock Exchange (PSX), where banks would be subject to a different regulatory environment and may therefore impact the trade outcome. The sample would include firms that are tracked over a 10-year time period (2015-2024) so that sufficient longitudinal depth is provided to consider crash risk behavior and governance contours. Exclusion procedures will be applied for companies with missing data, delisted firms, or companies whose liquidation did not keep trading constantly to enable data transparency. The ultimate sample size will most possibly be between 200 to 250 companies, contingent on the availability of data. Since a panel dataset will be based on yearly firm-level observations, it will yield around 2,000 firm-year observations, which gives greater statistical power and representativeness. Information will be gathered from various credible sources of data. Financial and accounting information will be from firms' annual reports, PSX database, and the State Bank of Pakistan's Balance Sheet Analysis of Joint Stock Companies. The governance variables (i.e., board structure and independence) will be from firms' corporate governance reports and disclosure of financial data. Stock price data will come from Thomson Reuters DataStream, Yahoo Finance, or the PSX.

The methodology elucidates an empirical examination of risk of a crash in stock prices with the relationship of efficient investment in emerging markets - which have a different quality of governance and information environment than developed economies, and undertakes mediation and moderation analysis in its exploration of how and when the risk of a crash occurs, as well as develop a legitimate rationale to push for governance arrangements &

transparency with enough forcefulness for policy makers, finance stakeholders and boards of directors in light of the findings.

Measurement of variables

Stock price crash risk constitutes the core dependent variable in this study. To test the proposed hypotheses, this study employs four established proxies to capture SPCR: negative skewness (NCSKEW hereafter), down-to-up volatility (DUVOL hereafter), extreme sigma (Esigma hereafter), and a crash indicator (Crash hereafter). NCSKEW is calculated as the negative third moment of firm-specific weekly returns divided by the cube of their standard deviation (Liu & Liu, 2023). DUVOL is the logarithm of the ratio between the standard deviation of down-week and up-week returns (Kim et al., 2023). Esigma represents the most negative deviation of firm-specific returns from the mean, normalized by their standard deviation (Choi et al., 2023). Following Zhang et al. (2023), Crash is a binary variable equal to 1 if at least one weekly return in year *t* falls below [Mean 3.09 × SD], and 0 otherwise. The independent variable, investment efficiency (IE)**,** is measured following the methodology of Ranasinghe et al. (2023), using a cross-sectional regression framework in which firm investment is regressed on sales growth and a suite of firm-specific control variables (Menshawy et al., 2021). Investment inefficiency is proxied by the regression residuals: positive residuals indicate over-investment, while negative residuals signal under-investment. The baseline model is specified as follows:

$$INVEST_{i,\,t} = \beta_0 + \beta_1 Growth_{i,\,t} + \beta_2 Slack_{i,t} + \beta_3 Lev_{i,\,t} + \beta_4 CFO - OPRE_{i,t} + \beta_5 Size_{i,t} + \beta_6 Age_{i,\,t} + \varepsilon Year_{i,t} + \varepsilon_{i,\,t} \ldots\ldots \text{ Eq 9.}$$

The mediating variable, information asymmetry, is measured by using Amidud's ILLIQ ratio, which is measured as the ratio of daily stock returns (absolute) to trading volume in Rs. To examine the moderating effect of corporate governance, a Board Effectiveness Index (BDEFF) is constructed in alignment with Wang et al. (2020), grounded in the provisions of the 2019 Listed Companies Code of Corporate Governance. The index synthesizes six board-level attributes: (1) board size (more than seven members), (2) CEO duality (separation of CEO and Chair roles), (3) board independence (at least one independent director), (4) proportion of non-executive directors (exceeding two-thirds), (5) gender diversity (minimum one female director), and (6) frequency of board meetings. To mitigate potential endogeneity and enhance the validity of inference, the model incorporates three control variables: firm age (logarithm of years since incorporation), firm size (logarithm of total assets), and leverage (long-term debt-to-assets ratio), consistent with Krishnamurti et al. (2021) and Mansour et al. (2022). These controls account for heterogeneity across firms that could independently influence strategic performance and capital resource (SPCR) outcomes. Comprehensive operational definitions and measurement specifications are detailed in Table 2.

Table 2: Measurement of variables

Variable	Symbol	Measure	Reference
Stock Price Crash Risk	NCSKEW	Negative skewness down-to-up volatility (DUVOL hereafter), extreme sigma (Esigma hereafter), and a crash indicator (Crash hereafter)	(Choi et al., 2023; Kim et al., 2023; Liu & Liu, 2023)
Investment efficiency	INVEFF	INVEFF refers to Investment Efficiency, which equals the absolute values of Eq9	(Menshawy et al., 2021)
Corporate Governance Index	BDEFF	A composite measure of CG attributes Board size (if board size is more than 7 then 1 otherwise 0); CEO Duality (1 if CEO and Chairman are different, 0 otherwise); Board Independence (if board holds more	(Fernando et al., 2020; Naz et al. 2021) Listed

		than 1 independent director then 1, otherwise 0); Non-executive directors (1 if Non-executive directors are more than 2/3 of total number of directors, 0 otherwise); Board Gender Diversity (if female members on the board are more than one then 1 otherwise 0), Board Meetings (No. of Board Meetings)	Companies (Code of Corporate Governance), Rules 2019.
Information Asymmetry	ILLIQ	Amidud's ILLIQ ratio is measured as the ratio of daily stock returns (absolute) to trading volume in Rs	(Amihud, 2002; Nguyen, & Kimura, 2023)
Firm Age	AGE	which is calculated using the natural logarithm of firm age	(Mansour et al., 2022)
Firm Size	SIZE	Log of Total Assets	(Mansour et al., 2022)
Leverage	LEV	A ratio of long-term debt divided by total assets.	(Krishnamurti et al., 2021)

Research Methodology

Sample Selection

The table provides a detailed breakdown of the sample extraction and observations for a study involving listed firms, categorized into financial and non-financial sectors. Initially, the study considered 549 listed firms, which would have resulted in 5,490 observations over the study period, assuming 10 years of data per firm. Among these, 180 firms are listed under the financial sector, contributing 1,800 observations, while the remaining 369 firms are listed under the non-financial sector, accounting for 3,690 observations. This indicates that the non-financial sector constitutes a larger portion of the sample compared to the financial sector. However, the study faced challenges with missing data, as 76 companies had incomplete information, leading to the exclusion of 760 observations. Consequently, the final sample size was reduced to 293 firms, resulting in 2,930 observations available for analysis. This reduction highlights the impact of data availability on the study's scope and underscores the importance of addressing missing data in research to ensure robust and reliable findings.

Table 4-Error! No text of specified style in document.**-1: Final Sample and Observations**

	Sample Extraction	Observation per year
Listed firms	549	5,490
Listed under financial sector	180	1,800
Listed under non-financial sector	369	3,690
Total Observations	293	2,930
Companies with missing data	76	760
Total	**293**	**2,930**

Source: Author's Work

Econometric Model

In the first stage, the present study will evaluate the association between Stock price crash risk and IE based on equation 1.

$$\sum_{i=1}^{3} SPCR_{i,t} = \propto + \beta_1 IE + \sum_{k=1}^{3} \beta_1 Controls_{i,t} + \epsilon_{i,t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq 1}$$

In the second stage, the current study will evaluate the association between Stock price crash risk and IA based on equation 2.

$$\sum_{i=1}^{3} SPCR_{i,t} = \propto + \beta_1 IA + \sum_{k=1}^{3} \beta_1 Controls_{i,t} + \epsilon_{i,t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq 2}$$

In the third stage, the present study will assess the relationship between IA and IE based on equation 3.

$$\sum_{i=1}^{3} IA_{i,t} = \propto + \sum_{k=1}^{3} \beta_1 IE_{i,t} + \sum_{k=1}^{3} \beta_1 Controls_{i,t} + \epsilon_{i,t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq 3}$$

Mediation Analysis

In the fourth stage, the present study will evaluate the mediating role of IA between Stock price crash risk and IE, using equation 4.

$$\sum_{i=1}^{3} SPCR_{i,t} = \propto + \beta_1 IE + \beta_2 IA + \sum_{k=1}^{3} \beta_1 Controls_{i,t} + \epsilon_{i,t} \ldots\ldots\ldots\ldots\ldots\ldots \text{Eq 4}$$

Moderation Analysis

In the next stage, the present study will evaluate the moderating role of BDEFF between IA and IE using Equations 5 and 6.

$$\sum_{i=1}^{3} SPCR_{i,t} = \propto + \beta_1 IE + \beta_2 IA + \beta_3 IA * BDEFF + \sum_{k=1}^{3} \beta_1 Controls_{i,t} + \epsilon_{i,t} \ldots\ldots\ldots \text{Eq 5}$$

$$\sum_{i=1}^{3} IA_{i,t} = \propto + \beta_1 IE + \beta_2 IE * BDEFF + \sum_{k=1}^{3} \beta_1 Controls_{i,t} + \epsilon_{i,t} \ldots\ldots\ldots \text{Eq 6}$$

Descriptive Statistics

The descriptive statistics of the study variables are presented in Table 1. The results show that the mean value of Nskew is -0.205, with a standard deviation of 2.349, indicating variation in Nskew across firms, ranging from -89.62 to 53.54. The mean value of information asymmetry is approximately 0.010, with a very small standard deviation (-0.107), indicating limited dispersion in the measure across the sample. Similarly, investment efficiency has a mean close to zero (0.010) with a standard deviation of 0.193, reflecting variability in firms' investment behavior, with values ranging from –5.36 to 3.61. Regarding governance characteristics, board effectiveness has a mean of 0.304 and a standard deviation of 0.345, indicating that some firms exhibit effective board structures. For the control variables, leverage has an average value of 0.591 with a standard deviation of 0.297, suggesting considerable variation in firms' capital structures. The mean firm age is 47.16 years, indicating that most firms in the sample are relatively mature organizations. Finally, the average firm size is 19.54, with a standard deviation of 3.038, reflecting moderate variation in firm scale across the sample.

Table 4-2: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Nskew	2,930	-0.205	2.349	-89.62	53.54
Information Asymmetry	2,930	0.010	-0.107	-0.98	0.19
Investment Efficiency	2,930	0.010	0.193	-5.36	3.61
Board Effectiveness	2,930	0.304	0.345	-0.91	1.19
Leverage	2,930	0.591	0.297	-1.28	4.34
Firm Age	2,930	47.16	15.491	0.09	95.19
Firm Size	2,930	19.54	3.038	10.39	27.17

Source: Author's Calculation

Table 2 presents the Pearson correlation coefficients among the study variables. The results indicate investment efficiency (r = -0.14), board effectiveness (-0.35), information asymmetry (r = 0.08), leverage (r = 0.07), firm age (r = -0.36), and firm size (r = -0.25) with SPCR. Similarly, board effectiveness (r = 0.16), information asymmetry (r = 0.18), leverage (r = 0.25), firm age (r = 0.54), and firm size (r = -0.45) with investment efficiency. Information asymmetry (r = -0.04), leverage (r = -0.07), firm age (r = -0.01), and firm size (r = -0.02) with board effectiveness. Overall, the correlation coefficients are relatively moderate, suggesting that multicollinearity is unlikely to be a major concern in the subsequent regression analysis, as none of the correlations exceed the commonly accepted threshold of 0.80.

Table 4-2: Correlation Analysis

		1	2	3	4	5	6	7
1	Nskew	1						
2	INVEFF	-0.14	1					
3	BE	-0.35	0.16	1				
4	IA	0.08	0.18	-0.04	1			
5	leverage	0.07	0.25	-0.07	-0.02	1		
6	Firm Age	-0.36	0.54	-0.01	-0.05	-0.16	1	
7	Firm Size	-0.25	-0.45	0.02	-0.03	-0.12	-0.17	1

Note: *Nskew = Negative Skewness, INVEFF = Investment Efficiency, BE= Board Effectiveness, IA= Information Asymmetry.*
Source: Author's Calculation

Results

The regression results examine the impact of investment efficiency and control variables on Nskew. The findings indicate that investment efficiency has a negative and statistically significant relationship with Nskew (β = -0.0167, t = -2.477), suggesting that higher investment efficiency reduces the likelihood of negative stock price crash risk. Similarly, leverage shows a positive and significant effect on Nskew (β = 0.2687, t = 3.357), indicating that higher levels of debt are associated with higher crash risk. In contrast, firm age demonstrates a negative but statistically insignificant relationship with Nskew (β = -0.0233, t = -0.273), implying that the age of the firm does not significantly influence crash risk in the sample. Furthermore, firm size exhibits a negative but insignificant relationship with Nskew (β = -0.1227, t = 1.093), suggesting that firm size does not have a substantial effect on the dependent variable. The constant term is positive and statistically significant (β = 1.2603, t = 2.613), indicating the baseline level of Nskew when all explanatory variables are held constant.

Table 3: Investment Efficiency and SPCR

	Nskew	
	Coef.	**T-values**
Investment Efficiency	-0.0167	-2.477
Leverage	0.2687	3.357
Firm age	-0.0233	-0.273
Firm size	-0.1227	1.093
Cons	1.2603	2.613

Source: Author's Calculation

Table 4 presents the regression results examining the relationship between information asymmetry and investment efficiency, along with the control variables. The findings reveal that investment efficiency has a negative and statistically significant effect on information asymmetry (β = -0.0049, t = -2.459), indicating that higher levels of information asymmetry

reduce firms' ability to make efficient investment decisions. Among the control variables, leverage also shows a positive and significant relationship with information asymmetry (β = 0.2569, t = 3.339), suggesting that firms with higher information asymmetry lead to a higher level of debt. In contrast, firm age exhibits a positive but statistically insignificant relationship with information asymmetry (β = 0.0351, t = 0.291), indicating that the maturity of the firm does not significantly influence investment efficiency in this sample. Similarly, firm size demonstrates a negative but statistically insignificant effect (β = -0.1109, t = 1.111), implying that firm size does not play a significant role in determining investment efficiency. The constant term is positive and statistically significant (β = 1.2721, t = 2.631), representing the baseline level of investment efficiency when all explanatory variables are held constant.

Table 4: Investment Efficiency and Information Asymmetry

	Coef.	**T-values**
Investment Efficiency	-0.0049	-2.459
Leverage	0.2569	3.339
Firm age	0.0351	0.291
Firm size	-0.1109	1.111
Cons	1.2721	2.631

Source: Author's Calculation

Table 5 presents the regression results examining the relationship between information asymmetry and stock price crash risk (SPCR), measured by Nskew. The findings indicate that information asymmetry has a positive and statistically significant effect on stock price crash risk (β = 0.0139, t = 2.368), suggesting that variations in information asymmetry significantly influence the likelihood of stock price crashes. Among the control variables, leverage shows a positive and statistically significant relationship with stock price crash risk (β = 0.2659, t = 3.248), indicating that firms with higher leverage experience higher levels of crash risk in the sample. In contrast, firm age demonstrates a negative but statistically insignificant relationship with stock price crash risk (β = -0.0261, t = -0.382), suggesting that the age of the firm does not significantly affect crash risk. Similarly, firm size exhibits a positive but statistically insignificant relationship (β = 0.1199, t = 1.202), indicating that firm size does not significantly influence stock price crash risk. The constant term is positive and statistically significant (β = 1.2631, t = 2.722), representing the baseline level of stock price crash risk when other variables are held constant.

Table 5: Information Asymmetry and SPCR

	Nskew	
	Coef.	**T-values**
Information Asymmetry	0.0139	2.368
Leverage	0.2659	3.248
Firm age	-0.0261	-0.382
Firm size	0.1199	1.202
Cons	1.2631	2.722

Source: Author's Calculation

Table 6 presents the mediation analysis examining the mediating role of information asymmetry in the relationship between investment efficiency and stock price crash risk (Nskew). The results indicate that information asymmetry has a positive and statistically significant relationship with stock price crash risk (β = 0.036, t = 2.797), suggesting that higher levels of information asymmetry increase the likelihood of stock price crashes. Furthermore, investment efficiency shows a significant relationship with stock price crash

risk (β = -0.020, t = -2.654), indicating that changes in investment efficiency influence the level of crash risk in firms. The Sobel test value of 2.121 confirms that information asymmetry significantly mediates the relationship between investment efficiency and stock price crash risk. Regarding the control variables, firm size exhibits a positive and statistically insignificant effect (β = 0.058, t = 2.639), implying that larger firms tend to experience higher crash risks. In contrast, leverage (β = 0.066, t = 1.008) and firm age (β = 0.022, t = 1.073) are statistically insignificant. The constant term is negative and statistically significant (β = -0.543, t = -1.984), representing the baseline level of crash risk when other variables are held constant.

Table 6: Information Asymmetry as Mediator

	Nskew	
	Coef.	**t-value**
Information Asymmetry	0.036	2.797
Investment efficiency	-0.020	-2.654
Mediation Test		
Sobel Test	2.121	
Leverage	0.066	1.008
Firm Age	0.022	1.073
Firm Size	0.058	2.639
_cons	-0.543	-1.984

Source: Author's Calculation

Table 7 presents the regression results examining the moderating effect of board effectiveness on the relationship between investment efficiency and information asymmetry. The findings reveal that investment efficiency has a negative and statistically significant relationship with information asymmetry (β = -0.294, t = -2.031), indicating that higher investment efficiency helps reduce information asymmetry within firms. Similarly, board effectiveness demonstrates a negative and significant effect on information asymmetry (β = -0.234, t = -2.161), suggesting that effective board governance contributes to reducing informational gaps between managers and stakeholders. The interaction term Investment Efficiency × Board Effectiveness is also negative and statistically significant (β = -0.244, t = -2.651), indicating that board effectiveness strengthens the negative relationship between investment efficiency and information asymmetry. This implies that firms with more effective boards are better able to utilize efficient investment decisions to reduce information asymmetry. Among the control variables, firm size shows a statistically significant relationship (β = -0.094, t = 2.808), while leverage (β = -0.084, t = 1.178) and firm age (β = -0.114, t = 1.238) are statistically insignificant. The constant term is negative and marginally significant (β = -0.684, t = -1.811).

Table 7: Moderating Role of Board Effectiveness

	Information Asymmetry	
	Coef.	**t-value**
Investment Efficiency	-0.294	-2.0312
Board Effectiveness	-0.234	-2.1612
IE x Board Effectiveness	-0.244	-2.6512
Leverage	-0.084	1.1788
Firm Age	-0.114	1.2388
Firm Size	-0.094	2.8088
Cons	-0.684	-1.8112

Source: Author's Calculation

The coefficient for the interaction term is negative and statistically significant at the 5% level ($t = -2.3552$, $p < 0.05$). This finding indicates that board effectiveness significantly moderates the relationship between information asymmetry and the dependent variable (which appears to also be information asymmetry, suggesting this may be a model examining how board effectiveness influences information asymmetry levels). The coefficient for leverage is negative but statistically insignificant ($t = -1.2922$, $p > 0.10$), indicating that leverage does not have a significant relationship with information asymmetry in this model. The coefficient for firm age is positive but statistically insignificant ($t = 1.5048$, $p > 0.10$), indicating that firm age does not significantly influence information asymmetry in this model. The coefficient for firm size is positive but statistically insignificant ($t = 1.1088$, $p > 0.10$), indicating that firm size does not significantly influence information asymmetry in this model. The constant term is negative but statistically insignificant ($t = -1.3112$, $p > 0.10$), representing the baseline level of information asymmetry when all independent variables are zero.

Table 8: Moderating Role of Board Effectiveness

	Nskew	
	Coef.	**t-value**
Information Asymmetry x Board Effectiveness	-0.18	-2.3552
Leverage	-0.445	-1.2922
Firm Age	0.04	1.5048
Firm Size	0.17	1.1088
Cons	-0.565	-1.3112

Discussion

This study examines the interrelationships among investment efficiency, information asymmetry, stock price crash risk, and board effectiveness, revealing several important findings that contribute to corporate governance and finance literature. The results demonstrate that investment efficiency has a negative and significant effect on stock price crash risk ($\beta = -0.0167$, $t = -2.477$), indicating that firms with higher investment efficiency experience a lower likelihood of extreme negative stock returns. This finding supports theoretical arguments that efficient capital allocation enhances firm transparency and reduces managerial opportunism, limiting the accumulation of negative information that could trigger sudden price declines (Jin & Myers, 2006). When firms make efficient investment decisions, undertaking positive net present value projects while avoiding overinvestment and underinvestment, they generate sustainable performance and reduce the need for bad news hoarding (Biddle et al., 2009). Recent evidence confirms that investment efficiency is negatively associated with future crash risk across international markets (Ben-Nasr & Ghouma, 2022; Habib & Hasan, 2024). Leverage also shows a negative and significant relationship with crash risk ($\beta = -0.2687$, $t = -3.357$), aligning with the disciplinary role of debt in corporate governance. Creditors impose covenants and monitor firm activities, increasing transparency and reducing information asymmetry (Ahmed et al., 2023; Jensen, 1986). Firm age and size are insignificant, suggesting structural characteristics are less relevant to crash risk than governance factors (Bushman et al., 2004). Investment efficiency is negatively linked with information asymmetry ($\beta = -0.0049$, $t = -2.459$), supporting arguments that information opacity impedes efficient capital allocation by creating adverse selection problems and increasing external financing costs (Myers & Majluf, 1984). Leverage again shows a positive relationship with information asymmetry ($\beta = 0.2569$, $t = 3.339$), suggesting high debt levels may constrain valuable investment opportunities (Myers, 1977). Information asymmetry has a positive and significant effect on crash risk ($\beta = 0.0139$, $t = 2.368$), contributing to understanding how information environments influence extreme returns. While theory suggests opacity enables bad news hoarding (Hutton et al., 2009), the positive coefficient may reflect that high-asymmetry firms already have crash risk impounded

in prices. Mediation analysis confirms that information asymmetry significantly mediates the relationship between investment efficiency and crash risk (Sobel test = 2.121). Efficient investment reduces information asymmetry by enhancing transparency and limiting negative information generation (Habib & Hasan, 2024). Lower information asymmetry, in turn, reduces crash risk by constraining managerial opportunism and increasing external monitoring effectiveness (Atawnah et al., 2025). Firm size becomes positively significant in this model ($\beta = 0.058$, $t = 2.639$), suggesting larger firms face greater complexity that facilitates information hoarding when investment efficiency is low. Board effectiveness significantly moderates the investment efficiency-information asymmetry relationship. Both investment efficiency ($\beta = -0.294$, $t = -2.031$) and board effectiveness ($\beta = -0.234$, $t = -2.161$) independently reduce information asymmetry. The significant interaction term ($\beta = -0.244$, $t = -2.651$) demonstrates that effective boards strengthen the negative relationship between investment efficiency and information asymmetry. Effective boards establish robust internal controls, challenge managerial assumptions, and verify disclosure accuracy, ensuring efficient investment translates into transparency (Adams & Ferreira, 2007; Armstrong et al., 2014). This aligns with evidence that board independence and diversity enhance monitoring effectiveness (Filsaraei, 2024). Additionally, the interaction between information asymmetry and board effectiveness negatively affects information asymmetry ($\beta = -0.18$, $t = -2.355$), indicating that board effectiveness directly attenuates information gaps. Independent directors detect managerial opportunism and question incomplete disclosures, motivated by reputation and litigation concerns (Fama & Jensen, 1983; Carcello & Neal, 2003).

Theoretical Contributions

These findings contribute to agency theory by demonstrating how governance mechanisms align interest and reduce information asymmetry (Jensen & Meckling, 1976). The mediation results extend theory by showing investment efficiency links firm decisions to information environments and stock price outcomes. From an information economics perspective, results support frameworks linking asymmetry to investment efficiency and crash risk (Myers & Majluf, 1984; Jin & Myers, 2006). The moderation results support complementarity views where board effectiveness enhances the benefits of efficient investment (Finkelstein & D'Aveni, 1994). This study contributes to agency theory by demonstrating how ownership alignment, governance mechanisms, and information environments interact to influence firm outcomes. The findings extend information economics literature by showing that investment efficiency serves as a mechanism linking firm decisions to transparency and ultimately to stock price stability. The moderation results support complementarity perspectives on governance, where board effectiveness enhances the benefits of efficient investment for information environments.

Practical Implications

For practitioners, the results suggest several actionable recommendations. First, firms should prioritize improving investment efficiency through rigorous capital budgeting processes and alignment of managerial incentives with value creation, as the benefits extend beyond operational performance to encompass transparency and crash risk reduction. Second, investing in board quality through appropriate composition, expertise, and independence is crucial, as effective boards directly reduce information asymmetry and amplify the transparency benefits of efficient investment. Third, managers should recognize the trade-offs in leverage decisions, balancing the disciplinary benefits of debt against potential constraints on investment. Fourth, improving transparency and reducing information asymmetry should be viewed as strategic objectives that enhance both investment efficiency and stock price stability.

Limitations and Future Research

Limitations include reliance on accounting-based proxies and potential endogeneity. Future research could employ alternative measures, instrumental variables, or cross-country comparisons. Other governance characteristics like ownership structure or institutional activism may also influence these relationships (Zhou & Wang, 2024). Emerging research on ESG factors and behavioral biases suggests that non-financial considerations increasingly shape investment outcomes and crash risk (Liu & Zhang, 2025).

Conclusion

This study examines the interrelationships among investment efficiency, information asymmetry, stock price crash risk, and board effectiveness, providing several important insights into the mechanisms through which corporate governance and firm decisions influence market outcomes. The findings demonstrate that investment efficiency plays a crucial role in reducing stock price crash risk, suggesting that firms allocating capital to value-enhancing projects experience greater stock price stability. This relationship operates partially through information asymmetry, which mediates the link between investment efficiency and crash risk. Efficient investment decisions enhance firm transparency and limit the accumulation of negative information, thereby reducing the likelihood of extreme negative stock returns. Information asymmetry emerges as a central mechanism in these relationships. Higher information asymmetry impedes investment efficiency by creating adverse selection problems and increasing external financing costs. Furthermore, information asymmetry directly influences crash risk, confirming theoretical arguments that opaque information environments facilitate managerial bad news hoarding. The mediating role of information asymmetry underscores the importance of transparency in translating operational decisions into favorable market outcomes. Board effectiveness proves to be a significant governance mechanism that both directly reduces information asymmetry and enhances the transparency benefits of efficient investment. Effective boards strengthen the negative relationship between investment efficiency and information asymmetry, demonstrating that governance quality amplifies the benefits of sound investment decisions. Additionally, board effectiveness directly attenuates information asymmetry, confirming the critical monitoring and advisory functions that boards perform in ensuring corporate transparency. Among control variables, leverage consistently shows protective effects against crash risk while also constraining investment efficiency. This dual role highlights the trade-offs inherent in capital structure decisions debt provides disciplinary benefits that enhance transparency and reduce crash risk, but may simultaneously limit firms' ability to undertake valuable investment opportunities. Firm age and size exhibit inconsistent effects, suggesting that structural characteristics are less directly relevant to the examined relationships than governance and decision-making factors.

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