



### Determinants of Stock Price Crash Probability: Evidence from Size Sorted Deciles

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**Abstract:** Concept of stock price crash probability is gaining interest in recent years. Less work is done in developing economies on the areas of political and economic instability, volatile conditions and uncertainty in financial markets. Pakistan, being the emerging country, still needs to focus this topic in order to mitigate chances of severe crashes. Firms can achieve sustainability by strengthening the corporate governance mechanism. So, this study aims at studying the determinants related to internal and external governance mechanism, and their impact on Stock Price crash probability on size sorted deciles. Feasible generalized least square (FGLS) is used to determine their relation by utilizing two proxies of stock price crash probability. With negative coefficient of skewness (NCSKEW), results suggest that board size, foreign investors and green energy transition are significant determinants of stock price crash probability for low deciles. While for top deciles, foreign investors and green energy transition are significantly related. Results deduced from Down to up volatility (DUVOL), another proxy used as a robustness analysis, suggest the same with the exception of one. This study assists investors and regulators to timely predict the chances of a stock price crash and make decisions accordingly. However, this study has certain limitations as some other factors like audit quality, number of female directors, inflation and economic policy uncertainty etc. can also be included to affect the stock performance. Some of these factors may be included in future studies for a more comprehensive understanding of the stock price crash probability. Furthermore, a comparative analysis may be carry out between the developed and developing economies to study the pattern of stock price crash probability.

Keywords: Stock Price Crash Probability, Pakistan, Board Size, Foreign Investors, Green Energy Transition, Size Sorted Deciles.

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### 1. Introduction

Probability of stock price crash is an unfavorable event in any business causing the market participants to face adverse reactions. Single stock or whole market both can undergo negative movements. These unfavorable fluctuations cause asymmetrical distribution in stock returns. The variation in security returns, i.e. considerable change in prices, result in crashes (Murata & Hamori, 2021). Moreover, it reduces the wealth of investors and

affect the stability and development of the capital market (Yin & Tian, 2017). Reputational capital is also at stake when an investor owning these stocks faces notable crash. Also, wealth of huge number of investors is swept away because of sudden decline in stock prices. Furthermore, it is a source of discouragement for the shareholders (Murata & Hamori, 2021).

### **1.1 Problem Statement**

This study attempts to extend the research conducted by Dang & Nguyen (2021). The authors conduct a study on impact of internal corporate governance on future crash risk in context of Vietnam non-financial listed firms. Following the past literature on stock price crash risk and research of Dang & Nguyen (2021), this research explains the determinants effecting probability of stock price crash for the emerging economy of Pakistan. Very less work is done in developing economies related to factors of corporate governance. Murata & Hamori (2021) propose that firms' ethical behavior is represented in the form of ESG score in three regions of Japan, Europe and United States. Hunjra et al. (2020) explain impact of corporate social responsibility on stock price crash risk in Pakistan and India. Other researches include factors like corporate governance (Andreou et al., 2016; Zaman et al., 2021), financial reporting transparency (Francis et al., 2016; Kim & Zhang, 2016), corporate tax avoidance (Garg et al., 2022), ways of management and compensation (Kim et al., 2016), religion (Callen & Fang, 2015). This study, however, combines factors of internal and external governance as means of internal and external monitoring mechanism. Pakistan, as market of study, is selected because economy of Pakistan is fragile, volatile and uncertain. Proper management, institutional quality, resources and ethical standards are not up to date. As a result, managers adopt opportunistic behavior in order to benefit themselves. This ultimately enhances probability of stock crashes which are more prominent in a developing country in contrast to developed ones. Together with this, it is not possible to completely eradicate possibility of stock crash. However, it can only be minimized through proper screening of the predictors causing it.

### **1.2 Objective of the Study**

To examine whether several determinants are significantly related to stock price crash probability or not. These factors act as institution's concern towards fulfilling the Sustainable Development Goals (SDGs) with reference to corporate governance mechanism (Buniamin et al., 2022).

### **1.3 Significance of the Study**

Extreme decline in stock prices make investors vulnerable to severe crashes. They are unable to foresee future stock crashes. Investigating stock price crash probabilities assist investors to make better decisions and accommodate future risk accordingly. Investors tend not to invest in the firms with the history of declining prices. Investor's wealth protection is the ultimate priority. Therefore, determining the factors causing stock crash is significant. Regulators can also enhance market stability by in depth analysis of stock price crash probability. Crash risk constitutes asymmetry risk that holds significance for investment decisions and risk management. This study is also helpful for policymakers who are eager to design new methods in an attempt to reduce the conflicts of the information asymmetry (Murata & Hamori, 2021).

In this perspective, the study contributes the literature in many ways. First, it involves determinants related to internal governance mechanism. In past studies, variables like corporate tax avoidance (Garg et al., 2022; Kim et al., 2011), foreign investors (Vo et al., 2020; Kim et al., 2020, Huang et al., 2020), corporate social responsibility (Kim et al., 2014; Feng et al., 2022) were studied separately in a concerned region. But here, together with board size and independent number of directors, corporate tax avoidance acts as an internal

monitoring determinant. Second, foreign investors and green energy transition as external governance determinants are also incorporated in the model. Third, renewable energy consumption as a proxy of green energy transition is utilized to study the impact of external monitoring. Very few literature focuses on impact of green commitment towards stock crash in a developing economy. Past literature focuses on the efficiency of green bonds (Bagnoli & Watts, 2020), green investments (D'Orazio & Popoyan, 2019) and government green funds (Carfora & Scandurra, 2019). When seen in a global perspective, renewable energy sources limit emission of carbon dioxide in the environment thereby making it more clean and green. The Sustainable Development Goals (SDGs) of the United Nations whose ultimate purpose is to accelerate global prosperity while protecting the environment. This perspective encapsulates SDG 7 that ensures access to affordable, reliable, sustainable and modern energy for all by 2030 (Siciliano, 2021). Therefore, it is need of the hour to study this factor in the market of Pakistan. Fourth, most researches are conducted in developed economies where high ethical standards, good corporate management, transparent financial reporting, strong internal and external monitoring systems are capable of reducing probability of stock crashes. On the other hand, Pakistan is still on the verge of strengthening these areas. Fifth, decile portfolios sorted on size are constructed in order to analyze the impact of small (low 50%) and big stocks (top 50%) against stock price crash probability.

Therefore, this study examines the determinants affecting stock price crash probability of 100 non-financial listed Pakistani firms during the period of 2006 to 2021. The remaining paper follows the following sequence. Section 2 outlines a theoretical and empirical overview of determinants of stock price crash probability. Section 3 refers to the methodology and data. Section 4 explains the empirical findings and discussion. Section 5 concludes and presents future directions.

## **2. Literature Review**

### **2.1 Theoretical Review**

Stock price crash risk is related to negative skewness for the distribution of returns of individual stocks (Callen & Fang, 2015; Kim et al., 2014). It represents the negative movements of the stocks i.e., on the higher side and investors hope to earn maximized profits (Conrad et al., 2013; Harvey & Siddique, 2000). Jin & Myers (2006) explain this phenomenon with the help of bad news hoarding theory, information asymmetry theory and agency theory. Managers possessing more information deliberately hide news from outside investors. At a certain point, managers send this accumulated information in the market causing severe decline in stock prices. This whole scenario thereby suggests that managers do not work according to the shareholders' interests. Their personal motives and goals are main focus.

### **2.2 Empirical Review**

#### **2.2.1 Internal Governance Determinants and Stock Price Crash Probability**

It is quite interesting to determine that companies with suitable corporate governance strategies are more or less likely to undergo price crashes. Firms incorporating an effective corporate governance mechanism exhibit better financial outcome and a desirable handling of stakeholders (Claessens & Yurtoglu, 2013). Investors are encouraged to invest in firms with effective corporate ethical strategies because it will assist in covering the loss incurred due to stock price crashes (Hunjra et al., 2020). Internal corporate governance comprises board that has a significant role in the management (Pathan, 2009). According to SECP, the board is responsible for speculation of risk and maintaining an effective control over the firm. The sole purpose of this obligation is to protect the wealth invested by the shareholders and assets of the company.

Andreou et al. (2016) propose board size as important while making important decisions regarding firm and infusing the board with fresh perspective. Ultimately, systematic board performance significantly lowers the probability of stock price crash (Jensen & Meckling, 1979). Moreover, efficiency of board is dependent on board size and plays an important part in enhancing harmony, unity and coordination (Yeung & Lento, 2018).

In context of internal governance, past studies exhibit that structure of ownership like state ownership (Xu et al., 2014), foreign ownership (Vo, 2020) and ownership concentration (Gao et al., 2017) result in rise in risk of stock crash. This is due to the fact that shareholders are capable of hiding bad news which ultimately enhances the probability of stock price crashes. Moreover, within a typical agency theory framework, managers work for their own interests. Therefore, large literature is of the view that board is the key to internal corporate governance in order to minimize agency issues (Pathan, 2009). Battaglia et al. (2014) suggests that small board size resolves the agency issue making managers more efficient towards their duty. Ayadi & Boujelbene (2015) explain that with small board size communication and coordination arises. Together with this, internal control enhances thereby minimizing the agency conflicts. Chang et al. (2017) proposes that an effective internal control mechanism decreases the chances of stock price crash. Also, shareholders require the board to monitor operations of a firm in order to reduce the agency issues (Jensen, 1976). In case of emerging economies, Hunjra et al. (2020) justifies that board size negatively impacts stock price crash risk. This suggests that implementing CSR and corporate governance attributes assist in reducing probability of stock crashes.

Dang & Nguyen (2021) explains that a strong board is capable of protecting shareholder's interests. It has the ability to make managers work according to shareholder's requirements. Furthermore, it allows them to conceal any bad news according to shareholder's motive. It ultimately increases the chance of stock crash. Also, small board and large independent directors reflect shareholder's interests thereby enhancing probability of stock crash. So, the hypothesis suggests:

H<sub>1</sub>: Small boards lead to a greater probability of stock price crash.

Past studies emphasize that board independence is a significant factor of corporate governance. It helps in increasing the board oversight and reducing the agency issues (Denis & McConnell, 2003). Andreou et al. (2016) propose that a large or an equal number of independent and non-executive directors ultimately reduces the chances of stock crashes. As, these directors possess a good and sound technical knowledge, well-described governance policy related information. Likewise, Fama & Jensen (1983) suggest that more number of independent directors aim at maintaining image in the market. For that purpose, independent directors control managers well thereby improving governance practices. Furthermore, chances of stock price to crash become minimum with adoption of such practices. So, the hypothesis suggests:

H<sub>2</sub>: Board independence leads to a lower probability of stock price crash.

With good corporate governance, the opportunistic behavior of management is also reduced. Managers avoid practices of earning management and accumulation of bad news (Kim et al., 2012). This decreases the probability of stock price crash.

Following Garg et al. (2022), literature exhibits two aspects in regard of tax avoidance. First suggests tax avoidance process as a key factor of enhancing cash flow for the shareholders. As, it reduces the tax liability of the firm thereby maximizing money of the shareholders. Several studies investigate tax avoidance as an extension of shareholders' preferred tax-favored activities like usage of debt. Graham & Tucker (2006) study a direct relation between firm's profitability and tax avoidance activities.

Other aspect suggests that agency conflict arises when managers and shareholders intend to work in their own best interests (Hanlon & Heitzman, 2010; Desai & Dharmapala, 2006; Slemrod, 2005; Chen & Chu, 2005). In agency theory, there lies disagreement in regard of interests between the agent and principal. Because of which, agents usually adopt opportunistic behavior like tax avoidance to maximize their own wealth. The wealth of shareholder ultimately declines affecting the information quality that enhances the probability of stock price crash (Desai & Dharmapala, 2006). Managers look for the accounting policies that just produce greater benefits for them thereby decreasing tax liabilities (Frank et al., 2009; Wilson, 2009). This produces a chance of agency costs for the firm. Kim et al. (2011b) explain that activities related to corporate tax avoidance result in squeezing corporate payments and accumulation of unfavorable news. Risk of stock price crash enhances consequently.

This study utilizes effective tax rate as proxy of corporate tax avoidance by following Chen et al. (2001). Effective tax rate (ETR) and tax avoidance possess an indirect relation (Garg et al., 2022). When effective tax rate is less, corporate tax avoidance is more, probability of stock price to crash rises. So, the hypothesis suggests:

H<sub>3</sub>: High effective tax rate leads to a lower probability of stock price crash.

### **2.2.2 External Governance Factors and Stock Price Crash Probability**

Past studies exhibit a direct link between foreign ownership and stock price crash risk probability. Information asymmetry and agency issues arise as a result of foreign investment in developing markets. Managers tend to control activities of a firm according to their own benefits. They also attempt to generate gains at the expense of shareholder's wealth (Chen et al., 2017; Jensen & Meckling 1976). Huang et al. (2020) suggest that foreign ownership could lead to a greater stock price crash risk. Reason accompanying is that local investors are aware of the private operations of a firm as compared to foreign investors. As a result, managers tend to hide bad news intentionally in order to protect the image of the firm. Past-accumulated news together with the recent bad news pool in the market causing probability of stock crash to rise.

Some past studies propose another aspect which suggest that existence of foreign shareholders cause the stock price crash risk to decline (Kim et al., 2020; DeFond et al., 2014). Foreign owners enhance external monitoring of firms by improving governance mechanism. Standard of financials and annual reporting are also improved. Due to strong governance mechanism, managers are unable to hide unfavorable news thereby decreasing probability of stock prices to crash. Kim et al. (2011a, 2011b, 2014); Kim & Zhang (2014); Callen & Fang (2015) also support this evidence that a good corporate governance ultimately reduces the probability of stock price crash. Al Amosh & Mansor (2020), on the other hand, justifies this aspect by suggesting that foreign ownership assists in attaining trust and transparency between firms and shareholders. Skills and expertise of foreign shareholders can be utilized in achieving targeted goals of a firm e.g., sustainability. Presence of foreign shareholders in a firm pressurize it not to conceal any information and make the environment favorable for investment.

In developing economies, foreign shareholders are institutional investors who occupy a major portion of assets (Ozel et al., 2021). They have expertise in processing the information of a firm thereby improving the corporate governance mechanism (Kim & Yi, 2015). Hence, it is said that foreign shareholders play a significant part in reducing the risk of stock price probability, because of enhanced strategies, more compatible skills and expertise. So, the hypothesis suggests:



H<sub>4</sub>: Presence of Foreign Investors lead to a lower probability of stock price crash.

To make environment favorable for the firms to operate, governments generally initiate environmental policies as a step towards green environment (Zhu et al., 2019; Singhania & Saini, 2021). This assists the organizations to expand and establish resilient business operations. In the absence of such government's green concerns, industries will work in their own interest to maximize their profits (Stavropoulos et al., 2019).

Several past studies discuss how environmental regulations effect the performance of energy firms in developed regions (Ramiah et al., 2013; Kong et al., 2014; Quan et al., 2018). Results point out that following government's environmental strategies improve financial performance of corporations. On the other hand, any violation to the government's green regulations causes serious damages to a firm. Zhang et al. (2021) study link between government's commitment towards environment and stock price crash risk. When companies follow government's initiatives towards friendly environment than prices of stock stabilize. Resultantly, probability of stock price to crash also decline.

Environmental regulations act as monitoring system on the governance mechanism of a firm. Any deviation with these regulations poorly effect the reputation of the firms. Managers respond to these green strategies in two ways. First managers tend to remain honest and disclose bad news remaining committed to green practices. This results in decrease in stock price crashes (Deterrent hypothesis). Second, executives voluntarily pile up bad news and conceal it for personal interests (Coverup hypothesis). This is in accordance of bad news hoarding theory. As a conclusion, probability of stock price crash rises (Zhang et al., 2021). Anwar et al. (2021) study impact of renewable energy consumption and non-renewable energy consumption on CO<sub>2</sub> emission. Renewable energy consumption refers to the energy generated from natural sources i.e., hydro, geothermal, wind, solar, tide/wave, biofuels and renewable waste sources (Khan et al., 2021). Such source of energy depicts efforts exerted by the government towards cleaner environment as they utilize natural resources. Together with this benefit, less cost is required in such green transitions. The more dependency on renewable energy sources comprehend the effective government efforts to sustain the environment because it does not involve such elements that pollute the environment (Farooq et al., 2021). So, the hypothesis suggests:

H<sub>5</sub>: Renewable energy consumption leads to lower probability of stock price crash.

### **2.2.3 Control variables**

The study utilizes two control variables i.e. leverage (Kim et al., 2011a, b; Chen et al., 2001; Hutton et al., 2009; Callen & Fang, 2013) and GDP (Moradi et al., 2021, Zaman et al., 2020, Hu et al., 2020) in this study. In significant terms, firms having greater debt to asset ratio is expected to experience greater crashes (Murata & Hamori, 2021). Real GDP exhibits value of goods and services for a concerned period adjusted for inflation. GDP represents economic condition of a country. In order to maintain financial image, firms usually hide bad news. Due to greater pressure, managers are involved in profit management actions causing the stock prices to crash (Moradi et al., 2021).

## **3. Methodology And Data**

Saleem & Usman (2021) argue that there is a need of studying concept of stock price crash probability in developing economies like Pakistan. The reason behind this is that the capital market environment of Pakistan is unique. Also, there is lack of financial reporting quality, transparency and accuracy. Institutional quality is low and system of implementation of proper governance strategies is weak. These drawbacks allow managers to

withhold bad news without limitations producing severe crash issues. Hence, in this study, economy of Pakistan, as market of interest has been selected.

### 3.1 Selection Criteria

There are total 513 companies listed on Pakistan stock exchange out of which 401 are non-financial firms (PSX as on Jan 25, 2023). For analysis, this research uses only non-financial sectors because of different operations, laws and accounting standards than those of financial sectors. The period for study is 2006 to 2021. The reason for selection of this time is to cover Global Financial Crisis period that begun from mid-2007.

Out of these actively trading non-financial companies, weekly closing prices of 100 stocks are selected, based on the following criteria:

- Active trading of the stock
- Representative of the sector
- Existence of the stock for the entire period of analysis.

Closing prices are then adjusted for any capital change. Also, if any firm has trading weeks less than 30 annually, then that firm will be excluded because of less trading activity and in order to capture greater crashes (Dang & Nguyen, 2021, Xu et al., 2013). The weekly returns from closing prices are calculated by taking the log of closing stock prices (Fama, 1965; Fortune, 1991).

This study uses positive ETRs' values, in order to analyze corporate tax avoidance, as negative ones are difficult to interpret. Either the numerator is negative or denominator's value is zero or less than zero, in both cases values are not included. Moreover, if ETR is greater than 1 or below zero, again values are not included in analysis (Garg et al., 2022). On the other hand, data for renewable energy consumption for Pakistan is available from 2006 to 2019 on world development indicator so this study analyzes unbalanced data.

### 3.2 Formation of Size Sorted Deciles

Next, on basis of market capitalization, 10 decile portfolios are formed (Aharon, 2021). These decile portfolios sorted on size are then categorized as small and big stocks. First five decile ranks correspond to 50% small stocks and last five deciles corresponds to 50% big stocks as data is arranged in ascending order.

### 3.3 Measurement of variables

#### 3.3.1 Stock Price Crash Probability

Three proxies are used in past studies (Chen et al., 2001; Jin & Myers, 2006) for measuring probability of stock price crash. This research utilizes two proxies of stock price crash probability deduced from the below mentioned expanded market model (Chen et al., 2001).

$$r_{k,t} = \alpha_k + \gamma_{1,k} r_{m,t-2} + \gamma_{2,k} r_{m,t-1} + \gamma_{3,k} r_{m,t} + \gamma_{4,k} r_{m,t+1} + \gamma_{5,k} r_{m,t+2} + \epsilon_{k,t} \dots \dots \dots Eq. (1)$$

Where,  $r_{k,t}$  is the return of a firm "k" for the concerned week "t".  $r_{m,t}$  is the return of KSE-100 index for the week "t". The above equation contains lead and lag terms for solving the issue of non-synchronous trading. As, different stocks have different trading intensities, and even this intensity is different from hour to hour.  $\epsilon_{k,t}$  represents residual that exhibit portion of a firm's stock return that is unexplained by the market factor. Negative coefficient of skewness (NCSKEW) estimates probability of stock price crash. It refers to the negative coefficient of firm-specific weekly returns over the year. This proxy on skewness captures the asymmetry of return distribution (Zaman et al., 2020). Formula for NCSKEW (Chen et al., 2001) is:

$$NCSKEW_{k,t} = -[n(n-1)^{3/2} \sum W_{k,t}^3] / [(n-1)(n-2)(\sum W_{k,t}^2)^{3/2}] \dots \dots \dots Eq. (2)$$

Where  $n$  = total observations for year 't' of a firm 'k'. Firstly, the negative of the third moment of firm-specific weekly returns for each year is calculated. After that, it is normalized by the standard deviation of firm-specific weekly returns raised to the third power. Negative sign in eq.2 exhibits that concerned variable rises as return distribution moves towards negative skewness. In other words, higher value of NCSKEW indicates more negative skewness (left side distribution) hence significant probability of stock price crash.

### 3.3.2 Robustness Analysis

Another proxy is used for estimating stock price crash probability as a robustness analysis. It is DUVOL referred as down to up volatility. This proxy is useful because the absence of third moment avoids the over-influence of extreme week return (Habib & Hasan, 2017). Its formula (Chen et al., 2001) is:

$$DUVOL_{k,t} = \log\left\{\frac{(n_u-1)\sum_{down} W_{k,t}^2}{(n_d-1)\sum_{up} W_{k,t}^2}\right\} \dots \dots \dots Eq. (3)$$

Where  $n_u$  = firm's 'k' weekly returns > firm's average weekly return for the year 't'.

$n_d$  = firm's 'k' weekly returns < mean weekly returns of the firm 'k' for the year 't'.

Firm specific weekly returns for firm are obtained for a year and then divided into two parts: up weeks and down weeks. When the week's returns are less than average yearly means it is referred as down weeks. However, when week returns are more than average yearly means it is referred as up weeks. The standard deviation for both groups is calculated separately. After that DUVOL is calculated as the log of the ratio of standard deviation of down weeks to up weeks. Higher the value of DUVOL, higher is the probability of stock price to crash. Above equation 2 and 3 is annualized following Chen et al. (2001).

### 3.3.3 Stock Price Crash Probability and its Determinants

Variable Name	Role	Definitions and Measurement	Data Source	Reference detail
Stock Price crash probability	DV	1) NCSKEW= it is a proxy of stock crash measuring asymmetry for the distribution of return calculated by Eq. 2.	Weekly prices from business recorder	Dang & Nguyen (2021)
		2) DUVOL= it is a second proxy of stock crash measuring log of the ratio of standard deviation of down to up weeks, calculated by Eq. 3.		
Internal Governance	IV	3) Board Size is defined as total number of directors on board.	Annual reports	Dang & Nguyen (2021)
		4) Independent directors is defined as proportion of total independent directors.		
		5) Corporate tax avoidance is defined as reduction of explicit taxes. It is proxied by Effective tax rate (ETR) that is measured as total current income tax expense <sub>t</sub> divided by Pretax book	Annual reports	Chen et al. (2010), Lennox et al. (2013)



income <sub>t</sub> . Greater ETR means less CTA.				
External Governance	IV	6)	Foreign Investors is explained as presence of foreign investors and is treated as an indicator variable. Value of 1 is given for firms having foreign investors and 0 otherwise.	Annual reports Kim et al. (2020)
		7)	Green energy transition is defined as conversion towards environmental friendly resources. Here, it is proxied by Renewable energy consumption which refers to the energy generated from natural sources i.e., hydro, geothermal, wind, solar, tide/wave, biofuels and renewable waste source.	World Development indicator Farooq et al. (2021), Khan et al. (2021)
Controls	Control variables	8)	Leverage is defined as total long-term debt divided by total assets.	Annual reports Chen et al. (2001)
		9)	GDP is defined as GDP growth in percentage adjusted for inflation.	WDI Hu et al. (2020)

### 3.4 Econometric Framework

This study employs Feasible Generalized Least square regression (FGLS) (Haiyue et al., 2021; Jory et al., 2020) for estimation of data for the period of 2006-2021 in order to control heteroscedasticity. Following is the panel data equation to analyze determinants of stock price crash probability:

$$SPCP_{k,t} = \alpha_0 + \alpha_1 BS_{k,t-1} + \alpha_2 IND_{k,t-1} + \alpha_3 CTA_{k,t-1} + \alpha_4 FI_{k,t-1} + \alpha_5 GET_{j,t-1} + \alpha_6 \sum_{k,j}^2 Controls_{t-1} + \varepsilon_{k,t} \dots \dots \dots Eq. (4)$$

Where SPCP represents stock price crash probability. It is measured by negative coefficient of skewness (NCSKEW) and down to up volatility (DUVOL) in this research. BS indicates board size, IND indicates board independence. CTA exhibits corporate tax avoidance. It is measured by effective tax rate (ETR). FI shows presence of foreign investors. GET represents green energy transitions. It is measured by renewable energy consumption (REC). Notation ‘k’ is used for firm level variables while notation ‘j’ is used for country level variables. Controls is an indicator of two control variables. One is firm level variable “leverage” and other is country level variable “GDP”.  $\varepsilon_{k,t}$  represents error term. One year lag “t-1” of independent variables is utilized to analyze its impact on dependent variable in period “t”.

With the proxies of stock price crash probability and its determinants, the above equation is regressed for decile portfolios sorted on size, dividing the data into two parts as small and big stocks. It is written as:

$$NCSKEW_{k,t} = \alpha_0 + \alpha_1 BS_{k,t-1} + \alpha_2 IND_{k,t-1} + \alpha_3 ETR_{k,t-1} + \alpha_4 FI_{k,t-1} + \alpha_5 REC_{j,t-1} + \alpha_6 \sum_{k,j}^2 Controls_{t-1} + \varepsilon_{k,t} \dots \dots Eq. (5)$$

$$DUVOL_{k,t} = \alpha_0 + \alpha_1 BS_{k,t-1} + \alpha_2 IND_{k,t-1} + \alpha_3 ETR_{k,t-1} + \alpha_4 FI_{k,t-1} + \alpha_5 REC_{j,t-1} + \alpha_6 \sum_{kj}^2 Controls_{t-1} + \varepsilon_{k,t} \dots \dots \dots Eq. (6)$$

#### 4. Empirical Findings and Results

Table 1 reports the descriptive statistics of dependent and independent variable. The mean value of NCSKEW for small stocks is 0.12 while for big stocks is 0.26 which suggests that big firms are more prone to crashes (Chen et al., 2001; Hutton et al., 2009; Kim et al., 2011a, b; Kim & Zhang, 2016). They have a greater probability to undergo stock crashes. Likewise, for DUVOL mean value for small stocks is 0.03 and for big stocks value is 0.16. Looking mean values for internal and external governance determinants, it is observed that big firms adopt better corporate governance strategies as compared to small firms.

Panel ADF test suggests that all variables are stationary at level and have no unit root. Table 2 and 3 exhibit Pearson's correlation matrix among variables and all independent variables of small and big stocks have value less than 0.5, which means there is no multi-collinearity in the data (Al-Shaer & Zaman, 2016). In addition, the variance inflation factor of 1.05 and 1.06 as suggested in Table 4 confirms that correlation among the regressors will not affect the coefficient estimates of a regression analysis.

**Table 1: Descriptive Statistics of All variables**

Variables	Small Stocks		Big Stocks	
	Mean	Standard deviation	Mean	Standard deviation
NCSKEW <sub>t</sub>	0.12	1.19	0.26	1.09
DUVOL <sub>t</sub>	0.03	1.11	0.16	0.97
BS <sub>t-1</sub>	2.06	0.16	2.17	0.23
IND <sub>t-1</sub>	0.22	0.25	0.22	0.20
ETR <sub>t-1</sub>	0.22	0.20	0.25	0.14
FI <sub>t-1</sub>	0.36	0.48	0.64	0.48
REC <sub>t-1</sub>	0.46	0.01	0.45	0.03
LEV <sub>t-1</sub>	0.16	0.17	0.14	0.14
GDP <sub>t-1</sub>	0.03	0.02	0.03	0.03

Note: NCSKEW<sub>t</sub>=negative coefficient of skewness, DUVOL<sub>t</sub>=down to up volatility, BS<sub>t-1</sub>=board size, IND<sub>t-1</sub>=board independence, ETR<sub>t-1</sub>=effective tax rate, FI<sub>t-1</sub>= presence of foreign investors, REC<sub>t-1</sub>= renewable energy consumption, LEV<sub>t-1</sub>= leverage, GDP<sub>t-1</sub>= gross domestic product

**Table 2: Correlation Analysis (Small Stocks) of All variables**

	1	2	3	4	5	6	7	8	9
<b>NCSKEW<sub>t</sub></b>	1								
<b>DUVOL<sub>t</sub></b>	0.93	1							
<b>BS<sub>t-1</sub></b>	-0.03	-0.03	1						
<b>IND<sub>t-1</sub></b>	-0.08	-0.06	0.06	1					
<b>ETR<sub>t-1</sub></b>	0.02	0.01	0.08	-0.00	1				
<b>FI<sub>t-1</sub></b>	-0.11	-0.12	-0.15	0.19	-0.02	1			
<b>REC<sub>t-1</sub></b>	-0.15	-0.18	0.02	0.03	0.04	-0.12	1		
<b>LEV<sub>t-1</sub></b>	0.02	0.04	-0.14	0.02	-0.03	0.09	0.08	1	
<b>GDP<sub>t-1</sub></b>	-0.05	-0.05	-0.02	-0.11	0.01	0.00	-	0.03	1
							0.29		

Note: NCSKEW<sub>t</sub>=negative coefficient of skewness, DUVOL<sub>t</sub>=down to up volatility, BS<sub>t-1</sub>=board size, IND<sub>t-1</sub>=board independence, ETR<sub>t-1</sub>=effective tax rate, FI<sub>t-1</sub> = presence of foreign investors, REC<sub>t-1</sub>= renewable energy consumption, LEV<sub>t-1</sub>= leverage, GDP<sub>t-1</sub> = gross domestic product for small stocks (low 5 deciles on basis of market capitalization).

**Table 3: Correlation Analysis (Big Stocks) of All variables**

	1	2	3	4	5	6	7	8	9
<b>NCSKEW<sub>t</sub></b>	1								
<b>DUVOL<sub>t</sub></b>	0.92	1							
<b>BS<sub>t-1</sub></b>	-0.01	-0.00	1						
<b>IND<sub>t-1</sub></b>	0.04	0.04	0.25	1					
<b>ETR<sub>t-1</sub></b>	-0.05	-0.05	0.01	-0.01	1				
<b>FI<sub>t-1</sub></b>	-0.07	-0.08	0.10	0.14	-0.04	1			
<b>REC<sub>t-1</sub></b>	-0.16	-0.21	0.04	-0.03	0.02	-0.16	1		
<b>LEV<sub>t-1</sub></b>	-0.01	0.03	0.20	0.04	-0.07	0.00	0.08	1	
<b>GDP<sub>t-1</sub></b>	-0.04	0.03	-0.06	-0.09	-0.12	0.09	-0.10	-0.01	1

Note: NCSKEW<sub>t</sub>=negative coefficient of skewness, DUVOL<sub>t</sub>=down to up volatility, BS<sub>t-1</sub>=board size, IND<sub>t-1</sub>=board independence, ETR<sub>t-1</sub>=effective tax rate, FI<sub>t-1</sub> = presence of foreign investors, REC<sub>t-1</sub>= renewable energy consumption, LEV<sub>t-1</sub>= leverage, GDP<sub>t-1</sub> = gross domestic product for big stocks (top 5 deciles on basis of market capitalization).

Diagnostic tests are shown in Table 4. According to it, p-value for Breusch-Pagan test is 0.00 which is less than 0.05. This result rejects null hypothesis  $H_0$ =constant variance and suggests there is issue of heteroscedasticity in the data. However, serial autocorrelation was not observed in panel data. P-value for Wooldridge test is 0.16 that is more than 0.05. Results suggest that there is no existence of autocorrelation in the data that accepts null hypothesis  $H_0$ =no first order autocorrelation. Therefore, to overcome the issue of heteroscedasticity the technique of FGLS is used.

**Table 4: Diagnostic Tests**

	$Ncskew_t$	$DuVol_t$
Heteroskedasticity test (Breusch-Pagan)	Prob>chi2=0.00	Prob>chi2=0.00
Serial Correlation test	F-statistics=1.94 Prob>F=0.16	F-statistics=1.96 Prob>F=0.16
Multi-collinearity (VIF)	1.05	1.06

Note: Diagnostic tests for heteroscedasticity, autocorrelation and multi collinearity for regressions of both dependent variables of Stock price crash probability. All deciles are included these tests.  $NCSKEW_t$ =negative coefficient of skewness,  $DUVOL_t$ =down to up volatility.

**Table 5: Regression Results for dependent variable NCSKEW**

	NCSKEW	
	<i>Small Stocks</i>	<i>Big Stocks</i>
<b>BS<sub>t-1</sub></b>	-0.47(-2.25) **	-0.02(-0.16)
<b>IND<sub>t-1</sub></b>	-0.13(-1.06)	0.13(0.71)
<b>ETR<sub>t-1</sub></b>	0.16(0.97)	-0.10(-0.44)
<b>FI<sub>t-1</sub></b>	-0.35(-5.21) ***	-0.20(-3.10) ***
<b>REC<sub>t-1</sub></b>	-15.49(-6.67) ***	-9.41(-6.63) ***
<b>LEV<sub>t-1</sub></b>	0.55(3.16) ***	-0.02(-0.11)
<b>GDP<sub>T-1</sub></b>	-8.89(4.09) ***	-5.34(-2.17) **
<b>Constant</b>	8.05(3.85) ***	4.86(6.73) ***
<b>No. of observations</b>	709	692

<b>Prob &gt;chi2</b>	0.00	0.00
<b>Wald chi2</b>	76.80	60.39

Note: Estimation results of predictors of Stock Price crash probability with NCSKEW as a dependent variable using FGLS technique. Robust standard errors are in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$  indicate statistical significance at 1, 5 and 10% level respectively. Small stocks represent low 5 deciles while big stocks represents top 5 deciles.

Table 5 represents the results of equation 5 by using NCSKEW as dependent variable. The estimates are for size ranked portfolios sorted as big and small stocks. The findings of FGLS method propose that for small stocks board size (BS) is negative and significant that suggests top executives possess more bad information and have the ability to influence chances of stock crash (Andreou et al., 2016). This result is also consistent with argument of Dang & Nguyen (2021) who propose that small boards work for shareholder's interests. They acquire the capability of withholding bad news as long as they want. This assists in enhancing the probability of stock price crash. While for big stocks, results remain insignificant so hypothesis  $H_1$  is accepted only for small stocks.

Results for board independence (IND), effective tax rate (ETR) remains insignificant for both small and big deciles. Therefore, it can be said that these two factors have no effect on stock price crash probability in setting of Pakistani market. So, hypothesis  $H_2$  and  $H_3$  remains unaccepted. Insignificant board independence result is consistent with work of Andreou et al. (2016). While result of insignificant effective tax rate (ETR) is consistent with study of Neifer & Utz (2019). It suggests that tax avoidance has no relation with shareholder's wealth. Managers are not interested in gaining personal benefits by reducing taxable income. Moreover, tax avoidance enhances stock crashes only if it is involved in managerial rent extraction and bad news hoarding activities (Kim et al., 2011b).

Findings of foreign investor (FI) reveal that foreign investors have a negative significant relation with probability of stock price crash. Our hypothesis  $H_4$  is accepted for both small and big stocks. However, this finding is consistent with the findings of Kim et al. (2019) that suggests that FI acts as an external monitoring system for the firms to duly regulate and monitor the news. It helps in reducing the probability of stock price crash.

Results of renewable energy transition (REC) is negative and significantly associated with probability of stock price crash in both stocks. These results are in accordance with the findings of Zhang et al. (2021) who propose that environmental regulations act as an external monitoring mechanism for the firms. Therefore, negative news is disclosed reducing the probability of stock price to crash. Hence, hypothesis  $H_5$  is accepted.

Leverage and GDP are used as controls in this study. Findings of leverage depict a positive significant relation for small stocks. This result is in consistent with Murata & Hamori (2021) finding who propose that glamorous stocks have a greater probability of stock crash. Leverage, on the other hand, has an insignificant relation in case of big stocks (Liu, 2018). GDP exhibits a negative and significant relation with stock price crash probability for both stocks. Findings suggest that due to uncertain economic conditions, managers tend to hide bad news in order to save the image of the firms. When this information is spread among the market, probability of stock price to crash increases (Luo & Zhang, 2020).



#### 4.1 Robust analysis Using Alternate Measure of Stock Price Crash Probability

Table 6 depicts the analysis of determinants of stock price crash probability by using another proxy. This study utilizes DUVOL (alternate proxy) as a robustness test. The results show that the coefficients of board size (BS) are insignificant for both small and big deciles. So, hypothesis  $H_1$  is not accepted in this case. This result is different from previous estimation where small stocks exhibit a significant relation. While for determinants of board independence (IND) and effective tax rate (ETR) results remain unchanged and are similar to our first results. Hypothesis  $H_2$  and  $H_3$  remains unaccepted.

For foreign investors (FI) and renewable energy consumption (REC), hypothesis  $H_4$  and  $H_5$  remain accepted for both stocks as in previous results. In context of control variables, results of Leverage remains same while for GDP results become insignificant in case of big stocks.

Overall, after using NCSKEW as measure of stock price crash probability, the study finds out that three out of five hypothesis gets accepted for small stocks. While for big stocks, two out of five hypothesis gets accepted. On the hand, by using alternate proxy i.e. DUVOL, two out of five hypothesis gets accepted for small stocks. And for big stocks, results remain unchanged. Robustness analysis is done to add more confidence to our results.

**Table 6: Regression Results for dependent variable DUVOL**

	DUVOL	
	<i>Small Stocks</i>	<i>Big Stocks</i>
<b>BS<sub>t-1</sub></b>	-0.29(-1.39)	-0.10(-0.70)
<b>IND<sub>t-1</sub></b>	-0.12(-1.01)	0.25(1.50)
<b>ETR<sub>t-1</sub></b>	0.07(0.45)	-0.16(-0.79)
<b>FI<sub>t-1</sub></b>	-0.32(-4.95) ***	-0.25(-4.49) ***
<b>REC<sub>t-1</sub></b>	-15.88(-6.97) ***	-10.11(-7.72) ***
<b>LEV<sub>t-1</sub></b>	0.40(2.08) **	0.21(0.88)
<b>GDP<sub>T-1</sub></b>	-9.40(-4.32) ***	-0.64(-0.29)
<b>Constant</b>	8.32(7.10) ***	5.04(7.52) ***
<b>No. of observations</b>	709	692
<b>Prob &gt;chi2</b>	0.00	0.00
<b>Wald chi2</b>	76.96	83.81

Note: Estimation results of predictors of Stock Price crash probability with DUVOL as a dependent variable using FGLS technique. Robust standard errors are in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$  indicate statistical significance at 1, 5 and 10% level respectively. Small stocks represent low 5 deciles while big stocks represents top 5 deciles.

## 4.2 Discussion

The results provide an important implication for investment and risk management in case of developing economies. From the findings, it is seen that small stocks exhibit greater probabilities of stock crash despite of earlier descriptive statistics. It is due to the fact that bigger firms invest in corporate governance strategies. They have greater resources to invest in such activities and sustainability practices (Naciti, 2019). Therefore, firms having effective internal control mechanism have the capability to control for probability of stock price crash (Hunjra et al., 2020).

More pronounced results are obtained in small stocks due to ineffective management practices and institutional quality. Nguyen et al. (2015) suggested that big firms are more stable as compared to small firms. In addition, big firms easily adopt flexible cost structure and technology tactics in order to delay the crashes. It further assists in mitigating the possible unfavorable outcomes (Chang et al., 2022). So, this study is helpful for investors to keep an eye on strategies, systems and mechanisms of firms and make investments accordingly. For regulators, it helps in determining the factors that can have effect on stock price crash probability. They can make decisions and look for the ways to reduce the chances of stock crash in an emerging economy.

## 5. Conclusion And Future Direction

This study investigates the impact of several determinants on stock price crash probability. Non-financial stocks listed on Pakistan stock exchange are sorted as big and small stocks. The purpose of this was to get an understanding that how different stocks react to probability of stock crashes. Furthermore, what are certain determinants related to external and internal governance mechanism and to what extent firms adopt them to mitigate chances of stock crash. Two measures of stock crash probability are used to analyze their impact. With Negative coefficient of skewness (NCSKEW) results suggest that board size, presence of foreign investors and commitment towards green transition are significant determinants of stock price crash probability in case of small stocks. While for big stocks, presence of foreign investors and implementation of green energy transitions effect significantly. When estimating with Down to up volatility (DUVOL) as a robustness analysis, for small stocks, predictor of board size became insignificant. While remaining all other results remain unchanged.

These conclusions propose that comparatively big firms have better sustainability practices that cause them less effected by stock price crash probability. Existence or being prone to stock crash does not necessarily mean that a firm will obviously default. In other sense, such firms are involved in sending signals to outside world. They are related to acquire more resources, investments, stability and institutional quality to delay or minimize the stock price crash probability (Huang et al., 2020). Small firms, on the other hand, are more reactive to stock price crash probability because they lack proper management policies, strong internal control and implementation of governance strategies.

These findings can have implications for the market participants in developing markets. Investors can make decision while investing in stocks. Policymakers can ponder on devising new policies thereby improving corporate governance practices in order to protect firms from severe real crashes. These corporate governance strategies will create a sustainable environment for the firms to operate encouraging the foreign investment. This study suffers from some limitations that can be addressed by future researchers. Other factors of corporate governance like audit quality; number of women directors on board can be studied. Full portfolio or market

analysis can be done and compared with big and small stocks. Other country level variables, like economic policy uncertainty, inflation etc. can be included in the model. This study analyzes only market of Pakistan; therefore, other emerging countries can be analyzed to study a trend of stock price crash probability in emerging economies.

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