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ORIGINAL RESEARCH

CEO power and firm risk at the onset of the 2007 financial crisis and the COVID-19 health crisis: international evidence

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Abstract

We investigate the association between CEO power and firm risk at the onset of the global financial crisis in 2007 and the COVID-19 pandemic health crisis in 2020. Examining an international sample of publicly listed firms in the G7 nations between 2006 and 2021, we show that firms led by CEOs with greater power are exposed to higher risk than firms led by CEOs with lesser power. The result is primarily driven by the impact of CEO power on idiosyncratic risk rather than systematic risk. Further, we find that powerful CEOs tend to be more cautious and conservative during crises that they have no reference for or experience of, as in the case of the pandemic, during which the positive power–risk associations are less pronounced. Nevertheless, the power–risk association remains relatively unchanged during the more familiar financial crisis. This study has important implications for firms, investors, regulators, and policymakers.

Keywords CEO power · Risk-taking · Financial crisis · COVID-19 pandemic

JEL Classification G30 · G32 · G02 · J33 · G01 · J16

1 Introduction

Chief executive officers (CEOs), the highest-level decision makers in corporations, are responsible for a range of strategic duties. These include decisions on strategic operations and planning; managing, reviewing, and revising organizational structures; managing

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productivity and profitability; communicating and maintaining stakeholder relationships; and, most importantly, controlling, assessing, and evaluating risk levels. Risk management is a fundamental aspect that directly influences firms' financial performance, survival, and long-term growth. CEOs are the agents that carry full responsibility for this.

Whether and how CEO characteristics impact firm risk-taking and firm risk outcomes have attracted extensive interest from both academic researchers and practitioners over recent decades (e.g., Serfling 2014; Neyland 2020; Brisley et al. 2021; Çolak and Korkeamäki 2021; Fan et al. 2021). Among the many CEO role characteristics, the institutional power that they possess particularly influences a firm's overall operations and strategic decisions (Grinstein and Hribar 2004; Lewellyn and Muller-Kahle 2012; Sheikh 2019), and especially firm risk (Pathan 2009; Lewellyn and Muller-Kahle 2012; Sheikh 2019; Fernandes et al. 2021). Extending the limited and inconclusive literature on the relationship between CEO power and firm risk, this study aims to further investigate this relationship on an international scale and in the face of economic, financial, and health turbulence. This study employs a cross-country panel data sample containing publicly listed non-financial and banking firms in the G7 countries: the United States, the United Kingdom, Germany, France, Italy, Canada, and Japan. The investigation covers a period from 2006 to 2021 with 12,836 firm-year observations. This period saw the global financial crisis of 2007 and the COVID-19 health crisis. This study further extends by investigating the effect of gender diversity on the relationship between CEO power on the firm risk. Studies in literature indicate that women tend to be more risk-averse and conservative compared to their male counterparts (Sila et al. 2016; Zalata et al. 2018).

The G7 members represent more than 60% of the world's net wealth and around 50% of the world's gross domestic product (Climate Transparency 2018). The considerable population sizes and solid economies give advantage to the participating G7 members to be key players in global markets and maintain solid political, environmental, economic, cultural, and diplomatic relations to strengthen their economic situations and support the world's weaker economies, given the availability of the means of production and manpower within their borders.

The relationship between CEO power and firm risk is built on the theory of behavioral agency (Wiseman and Gomez-Mejia 1998) and the approach/inhibition theory of power (Keltner et al. 2003). The former enhances the agency-based model (Wiseman and Gomez-Mejia 1998) by suggesting that executives are not solely risk-averse agents but can also exhibit risk-seeking attitudes and behaviors. Together with this view, the approach/inhibition model conceptualises that executives with power tend to act following their behavioral approach system, triggering them to focus more on positive outcomes, such as winning, achievements, and rewards (Keltner et al. 2003; Magee and Galinsky 2008). Indeed, the social psychology literature strongly supports the idea that CEO power is associated with higher risk-taking decisions as CEOs are more optimistic and exposed to higher judgment error in their risk evaluation (Sah and Stiglitz 1991; Adams et al. 2005; Anderson and Galinsky 2006). Consequently, it is expected that firms led by more powerful CEOs have higher risk levels compared to those led by less powerful CEOs, indicating a positive association.

Empirically, the studies of Lewellyn and Muller-Kahle (2012) and Sheikh (2019) support this view, using non-financial and non-banking samples. Sheikh (2019) scrutinizes the relationship between powerful CEOs and their corporate risk about market competition and corporate governance for non-banking firms. The results suggest that significant market competition and effective corporate governance may increase risk-taking tendencies among CEOs with power. Based on the total and idiosyncratic analysis of risk, their results show that CEOs who had power preferred to take more risks. However, CEOs with more power tended to develop a significant risk-taking disposition mainly when the market competition is high and corporate governance is strong. Lewellyn and Muller-Kahle (2012) also reveal that CEO power of non-banking firms and firm risk showed a significantly positive link in the subprime lending industry. Lewellyn and Muller-Kahle (2012, pp. 291) further explain that powerful CEOs tended to have "failed to consider the well-established view that subprime mortgages [were] likely to end up in default", leading them to commit heavily in such high-risk lending.

Thus, this paper investigates three hypotheses. The first is the potential positive relationship between the CEO power and firm risk. Second, we further investigate the effect of the financial crisis of 2007 and the COVID-19 pandemic effect of 2020 on this potential positive relationship. Third, we examine the effect of gender diversity on this potential positive relationship. A baseline Ordinary Least Square (OLS) with various robustness checks are applied to corroborate the findings obtained from the baseline methods. These include the fixed effect model, the lagged approach, the generalized method of moments (GMM), and 2SLS, to account for endogeneity issues, and models with alternative dependent variables as well as independent variables. Following Anderson and Fraser (2000), we measure firm risk using three proxies: total risk (TR), systematic risk (Risk_Sys), and idiosyncratic risk (Risk_Idio). Total risk is the standard deviation of each firm's daily stock returns annually. Idiosyncratic risk is the standard deviation of the residuals from the single-index market model, and systematic risk is calculated by subtracting total risk from idiosyncratic risk. To further validate the findings obtained from the baseline method, three additional risk measures are used. We estimate a GARCH (1,1) model to measure the daily stock volatility for total risk and the Fama–French three-factor model for both idiosyncratic and systematic risks, following Bollerslev (1986), Fama and French (1993), Bello (2008), Ashley and Patterson (2010), Cotter et al. (2015), and Li and Luo (2017). The results indicate that CEO power positively affects the firm risk. Specifically, when CEO power increases by 1%, the firm's total risk increases by approximately 4–10%. This association is mainly driven by the influence of CEO power on firm-specific risk rather than on market-based risk, from the economic significance perspective. The results indicate that CEO power positively affects the firm risk.

Furthermore, to investigate the effects of the financial and COVID-19 crises on the association, the difference-in-difference (DiD) method and models on different subsamples with Chow's test are employed (Contessi et al. 2014). A distinction is made between the 2007 global financial crisis and 2020 COVID crisis. Particularly, the increased risk with CEO power remains relatively unchanged across financial crises and non-financial crises. However, such an effect only remains during non-COVID crises and disappears during COVID crises. This may be because the optimism and confidence of powerful CEOs is reduced during turbulence that they are unfamiliar with and have no reference to or experience of, which was the COVID case. Conceivably, CEOs with power are more reluctant to increase firm risk during new or 'strange' occurrences like a pandemic. The study also finds that the association between CEO power and risk is stronger in non-crisis periods. This suggests that power may allow and incline CEOs to take more risk in times of financial stability and discourage them (or at least encourage caution) from taking risk during crises.

Moreover, in examining the third hypothesis (H3), we applied an OLS model with clustered standard error at the firm level to assess the impacts of CEO power on firm risk, moderated by Board Gender Diversity (BGD). The coefficients of the interaction term between CPS × BGD show a significant impact. Specifically, the coefficients of

CPS_BGD are negative and statistically significant at the 10% level or below for total risk, idiosyncratic risk, and systematic risk. The finding supports the view of agency theory that the presence of women directors can enhance board independence, improve the effectiveness of oversight functions (Carter et al. 2010) and, thus, curb the opportunistic, self-serving behavior of managers.

The contributions of this study are, thus, threefold. First, extant studies on CEO power and corporate risk have been conducted in a single country. This means that the findings are likely to apply specifically to firms that operate there. Extending the research stream, the current study is conducted on an international sample from G7 countries, so the findings will be more generalizable and relevant to a broader context. Second, this study employs the most updated dataset for the period between 2006 and 2021, which is important after a series of market-impacting events like the COVID-19 pandemic and the many related changes in governance codes around the globe. Third, given the significant effect of gender diversity on the decision made by CEOs, we further investigate the effect of risk-averse women CEOs on the relationship between CEO power and firm risk. Such risk aversion is seen as beneficial during the post crisis period, with firms that avoid extreme risks perceived as more likely to endure. To date, there has only been very limited assessment of these hypotheses, and they have never been juxtaposed in relevant previous studies. Thus, the results of this study will indicate whether the association between CEO power and firm risk is either unaffected, stronger, or weaker in different types of turbulence. As such, they will confirm and extend the results of relevant previous studies.

This study has important implications for firms, investors, regulators, and policymakers. For instance, policymakers can proactively use evidence from this study as a tool to anticipate the impact of crises on investors and markets by analyzing how CEO power affects corporate risk. Regulators may establish improved rules and regulations to minimize risk and prevent future turbulence. Firms and investors can acquire deeper insights into how to manage the risks associated with powerful CEOs, based on the recommendations. This study is also helpful for enhancing senior managers' hiring criteria and understanding the risks associated with powerful CEOs during crises. Further, boards of directors and top management are encouraged to delegate more power to CEOs to avoid value-damage by conservative CEOs, and hence stimulate positive firm outcomes, given that CEO power is expected to work effectively and help to achieve a reasonable return on investment. At the same time, the board of directors should pay attention to risk-taking by powerful CEOs attempting to assure related value-enhancing strategies, because higher risk can eventually lead to excessive risk, which is detrimental to firms if not subject to cautious surveillance. Moreover, this study further investigates the mitigating role of Board Gender Diversity (BGD) on the relationship between CEO power and firm risk. It provides essential insights into corporate governance, revealing how gender diversity within boards can influence governance dynamics and decision making, particularly in risk management and CEO power. Policymakers and regulators can play a pivotal role in introducing or enhancing diversity initiatives. The findings suggest that gender-diverse boards might adopt more conservative risk management strategies, encouraging companies to reassess their CEO and board composition and aim for greater gender diversity, thus enhancing overall corporate governance practices.

The rest of the paper is structured as follows. Section 2 discusses and formulates the hypotheses. Subsequently, Sect. 3 explains the sample and analytical methodology employed in the study and provides an analysis and discussion of the results. Finally, Sect. 4 provides the conclusion.

2 Hypotheses

As stated above, this paper investigates three hypotheses. First, as posited above, the institutional power possessed by the CEOs directly influences firm risk. Accordingly, the following hypothesis is tested:

H1 CEO power significantly and positively affects firm risk.

To delve more into the association between CEO power and firm risk, this paper further assesses whether it remains unchanged during crises. During the corporate financial distress caused by market-borne crises, corporations are exposed to much greater uncertainty, given that such conditions can raise the awareness of powerful CEOs, reducing their optimism and risk-taking propensity. We, therefore, expect that the positive power–risk association reduces during crises.

The global financial crisis (GFC) of 2007 and the COVID-19 pandemic of 2020–2021 are considered the riskiest events to impact the world's economy since the Great Depression of 1929–1932 (Moschonas 2020). In this regard, both events have revealed the global economy's vulnerability and its impact on firms' risk-taking. Therefore, it is necessary to continuously reassess the determinants of firm risk today more than ever before. Throughout and beyond GFC of 2007, risk management has received a crucial echo in the media (Huber and Scheytt 2013), with interest in it gradually increasing through the 20 years leading up to the financial crisis. Accordingly, policymakers constantly attempt to develop conditions that impose requirements to monitor firm activities involving risk (Sheikh 2019), specifically during crises.

The topic of CEO power and corporate risk during and after both the financial and COVID-19 crises is important for different reasons. First, financial, and global health crises can have dramatic economic and social impacts, such as economic downturn, job losses, and economic hardship. Thus, understanding the relationship between CEO power and corporate risk-taking can determine the required effort to reduce risk-taking and mitigate the impact of crises. Second, financial and global health crises can significantly impact investors. Research on CEO power and corporate risk can, thus, help shape investment decisions. Third, financial and global health crises can dramatically impact corporate leaders. For instance, studies have shown that firms with more powerful CEOs are more likely to engage in risky behaviors (Sheikh 2019), which may result in negative consequences during a crisis. Hence, understanding the relationship between CEO power and corporate risk can provide insights into a corporate leader's decisions to implement strategies that balance CEO power to alleviate risk and improve their firms' resilience during a crisis.

Therefore, this study focuses on the context of the GFC of 2007 and the COVID-19 pandemic of 2020–2021 to find out whether the influence of CEO power on firm risk is mitigated under uncertain and distressed market conditions. We expect our results to show that GFC 2007 financial and COVID-19 2020 crises reduce the positive impact of CEO power on firm risk; therefore, the following hypothesis is tested:

H2 The global financial crisis 2007 and COVID crisis 2020 significantly and negatively affect the direct relationship between CEO power and firm risk.

The presence and importance of female directors in top management positions have gained considerable attention in recent years, with numerous studies examining this topic in both developing and developed economies (e.g., Adams and Ferreira 2009; Nguyen et al. 2020). Kramer et al. (2006) emphasize the significance of female presence in organizations, particularly in the context of corporate governance.

From the perspective of agency theory, board gender diversity enhances board independence and improves the effectiveness of oversight functions (Carter et al. 2010; Sarhan et al. 2019). Further studies corroborate that companies with gender-diverse boards are characterized by stronger governance, including robust internal controls and enhanced oversight (Adams and Ferreira 2009; Shahab et al. 2020; Farooq et al. 2023). The addition of women directors significantly changes the dynamics within the boardroom, increasing scrutiny of management and showing less tolerance for poor executive performance (Gul et al. 2011; Zalata et al. 2018). These points suggest that companies with gender-diverse boards exhibit robust governance and are more inclined to strengthen board oversight of CEO decisions.

In terms of risk management, studies indicate that women tend to be more risk-averse and conservative compared to their male counterparts (Sila et al. 2016; Zalata et al. 2018) and are less inclined to be involved in unethical acts (Jia 2019). This conservative approach extends to financial decisions, such as preferring stable investments and avoiding risky loans, which is particularly valuable in managing firm risk (Huang and Kisgen 2013). After the global financial crisis, such risk aversion is seen as beneficial, with firms that avoid extreme risks perceived as more likely to endure (Hutchinson et al. 2015). Consequently, in firms where the CEO has power, board gender diversity is positively associated with a reduction in firm risk, as female directors are more likely to reduce risk and improve corporate financial stability through their conservative assessment of CEOs' risk decisions. Given the significant effect of gender diversity on the decisions made by CEOs, we further investigate the effect of women CEOs on the relationship between CEO power and firm risk. Accordingly, the following hypothesis is tested:

H3 In firms where the CEO holds higher power, Board Gender Diversity (BGD) mitigates the positive effect of CEO power on firm risk.

3 Methodology

3.1 Sample formation

The study employs a cross-country panel data sample containing publicly listed firms in the G7 countries: the United States, the United Kingdom, Germany, France, Italy, Canada, and Japan. The investigation covers the period from 2006 to 2021, throughout which both the global financial crisis 2007 and the COVID-19 crisis are very relevant occurrences. The financial and governance composition, and macro-economic data are obtained from several databases. Particularly, firms' accounting data and daily stock prices are collected from the Refinitiv Datastream database. The governance-related data, including board composition and CEO characteristics, are obtained from WRDS BoardEx. Last, macroeconomic data derived are from various sources, including the World Bank and International Monetary Fund databases. After dealing with missing values, the final sample employed in this study contains 12,836 firm-year observations. All accounting variables are winsorized at the 1st and 99th percentiles to tackle the potential issue of outliers.

3.2 Dependent variable: firm risk

To measure firm risk, the study employs three proxies: namely, total risk (TR), systematic risk (Risk_Sys), and idiosyncratic risk (Risk_Idio). These three measures of corporate risk have been widely used in the literature (Anderson and Fraser 2000; Pathan 2009; Bernile et al. 2018). Following Anderson and Fraser (2000), the risk measures are computed as follows:

Total risk (TR) is equal to the standard deviation of each firm's daily stock returns for each year. A firm's daily stock return can be measured as $R_{it} = \ln\left(\frac{P_{it}}{P_{i,t-1}}\right)$, where R_{it} is the daily stock return of firm i for day t; and P_{it} and $P_{i,t-1}$ are firm i's closing stock price for day t and day t-1, respectively. The firm total risk captures the volatility of a firm's stock returns each year, providing the perceptions of market participants about the risks that the firm is expose to. Idiosyncratic risk (Risk_Idio) is measured as the standard deviation of the residuals obtained from the single-index market model, as presented in Eq. 1:

$$R_{it} = \alpha + \beta * R_{M,t} + \epsilon_{i,t} \tag{1}$$

where R_{it} is the daily stock return of firm i for day t; $R_{M,t}$ is the daily return of the market index for day t; the market index is the main index of each country; and $\epsilon_{i,t}$ is the error terms. Idiosyncratic risk is the firm-specific risk capturing the influences of firm-specific factors and conditions on the firm's stock volatility. Systematic risk (Risk_Sys) is equal to total risk—idiosyncratic risk. This risk is the market risk, capturing the impacts of the whole market conditions on firms.

3.3 Main independent variable: CEO power

CEO power is not a characteristic that can be directly observable (Liu and Jirapor 2010) so the literature has been debating on more objective proxies, measures, or indicators to capture it (Salancik and Pfeffer 1974; Provan 1980; Pfeffer 1981). Several proxies have been employed by the extant literature. These include CEO duality, where a firm appoints the same person for both chairperson and CEO roles (Pathan 2009; Haynes and Hillman 2010); CEO tenure, which captures the length in years they have been in their positions, with logarithm values taken (Onali et al. 2016); and board independence, which measures the proportion of independent (outside) board members (Daily and Johnson 1997; Lewellyn and Muller-Kahle 2012).

In the current study, the main proxy employed for CEO power is the CEO Pay Slice (CPS), which measures the CEO's relative compensation among top executives. It captures the CEO's relative significance in the management team in terms of their contribution, power, and ability. The CPS as a proxy of CEO power has been increasingly used in recent years by, for example, Liu and Jiraporn (2010) and Vo and Canil (2019). It has been claimed to be a more objective, useful, and advantageous measure in comparison to others due to its ability to capture "the relative centrality of the CEO in the top management team" (Liu and Jiraporn 2010, p.748; Finkelstein 1992) as well as its strong explanatory power for a firm's corporate outcomes (Bebchuk et al. 2009). Furthermore, CPS is constructed using the compensation of executive directors in the same company; therefore, any firm-specific characteristics are controlled for (Bebchuk et al. 2009).

Following the same approach employed in the literature, the CEO pay slice (CPS) is computed as the percentage of a CEO's total compensation to the total compensation of the top five executives in each firm. The computation can be written as follows:

$$CPS = \frac{CEO\ total\ compensation}{\sum Top - five\ executives'\ compensations\ (including\ CEO)} \quad (2)$$

3.4 Controlling variables

Following the literature (Coles et al. 2006; Yung and Chen 2018), four groups of controlling variables are employed—firm-level characteristics, CEO characteristics, corporate governance composition, and country-level controls. For the firm-specific controls, the study uses firm size (the logarithm of firm total asset), sales growth (annual sale growth, as a percentage), profitability (EBITDA/total asset), research and development expense (the percentage of R&D to total asset), growth opportunity (market-to-book ratio), asset tangibility (the percentage of net fixed asset to total asset), market leverage, dividend cut (dummy variable), and cash surplus (the percentage of surplus cash to total asset). For corporate governance and CEO characteristics, the study uses board size (number of board directors), female board representation (the percentage of female directors on the board), CEO age, CEO gender, CEO wealth delta, CEO tenure, and CEO education. Last, macroeconomic variables are controlled for, including annual GDP growth rate, annual inflation rate, foreign direct investment, trade per capita GDP, financial crisis, and COVID-19 crisis dummies. The definitions and detailed computations of these variables are explained in Appendix (Table 9).

3.5 Data analysis: estimation models

The study employs the Ordinary Least Squares (OLS) with clustered standard error at the firm level as the baseline method. The following regression models is performed:

$$\begin{aligned} \mathrm{TR}_{\mathrm{i,t}}/\mathrm{Risk\_Idio}_{\mathrm{i,t}}/\mathrm{Risk\_Sys}_{\mathrm{i,t}} = {} & \alpha_{\mathrm{i,t}} + \beta_1 * \mathrm{CPS}_{\mathrm{i,t}} + \sum_{n=2}^{n=22} \beta_n * X_{n,i,t} + \mathrm{Year.FE} \\ & + \mathrm{Industry.FE} + \mathrm{Country.FE} + \in_{\mathrm{i,t}} \end{aligned} \quad (3)$$

The dependent variables are the three primary risk measures capturing the total risk, idiosyncratic risk, and systematic risk of firm I for year t ($\mathrm{TR}_{\mathrm{i,t}}$, $\mathrm{Risk\_Idio}_{\mathrm{i,t}}$, $\mathrm{Risk\_Sys}_{\mathrm{i,t}}$, respectively). $\mathrm{CPS}_{\mathrm{i,t}}$ is the main independent variable, which is the CEO power proxied by the CEO pay slice (CPS) so β_1 captures the potential association between CEO power and firm risk. $X_{n,i,t}$ are all controlling variables accounted for and explained in the previous section, and β_n are their corresponding associations with firm risk. The regression estimation also considers year fixed effect, industry fixed effect, and country fixed effect. These dummy variables tackle the *time-invariant* omitted or unobservable issues that are related to each industry and country. Furthermore, the clustered standard error option is used to deal with the issue of heteroskedasticity and autocorrelation—namely, inconstant, and correlated error terms, respectively. This cluster option has been claimed to provide true standard errors even when the error terms are not independently and identically distributed (i.i.d), as per White (1980) and Abadie et al. (2022).

3.6 Robustness checks

To provide further assurance to the findings obtained from the baseline method, several robustness checks are performed, which can be classified in the following ways:

3.6.1 Robustness checks with alternative dependent variables

Three additional risk measures are employed. These are (1) assets return risk (ARR), (2) bankruptcy risk (Z_score), and (3) operating risk (SD_ROA). Following Flannery and Rangan (2008) and Pathan (2009), the ARR measure is computed as follows:

$$\text{ARR} = \text{SD(Rit)} * \frac{\textit{Market capitalisation}}{\textit{Total liabilities} + \textit{Market Equity}} * \sqrt{250} \tag{4}$$

On the other hand, the insolvency risk is measured by the Z-score as follows:

$$\text{Z\_Score} = \frac{(3.3 * \textit{EBIT}) + (1 * \textit{Net sales}) + (1.4 * \textit{Retained earning}) + (1.2 * (\textit{Working Capital}))}{\textit{Total Asset}} \tag{5}$$

where EBIT is the earnings before interest and tax. The higher the Z-score, the lower the bankruptcy risk (Altman 1983; Altman et al. 2017). In addition, the operating risk can be measured as the standard deviation of return on assets over the previous four-year period (t-4, t), following Yung and Chen (2018).

$$\text{SD\_ROA} = \sigma\left(\text{ROA}_{\text{t}-4,\text{t}}\right) \tag{6}$$

Last, the GARCH model builds upon the autoregressive conditional heteroskedasticity (ARCH) model by allowing for the conditional variance of a series to be dependent not only on past values of the series but also on past conditional variances. The first order GARCH model—i.e., the generalized ARCH model (Bollerslev 1986)—is the most commonly used specification for conditional variance in empirical work. We estimate a GARCH (1,1) model to measure the daily stock volatility following (Ashley and Patterson 2010; Cotter et al. 2015). After the GARCH model parameters are estimated, the model can be used to forecast future volatility. This involves generating conditional volatility forecasts based on the estimated parameters and past information. The estimated volatility from the GARCH model provides insights into the level of risk associated with the stock. Higher volatility implies greater uncertainty and risk.

The Fama–French Three-Factor Model (FF 3-factor) and the Capital Asset Pricing Model (CAPM) are widely acknowledged price models in the Finance field. The CAPM, originally proposed by Sharpe (1964), Lintner (1965), and Black (1972), is based on the idea that expected returns are solely determined by the market risk premium. Investors are assumed to be compensated for the risk associated with the overall market. In contrast, the FF 3-factor model expands the CAPM by incorporating two additional factors: size and value (Fama and French 1993).

The FF 3-factor model suggests that a firm's expected return is influenced by the market risk premium, the size premium, and the value premium. To calculate systematic risk using this model, FF 3-factor regressions are conducted for each firm each year as follows:

$$R_{i,t} - R_{f,t} = \beta_{Mkt}\left(R_{m,t} - R_{f,t}\right) + \beta_{SMB}SMB_t + \beta_{HML}HML_t + \in_{\mathrm{I,t}} \quad (7)$$

where $R_{i,t}$ is the expected return on the firm stock i on day t; $R_{f,t}$ is the risk-free rate; $R_{m,t}$ is the return on the market on day t; SMB_t represents the size premium (Small Minus Big) of stock i on day t; HML_t represents the value premium (High Minus Low) of stock i on day t; $\epsilon_{\mathrm{i,t}}$ is the error term.

The beta value β_{Mkt} serves as a measure of systematic risk for each firm. The idiosyncratic risk is measured as the standard deviation of the residuals obtained from the Fama–French three factors model. The data on the Fama and French three factors are collected from the Fama and French database.[1] We also find that our results remain consistent when idiosyncratic risk is estimated using the FF 5-factor model (Fama and French 2015). The FF 5-factor model results are not presented to save space but are available on request from the authors.

3.6.2 Robustness checks with alternative independent variables

In addition to the CPS as the main independent variable, this study also employs other measures of CEO power—namely, the CEO power index, CEO duality, and board independence—as robustness checks to provide further assurance to the findings. Their computations are explained below.

The paper constructs an index for CEO power, which is the sum of three CEO-power dummy proxies: CEO pay slice (Cpower_D), CEO duality, and board independence. The board independence dummy takes the value of 1 if the percentage of independent directors on the board is lower than the median of the sample, and 0 otherwise. Notably, lower board independence is claimed to be associated with higher CEO power, since it is a determinant of board effectiveness. Second, Cpower_D is a dummy variable equal to 1 if the CEO pay slice (CPS) is above the median value of the sample, and 0 otherwise. Last, CEO duality is a dummy variable that equals 1 if the firm's CEO and chairperson roles are held by the same person, and 0 otherwise. By taking the sum of these three dummies, the CEO power index is an ordinary variable with the value 0, 1, 2, or 3. The higher the index, the higher the CEO power.

CEO duality (CEO_DUAL) is a dummy variable equal to 1 if a firm's CEO and chairperson roles are held by the same person, and 0 otherwise (Lewellyn and Muller-Kahle 2012). CEO duality occurs when a firm's CEO is also the board chair, which appears to strengthen the CEO's position and weaken board monitoring. Perhaps, CEO duality promotes well-informed decision making and leadership. However, such duality may increase CEO power and a firm's risk-taking in parallel by decreasing board oversight and their effectiveness in monitoring their CEO's management activity. Thus, duality may serve CEOs' interests, but it does not best serve shareholders' interests. In other words, CEO duality may result in CEO overconfidence, firm risk-taking, and even bankruptcy (Li and Tang 2010; Lewellyn and Muller-Kahle 2012).

Board independence (Board_INDEP_%) is the fraction of board members who are independent, so they are not affiliated with the firm (Lewellyn and Muller-Kahle 2012). Its computation is as follows:

[1] https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

$$Board\_INDEP(\%) = \frac{Number\ of\ independent\ board\ directors}{Board\ size} \tag{8}$$

CEOs may appoint interdependent boards of directors to act in their favor, but they may not appoint independent boards. Theoretically, a firm's board should maintain an independent majority to serve the best interests of shareowners and promote independent decision making to reduce any possible conflicts of interest that may occur between firms and their CEOs (Lewellyn and Muller-Kahle 2012). Such conflicts arise because interdependent directors are more likely to provide the CEO with more power and less monitoring (Lewellyn and Muller-Kahle 2012). Therefore, board independence appears to be a decisive factor in a firms risk-taking. A higher number of independent directors on boards indicates less power for the CEO because independent directors are more likely to reduce the CEO power, imposing greater monitoring to serve the best interests of shareholders (Lewellyn and Muller-Kahle 2012).

3.6.3 Robustness checks with alternative model estimation approaches

Whilst cluster standard error can tackle the issues of heteroskedasticity and autocorrelation by providing more efficient and true standard errors, these two statistical issues do not yield biased coefficients. On the other hand, the endogeneity issue in regression can provide biased estimates. Endogenous variables indicate whether a variable is correlated or causes a particular effect. In this regard, simultaneity bias occurs when one or more factors are determined in equilibrium, so that it can plausibly be argued that either factor has the same effect (Roberts and Whited 2013). Omitted variables are any variables that should be included in the directory of explanatory variables, but for some reason are not (Roberts and Whited 2013). Measurement errors refer to proxies used for any difficulties in quantifying or observing variables. Such errors in quantifying variables may lead to measurement errors (Roberts and Whited 2013).

To tackle this problem, five estimation models are employed including the lagged approach and fixed/random effect, the system General Method of Moment (GMM), the instrumental 2-stage least square (2SLS) approach, and the propensity score matching (PSM) approach. First, the lagged approach aims to tackle the issue of simultaneity (reverse causality) by using one-year lagged independent variables (Chen 2014). The rationale behind this approach is that explanatory factors this year cannot affect the risk level of a firm in the previous year. The fixed effect is employed if the model is exposed to unobservable variables that do not change over time (time-invariant) (Chen 2014). If the unobservable variables change across time, the random effect model is more appropriate. The choice between fixed effect and random effect will be decided based on the Hausman test (Guggenberger 2010). Generally, this approach helps when variable omission is the source of endogeneity.

Furthermore, it is possible that the characteristics of high-power CEOs exhibit distinct patterns that are different from those of low-power CEOs. Such differences can be attributed to the firm risk rather than the power of a CEO per se. Therefore, the PSM method may be able to tackle this issue of selection bias, another source of endogeneity (Shipman et al. 2017).[2] Last, the system GMM and 2SLS approaches are performed, having been claimed to tackle all three sources of endogeneity (Ullah et al. 2018; Gretz and Malshe 2019).

3.7 Additional analyses: CEO power and firm risk during global financial and health crises

To examine the differences in the relationship between CEO power and firm risk across financial and non-financial crises and across COVID and non-COVID periods, two approaches are employed:

3.7.1 Difference-in-difference approach

A difference-in-difference (DiD) approach was also employed. The CEO power variable (CPS) was applied as a dummy variable (Cpower_D), which will take a value of 1 if the firm's CPS is higher than the industry median (i.e., firms run by a powerful CEOs), and 0 otherwise (i.e., firms run by non-powerful CEOs). An interaction term between the CPS dummy and the COVID dummy (Cpower_Covid) and between the CPS dummy and the financial crisis dummy (Cpower_Crisis) are included in the baseline OLS Eq. 3 (see Eq. 7):

$$\begin{aligned} \mathrm{TR}_{i,t}/\mathrm{Risk\_Idio}_{i,t}/\mathrm{Risk\_Sys}_{i,t} &= \alpha_{i,t} + \beta_1 * \mathrm{Cpower\_D}_{i,t} + \beta_2 \\ &* \mathrm{Cpower\_Covid} + \beta_3 * \mathrm{Crisis\_C} + \beta_4 * \mathrm{Cpower\_Crisis} + \beta_5 * \mathrm{Crisis\_F} \\ &+ \sum_{n=6}^{n=25} \beta_n * X_{n,i,t} + \mathrm{Year.FE} + \mathrm{Firm.FE} + \mathrm{Industry.FE} + \mathrm{Country.FE} + \epsilon_{i,t} \end{aligned} \tag{9}$$

The DiD approach aims to examine the differences in a response variable (i.e., firm risk) across a group with treatment (i.e., firms run by powerful CEOs) and without treatment (i.e., firms run by non-powerful CEOs) over two distinct periods of time (the global financial crisis and the pandemic health crisis).

3.7.2 OLS cluster estimation on four subsamples

The same OLS cluster regression as in Eq. 3 are performed separately on the financial crisis, non-financial crisis, COVID, and non-COVID samples. Subsequently, a Chow's test is run to examine the differences in the coefficients of CEO power (CPS) across financial and non-financial crisis samples, and across COVID and non-COVID samples.

3.7.3 Difference-in-difference approach with propensity score matching (PSM)

A difference-in-difference (DiD) approach with PSM will also be employed. To implement this test, similar to the PSM approach, the CEO power variable (CPS) will be converted to a dummy variable (Cpower_D), which will take a value of 1 if the firm's CPS is higher than the industry median (i.e., firms run by powerful CEOs), and 0 otherwise (i.e., firms

[2] Note that, to perform this estimation approach, the main independent variable (CPS), which is denoted as a percentage, will be converted to a dummy variable. This dummy will take a value of 1 if the firm's CPS is higher than the industry median (i.e., firms run by powerful CEOs), and 0 otherwise (i.e., firms run by non-powerful CEOs).

run by non-powerful CEOs). An interaction term between the CPS dummy and the COVID dummy (Cpower_Covid) and between the CPS dummy and the financial crisis dummy (Cpower_Crisis) will be included in the baseline OLS Eq. 3 (see Eq. 8):

$$\begin{aligned} \mathrm{TR}_{\mathrm{i,t}}/\mathrm{Risk\_Idio}_{\mathrm{i,t}}/\mathrm{Risk\_Sys}_{\mathrm{i,t}} = \alpha_{\mathrm{i,t}} + \beta_1 * \mathrm{Cpower\_D}_{\mathrm{i,t}} \\ + \beta_2 * \mathrm{Cpower\_COVID} + \beta_3 * \mathrm{Cpower\_Crisis} \\ + \sum_{n=2}^{n=24} \beta_n * X_{n,i,t} + \mathrm{Year.FE} + \mathrm{Industry.FE} + \mathrm{Country.FE} + \in_{\mathrm{i,t}} \end{aligned} \tag{10}$$

3.7.4 Association between CEO power and risk across firms with different growth opportunities and R&D expenditure

The OLS cluster regression explained in Eq. (3) will be performed separately across different characteristics and conditions of firms: high (low) growth opportunity and high (low) research and development (R&D) intensity. For this purpose, firms will be categorized into those with high growth opportunity, those with low growth opportunity, those with high R&D expenditure, and those with low R&D expenditure. This categorization is essential to observe any significant change in the relationship between a CEO's power and firm risk across the growth and R&D expenditure spectrum (Carline et al. 2023).

3.7.5 Association between CEO power and risk across non-financial and financial firms

Last, the OLS cluster regression discussed in Eq. (3) will be performed separately across firms. For this purpose, firms will be categorized into financial and non-financial firms. This is necessary to observe any significant changes in the relationship between a CEO's power and firm risk between financial and non-financial firms.

3.8 Empirical findings

3.8.1 Descriptive statistics

Table 1 illustrates the descriptive statistics for all variables during the years from 2006 through 2021. The table comprises a univariate analysis for each dependent variable, independent variable, and control variable. All variables are winsorized at the one per cent level to reduce the impact of any potential outliers on the employed variables, following Kim and Lu (2011). Total risk (TR), idiosyncratic risk (Risk_Idio), and systematic risk (Risk_sys) exhibit right-skewed distributions; hence, log transformations were employed for them. The three variables have average values of −1.997, −2.007, and −2.289. These are equivalent to 0.035, 0.034, and 0.001, respectively. For the main independent variable, particularly the CEO pay slice (CPS), there is indication that, on average, CEOs receive a total compensation package that is around 25% of the total top five earning directors of companies; thus, CEOs are commonly the highest earners among these top five. This statistic is similar to that in a study by Li et al. (2018). Regarding control variables, the average CEO age was 63, ranging from 41 to 85. In terms of CEO gender, female CEOs represented around 5% of all the firm-year observations. The average delta of CEOs' wealth was around 2.9, and the maximum delta was around 9. This indicates that, on average, for every

Table 1 Variable descriptive statistics for full sample

Variable	N	Mean	p50	Std.Dev	Min	Max	Skewness	Kurtosis
TR	250,956	−1.997	−2.099	.417	−2.303	.178	3.476	16.522
Risk_Idio	250,610	−2.007	−2.115	.418	−2.303	.177	3.498	16.596
Risk_Sys	250,610	−2.289	−2.299	.022	−2.303	−2.186	2.596	10.327
CPS	75,537	.241	0.222	.137	0	.75	.984	4.702
CEO_Age	252,493	63.456	63.800	9.023	41	85.111	−.106	2.824
CEO_ female	119,806	.049	0.000	.215	0	1	4.196	18.608
Delta	76,848	2.914	2.226	2.345	0	8.543	.613	2.215
CEO_Tenure	263,532	1.287	1.194	.746	0	3.199	.451	2.639
CEO_Edu	99,867	.535	1.000	.499	0	1	−.142	1.02
SIZE	239,488	12.435	12.473	2.603	5.681	18.553	−.11	2.85
Growth	222,624	.145	0.088	.44	−1.222	2.19	1.403	9.959
Profit	232,304	−.088	0.048	.504	−3.315	.417	−4.166	23.671
R&D %	128,272	.133	0.030	.27	0	1.797	3.906	21.038
Growth_oppo	233,888	2.869	1.690	7.286	−26.49	48.35	2.601	22.652
CAPEX	234,496	.289	0.413	.839	−5.713	.997	−5.016	33.25
Leverage	237,264	.155	0.099	.172	0	.745	1.351	4.383
Cash_surp	127,024	.25	0.149	.283	−.119	.961	.978	2.875
Div_cut	136,902	.167	0.000	.373	0	1	1.786	4.191
Board_size	239,020	8.04	7.333	3.102	3	18.571	1.003	3.987
%Female/BGD	263,532	.107	0.083	.121	0	.5	1.072	3.577
Crisis_F	49,256	.187	0.000	.39	0	1	1.606	3.58
Crisis_C	32,912	.125	0.000	.331	0	1	2.269	6.15
GDP_ Growth	119,548	1.052	1.880	2.62	−9.396	6.869	−2.067	7.393
Inflation_Rate	119,548	1.785	1.850	.955	−2.312	5.348	.331	7.021
Foreign_ Inv	119,548	2.275	1.761	1.987	−1.17	11.929	2.656	11.299
Trade (% of GDP)	119,548	42.208	30.790	17.45	23.376	88.434	.595	1.983

The table provides the descriptive statistics of all variables employed in the study. **TR** refers to the firm total risk measured by the natural logarithm of the standard deviation of an individual firm's daily stock returns yearly, **Risk_Idio** refers to the firm idiosyncratic risk measured by the natural logarithm of the standard deviation of the residuals obtained from the single-index market model, and **Risk_Sys** refers to the market risk measured by the natural logarithm of the difference between TR and Risk_Idio. **CPS** captures the percentage of a CEO's total compensation to the total compensation of the top five executives in each firm. **CEO_Age** is the biological age of the CEO (in years). **CEO_ female** carries the value of 1 if the CEO is female, and 0 otherwise. **Delta** is the natural logarithm of the change in dollar value of CEOs' wealth for a one percentage point change in stock price. **CEO_Tenure** is the natural logarithm of the number of years the CEO has held the position. **CEO_Edu** is equal to 1 if the CEO has a Master's degree or higher, and 0 otherwise. **Size** refers to the logarithm of firm total asset. **Growth** captures the percentage annual growth rate in sales. **Profit** is the ratio of earnings before interest payments and income taxes to total assets. **R&D%** is the R&D expenses to total assets. **Growth_oppo** is the market-to-book ratio. **CAPEX** captures the percentage of net fixed asset to total asset. **Div_cut** is a dummy equal to 1 if there is a reduction in annual dividend payout, and 0 otherwise. **Board_size** is the number of directors on the firm's board of directors. **%Female** is the fraction of female directors on board. **Financial and COVID crisis** is equal to 1 if the firm-year observations fall in the periods 2007–2009 and 2020–2021, and 0 otherwise. **GDP_growth** measures the percentage growth in GDP for each country. **Inflation_rate** is the percentage annual change in the consumer price index (CPI) of each country. **Foreign_Inv** measures foreign direct investment as a percentage of GDP for each country, and **Trade (% of GDP)** measures the percentage of a country's GDP stemming from trade

N.B: The observation (N) is for each variable, which can be different with the observation of the regres-

Table 1 (continued)

sions due to missing data once all variables are included in an estimation model

one percentage point increase in stock price of a CEO's operating firm, their wealth (in dollar terms) will increase by three percentage points, which is triple the stock price increase. Moreover, the average CEO tenure was around 1.3 years, a median of 1.20 years, a minimum of 0 years (less than one year, newly appointed), and a maximum of three years. This also shows that more than half of the CEOs in the full sample had an education to Master's degree level or higher (Mean $_{(CEO\_edu)}$ = 53.5%).

Regarding firm characteristics, the average firm size in the sample was 12.425 (log term) with a minimum value of 5.7 and a maximum value of 18.6. The average sales growth rate (Growth) was around 15%, while the median was around 9%. The average of profitability was around −9%, while the median was 5%. The R&D variable has an average of 13%, signifying that firms spend, on average, around 13% of their total assets on R&D projects. Growth opportunity was the market-to-book ratio, with a mean of 2.86 and median of 1.69. This implies that market participants value the stock of the sampled firms 300% higher than their book values. This represents the trust and belief of market investors in the future growth of firms. The tangibility of firms is measured by the proportion of total fixed assets to total asset. The average value was around 29% of firms' total assets are tangible assets such as plants, equipment, buildings, or vehicles. Next, leverage had an average value of 15.5% for the full sample, and a median value of around 10%, ranging from 0% (for unlevered firms) to approximately 74.5%. Cash surplus (cash_surp) recorded an average value of 25% for the full sample and a median value of around 15%. As shown in the results of the employed data, dividend cut was used as a dummy variable generating the value of 1 if there was a reduction in annual dividend pay-out, and 0 otherwise. The mean value was 16.7%, indicating that 16.7% of firm-year observations show a dividend cut over a one-year period. The median value of this variable is 0%. This reveals that firms are very cautious in implementing a dividend cut policy as it is associated with great market sensitivity due to the signalling effects of dividends.

Moving on to board composition, firms appoint an average of eight directors on the board with a median value of 7. As shown by the data, the average female representation was 10.7% and the median was around 8%, which indicates the proportion of female directors on boards generally. In relation to the global financial crisis, it was employed as a dummy variable with a value of 1 if the firm-year observations fell between 2007 and 2009, and 0 otherwise. In the present study, the total number of observations summed around 49,256, which represented around 19% of the complete observations. For the global health crisis, the COVID variable (Crisis_C) was employed as a dummy variable generating the value of 1 if the firm-year observations fell between 2020 and 2021, and 0 otherwise. As shown in the data, the total number of observations is 32,912, representing 13% of the whole sample.

Table 2 displays the Pearson correlation matrix between the employed independent variables. As seen, most correlation pairs are within the weak zone (<0.5) with a few exceptions. These are profitability and CAPEX (0.505); size and CEO delta (0.586); board size and delta (0.635); board size and growth opportunity (0.675); and GDP growth and COVID crisis (-0.755). The positively correlated value of profitability and CAPEX can be explained such that when firms achieve a higher profitability, they tend to reinvest their earned returns for future growth on fixed assets. Additionally, the positive associations

Table 2 Pairwise correlations matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) TR	1.000												
(2) Risk_Idio	**0.999**	1.000											
(3) Risk_Sys	**0.195**	**0.151**	1.000										
(4) CPS	**0.035**	**0.064**	**0.051**	1.000									
(5) CEO_Age	**−0.112**	**−0.112**	**−0.023**	**−0.008**	1.000								
(6) CEO_ female	**−0.007**	**−0.008**	**0.012**	**−0.071**	**−0.086**	1.000							
(7) Delta	**−0.206**	**−0.209**	**0.040**	**0.348**	**0.089**	**−0.127**	1.000						
(8) CEO_Tenure	**−0.077**	**−0.078**	**−0.006**	**0.075**	**0.317**	**−0.049**	**0.164**	1.000					
(9) CEO_edu	−0.005	−0.006	**0.014**	**0.058**	**0.019**	0.004	**0.190**	**−0.013**	1.000				
(10) SIZE	**−0.351**	**−0.364**	**0.224**	**0.157**	**0.179**	**−0.006**	**0.586**	**0.113**	**0.033**	1.000			
(11) Growth	**0.014**	**0.016**	**−0.038**	**−0.029**	**−0.100**	**−0.011**	**−0.044**	**−0.118**	**0.010**	**−0.120**	1.000		
(12) Profit	**−0.290**	**−0.293**	**0.035**	**0.028**	**0.121**	**−0.006**	**0.225**	**0.163**	**−0.045**	**0.468**	**−0.075**	1.000	
(13) R&D %	**0.166**	**0.168**	**−0.019**	**−0.034**	**−0.122**	**0.014**	**−0.125**	**−0.148**	**0.108**	**−0.388**	**0.071**	**−0.652**	1.000
(14) Growth_oppo	**−0.030**	**−0.029**	**−0.009**	**0.011**	**−0.075**	**0.008**	**0.111**	**−0.064**	**0.026**	**−0.060**	**0.039**	**0.007**	**0.032**
(15) CAPEX	**−0.138**	**−0.138**	**−0.008**	**−0.027**	**0.075**	**0.021**	**−0.012**	**0.126**	**0.022**	**0.173**	**−0.026**	**0.505**	**−0.495**
(16) Leverage	**−0.023**	**−0.025**	**0.038**	**0.025**	**0.070**	**−0.022**	**0.054**	**0.044**	**−0.023**	**0.327**	**−0.066**	**0.147**	**−0.209**
(17) Cash_surp	**0.092**	**0.094**	**−0.040**	−0.002	**−0.205**	**0.017**	**−0.017**	**−0.148**	**0.126**	**−0.342**	**0.138**	**−0.350**	**0.449**
(18) Div_cut	**−0.088**	**−0.095**	**0.109**	**−0.026**	**0.015**	**0.037**	**−0.084**	**0.042**	**−0.048**	**0.162**	**−0.135**	**0.098**	**−0.116**
(19) Board_size	**−0.220**	**−0.228**	**0.153**	**0.213**	**0.194**	**−0.025**	**0.635**	**0.069**	**0.052**	**0.675**	**−0.097**	**0.222**	**−0.184**
(20) %Female/BGD	**−0.079**	**−0.083**	**0.100**	**0.034**	**−0.168**	**0.295**	**0.183**	**−0.046**	**0.030**	**0.205**	**−0.030**	**0.050**	**0.019**
(21) Crisis_F	**0.067**	**0.062**	**0.123**	**−0.010**	**0.023**	**−0.021**	**−0.015**	**−0.006**	**−0.007**	**−0.012**	**−0.010**	**−0.007**	**0.009**
(22) Crisis_C	0.000	−0.001	**0.018**	0.005	**−0.047**	**0.050**	−0.003	0.003	0.003	**0.034**	**−0.025**	**0.004**	**−0.019**
(23) GDP_ Growth	**−0.161**	**−0.144**	**−0.263**	**0.043**	**0.163**	**−0.057**	**0.137**	**0.018**	**0.025**	**0.033**	**0.125**	**0.041**	−0.003
(24) Inflation_Rate	**−0.018**	**−0.013**	**−0.057**	**−0.064**	**0.112**	**0.034**	**−0.153**	**−0.027**	**−0.016**	**−0.119**	**0.095**	**0.009**	0.005
(25) Foreign_ Inv	**0.045**	**0.046**	**−0.011**	**−0.130**	**0.061**	**0.007**	**−0.264**	**−0.043**	**−0.070**	**−0.146**	**0.058**	**−0.028**	0.000
(26) Trade (% of GDP)	**0.127**	**0.126**	0.002	**−0.245**	**−0.159**	**0.052**	**−0.726**	−0.003	**−0.132**	**−0.191**	−0.004	**−0.050**	**−0.031**

Variables	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
(1) TR													

Table 2 (continued)

Variables	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
(2) Risk_Idio													
(3) Risk_Sys													
(4) CPS													
(5) CEO_Age													
(6) CEO_ female													
(7) Delta													
(8) CEO_Tenure													
(9) CEO_edu													
(10) SIZE													
(11) Growth													
(12) Profit													
(13) R&D %													
(14) Growth_oppo	1.000												
(15) CAPEX	**0.063**	1.000											
(16) Leverage	**−0.108**	**−0.109**	1.000										
(17) Cash_surp	**0.108**	**−0.098**	**−0.440**	1.000									
(18) Div_cut	**−0.046**	**0.015**	**0.114**	**−0.146**	1.000								
(19) Board_size	**−0.014**	0.001	**0.142**	**−0.206**	**0.084**	1.000							
(20) %Female/BGD	**0.036**	**−0.034**	0.003	**0.023**	**0.083**	**0.203**	1.000						
(21) Crisis_F	−0.003	−0.002	**0.015**	0.001	**0.023**	0.002	**−0.034**	1.000					
(22) Crisis_C	−0.002	**0.012**	**0.012**	0.005	**0.062**	**−0.014**	**0.062**	**−0.129**	1.000				
(23) GDP_ Growth	**0.029**	**0.008**	**−0.033**	**−0.009**	**−0.169**	**0.071**	**−0.159**	**−0.275**	**−0.755**	1.000			
(24) Inflation_Rate	**0.018**	**0.018**	**−0.043**	0.001	**−0.054**	**−0.070**	**−0.069**	**0.007**	**0.053**	0.001	1.000		
(25) Foreign_ Inv	0.005	**0.011**	**−0.038**	**−0.046**	**−0.030**	**−0.152**	**−0.127**	**0.139**	**−0.157**	**0.197**	**0.156**	1.000	
(26) Trade (% of GDP)	**−0.024**	**0.038**	**−0.020**	**−0.114**	**0.112**	**−0.238**	**0.028**	**−0.034**	**0.009**	**−0.111**	**−0.042**	**0.295**	1.000

The table presents the correlations between all the variables analyzed in this present study. Bold coefficients signify statistically significant correlations at the 5% critical level or below

Definitions for variables in the table are provided in Sects. 3.2 and 3.3 and Appendix 1(Table 9). The sample period is from 2006 to 2021 between firm size and CEO delta, and board size and CEO delta may be because larger firms and firms with bigger boards provide better compensation and/or incentive packages for CEOs which are linked to stock performance. Furthermore, a positive correlation between board size and growth opportunity supports the literature on the efficiency of bigger boards enhancing the growth opportunity of their firms (Dalton et al. 1999). Last, regarding GDP Growth and COVID crisis, it is apparent that the correlation is coincident since the COVID crisis dummy is determined by the years, but not by other characteristics of the crisis.

According to Sharma (2005), any correlation value higher than 0.8 indicates a concern of multicollinearity in the analyzed data. In the present study, the highest correlation was around 75%. Therefore, the issue of multicollinearity is not a concern. For greater assurance, additional Variance Inflation Factor (VIF) tests are employed when running regressions and all returned VIF values are less than 10. This, once again, confirms that the multicollinearity issue is not a significant concern with the employed dataset. These results are available on request from the authors.

3.8.2 CEO power and firm risk: baseline OLS cluster at firm level

Table 3 shows the results of the baseline estimation model (Eq. 3) that was performed using the Ordinary Least Squares (OLS) with clustered standard error at the firm level. First, the association between CEO power and total risk (TR) is captured in Columns 1–4. These represent four variation models. The first includes solely CEO power as the main independent variable with year, industry, and country fixed effects. The second variation model considers other CEOs' characteristics as controlling variables. These are a CEO's age, gender, delta, tenure, and education. The third variation model additionally controls for firms' specific characteristics and their boards' characteristics, including firm size, sales growth, profitability, R&D expense, growth opportunity, asset tangibility, surplus cash, dividend cut, board size, and female directors on the board. The last variation model is the full model containing all variables: CEO characteristics, firm characteristics, board characteristics, and microeconomics variables. Across the four model variations, the adjusted R-squared increases and the highest value are obtained for the last full model (Column 4) where all other variables were included. Accordingly, the finding is interpreted based on this full model. The last two columns (Columns 5 and 6) of Table 3 show the results of the association between CEO power and the two components of total risk, idiosyncratic (Risk_Idio) and systematic (Risk_Sys) risk, respectively. These two models contain all variables as included in the full model for total risk (Column 4).

As seen in Table 3, the coefficient β_1 of the CEO power variable (CPS) (see Eq. 3) shows a positive value of 0.146, 0.18, 0.093, and 0.092 for the four model variations (Columns 1–4), respectively. All these coefficients are statistically significant at the 1% level or below. This indicates a consistent finding on the positive association between CEO power and firm total risk, consistent with H1. Specifically, everyone per cent increase in CEO power (measured by a one per cent increase in the CEO's pay, relative to the total pay of the top five directors) would be associated with an approximate 10% increase in firm total risk. Our findings are consistent with Sheikh (2019) and Lewellyn and Muller-Kahle (2012). An explanation for this positive association is that CEOs who are awarded more power tend to be more confident and optimistic about their decision making and, at the same time, they tend to overlook and underestimate any downside risk associated with their decisions (Anderson and Galinsky 2006). This justification is built on the approach/inhibition theory of power (Keltner et al. 2003).

Decomposing total risk into idiosyncratic risk and systematic risk, the results of Columns 5 and 6 indicate that the positive influence of CEO power on firm risk is mainly driven by its influence on firm-specific risk rather than on market risk. This can be drawn from the economic significance of the CEO power association with the two risk components. Particularly, although both coefficients are statistically significant at 5% or below ($\beta_1 = 0.89$ and 0.007, Columns 5 and 6, respectively), the magnitude of the coefficient in the idiosyncratic risk model is much higher than that in the systematic risk model; it is closer to that of the total risk model. Idiosyncratic risk refers to risk borne by firm decisions, so it is related exclusively to each firm, whilst systematic risk relates to market-borne factors independent of firm strategy or decisions. It is understandable that a powerful CEO will influence and exert greater control over the firm's strategic decision-making processes and, hence, alter the overall risk level of that firm. However, such CEO power seems hardly likely to affect market-borne risks. This may be the reason why Sheikh (2019) only focuses on the idiosyncratic risk, a risk that is primarily born by firm-specific factors.

Regarding control variables, the analysis shows that firm total risk is negatively affected by CEO delta, CEO tenure,[3,4] firm size, profitability, and dividend cut policy, while it is positively affected by firm leverage and tends to be higher during crises. These findings are consistent with the literature (Yung and Chen 2018).

3.8.3 Robustness check

As stated above, several different sets of robustness tests are conducted. To confirm the findings obtained above by the baseline estimations, the fixed effect model and lagged approach are employed to deal with the issues of endogeneity. To identify the choice between fixed effect and random effect models, the Hausman test is employed (Guggenberger 2010). This test helps to deal with the source of omitted variable endogeneity. All Hausman tests yield significant Chi-square values, which indicates that the fixed effect model should be used rather than the random effect model. Second, the lagged approach aims to manage the simultaneity (reverse causality) issue of endogeneity by utilising one-year lagged independent variables. The rationale behind this is simply that future events cannot influence an event in the past. Particularly, the explanatory factors in the model (CEO power last year (year t-1)) cannot be affected by the dependent variable (firm risk in the current year (year t)). Consistent with the findings of the baseline method, the fixed effect and lagged models show that CEO power is significantly positively associated with all three risks—total risk, idiosyncratic risk and systematic risk.

Further, the paper also employs a two-step system Generalized Method of Moments (GMM) estimator and the instrumental 2-stage least square (2SLS) approach as another robustness estimation. As stated above, the fixed effect tackles time-invariant

[3] For example, Sheikh (2019) found a significant positive correlation between CEO power and CEO age, but the main regression showed opposite coefficient estimates with risk. Similarly, Shahab et al. (2020) found that CEO age and CEO salary are positively related to CPS, but the main regression showed opposite coefficient estimates. Moreover, while CPS and CEO tenure are positively related, CPS is positively associated with crash risk, whereas CEO tenure is negatively associated with crash risk.

[4] The effect of CPS or CEO tenure on risk in a multiple regression can be determined by partialing out the effects of other variables, as described by the Frisch–Waugh–Lovell theorem (Davidson and MacKinnon 1993).

Table 3 Influences of CEO power on firm risk—the baseline estimation model

Variable	(1) TR	(2)	(3)	(4)	(5)	(6)
		TR	TR	TR	Risk_Idio	Risk_Sys
CPS	.146***	.18***	.093***	.092***	.089**	.007***
	(0.00)	(0.00)	(.008)	(.008)	(.011)	(.001)
CEO_Age		−.002***	0.0003	0.0003	0.0004	0.00003
		(0.00)	(.495)	(.519)	(.49)	(.376)
CEO_ female		−.093***	−.005	−.007	−.007	.001
		(0.00)	(.686)	(.565)	(.547)	(.569)
Delta		−.035***	−.013***	−.013***	−.013***	−.001***
		(0.00)	(0.00)	(0.00)	(0.00)	(.003)
CEO_Tenure		−.015***	−.012***	−.012***	−.013***	−.00009
		(0.00)	(.01)	(.009)	(.006)	(.816)
CEO_Edu		.001	.01	.009	.009	0.0002
		(.822)	(.185)	(.197)	(.208)	(.671)
SIZE			−.043***	−.043***	−.048***	.004***
			(0.00)	(0.00)	(0.00)	(0.00)
Growth			−.01	−.009	−.01	0.0002
			(.47)	(.506)	(.481)	(.527)
Profit			−.164***	−.164***	−.163***	−.002**
			(0.00)	(0.00)	(0.00)	(.046)
R&D %			−.008	−.009	−.015	.003
			(.908)	(.896)	(.83)	(.21)
Growth_oppo			−.001	−.001	−.001	0.00006*
			(.102)	(.133)	(.105)	(.066)
CAPEX			−.024	−.025	−.025	−.001**
			(.303)	(.274)	(.289)	(.033)
Leverage			.169***	.168***	.178***	−.006*
			(.001)	(.001)	(0.00)	(.067)
Cash_surp			−.053	−.053	−.059*	.004**
			(.128)	(.134)	(.099)	(.01)
Div_cut			−.04***	−.042***	−.045***	.003***
			(0.00)	(0.00)	(0.00)	(0.00)
Board_size			.001	.001	.001	−.0001
			(.51)	(.557)	(.417)	(.357)
%Female			−.12***	−.119***	−.109**	−.009***
			(.008)	(.009)	(.017)	(.006)
Crisis_F			.152***	.246***	.219***	.033***
			(0.00)	(0.00)	(0.00)	(0.00)
Crisis_C			.137***	.2***	.183***	.016***
			(0.00)	(0.00)	(.001)	(0.00)
GDP_ Growth[a]				.008	.006	.001***
				(.182)	(.29)	(0.00)
Inflation_Rate				.021***	.022***	−.001
				(.004)	(.003)	(.301)

Table 3 (continued)

Variable	(1) TR	(2)	(3)	(4)	(5)		(6)
		TR	TR	TR	Risk_Idio		Risk_Sys
Foreign_ Inv				–.001	–.001		.001***
				(.787)	(.561)		(0.00)
Trade (% of GDP)				.005***	.004***		.001***
				(.004)	(.01)		(0.00)
Constant	–2.003***	–1.675***	–1.227***	–1.608***	–1.492***		–2.429***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		(0.00)
Year fixed effect	Yes	Yes	Yes	Yes	Yes		Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes		Yes
Country fixed effect	Yes	Yes	Yes	Yes	Yes		Yes
Observations	35,267	27,887	12,836	12,836	12,685	12,685	
R–squared	0.105	0.142	0.250	0.251	0.263	0.464	

The table presents the results of the estimation of baseline methods (OLS) with clustered standard error at the firm level from 2006 through to 2021. The dependent variables are total risk (TR) in Columns 1–4; idiosyncratic risk (**Risk_idio**) in Column 5; and systematic risk (**Risk_Sys**) in Column 6. **TR** refers to the firm total risk measured by the natural logarithm of the standard deviation of an individual firm's daily stock returns yearly, **Risk_Idio** refers to the firm idiosyncratic risk measured by the natural logarithm of the standard deviation of the residuals obtained from the single-index market model, and **Risk_Sys** refers to the market risk measured by the natural logarithm of the difference between TR and Risk_Idio. **CPS** captures the percentage of a CEO's total compensation to the total compensation of the top five executives in each firm. **CEO_Age** is the biological age of the CEO (in years). **CEO_ female** equals 1 if the CEO is female, and 0 otherwise. **Delta** is the natural logarithm of the change in dollar value of a CEO's wealth for a one percentage point change in stock price. **CEO_Tenure** is the natural logarithm of the number of years the CEO has held the position. **CEO_Edu** is equal to 1 if the CEO has a Master's degree or higher, and 0 otherwise. **Size** refers to the logarithm of firm total asset. **Growth** captures the percentage annual growth rate in sales. **Profit** is the ratio of earnings before interest payments and income taxes to total assets. **R&D%** is the R&D expenses to total assets. **Growth_oppo** is the market-to-book ratio. **CAPEX** captures the percentage of net fixed asset to total asset. **Div_cut** is a dummy equal to 1 if there is a reduction in annual dividend payout, and 0 otherwise. **Board_size** is the number of directors on the firm's board of directors. **%Female is** the proportion of female directors on the board. **Financial and COVID crisis** is equal to 1 if the firm-year observations fall in the period 2007–2009 and 2020–2021, and 0 otherwise. **GDP_growth** measures the percentage growth in GDP of each country, while **Inflation_rate** is the percentage annual change in the consumer price index (CPI) of each country. **Foreign_Inv** measures the percentage of GDP that is foreign direct investment for each country, and **Trade (% of GDP)** measures the percentage of each country's GDP derived from trade

[a]During times of economic growth, CEOs have more freedom to make decisions and may be more likely to take risks (DeYoung et al. 2013; Srivastav et al. 2018). For instance, firms with growing demand can benefit from taking risks to achieve quick growth and take advantage of new investment opportunities (Core and Guay 1999; Guay 1999)

omitted variables, and the lagged approach deals with any reverse causality from endogeneity. The GMM and 2SLS, on the other hand, are employed to tackle all three varieties of endogeneity (Ullah et al. 2018; Gretz and Malshe 2019). The results of the GMM model show that CEO pay slice (CEO power) recorded positive significant coefficients across all tested GMM models. Nevertheless, we employed the instrumental 2-stage least square (2SLS) approach as well. For its implementation, we adopt two instrumental variables: the median of CPS at the country and industry levels, and CEO retirement (Chintrakarn et al. 2015; Fan et al. 2021). The two key criteria of an instrumental variable (IV) are that the variable is (1) exogenous and (2) significantly related to the investigated explanatory variable, firm risk. The median value of CEO power (CPS) is employed by other studies (Chintrakarn et al. 2015). The rationale is that median CPS across each industry and country is likely to be positively related to the CPS of the firm, which may be because of similar criteria in the appointment of CEOs in that industry and country, and the relative compensation (relative power) assigned to CEOs should be similar. At the same time, the CPS median value is not a firm characteristic and is, hence, likely to be exogenous. We further employ CEO retirement as another instrumental variable, which carries a value of 1 if the time to retirement age of a CEO is less than two years or negative (beyond their retirement age). This variable is exogenous because its key determination is the country's retirement law and the biological age of the CEO. We predict that this factor is positively related to CEO power because the closer the time to retirement, the more experience CEOs have as a CEO in a corporate environment. Consequently, the higher power is accumulating. In our regression analysis, we report the results of the 2SLS estimator. In the first stage, we regress CEO power on the two IVs: retirement and CPS_med. The coefficients of CPS_med and CEO retirement are positive as expected, but the latter is not statistically significant. In the second stage, we regress firm risk variables on fitted values obtained from the first-stage regressions. All results show a positive and significant impact of CEO power on firm risk, and its components at the 1% level or below.

The GMM and 2SLS results imply that higher CEO power is expected to lead to higher firm risk. These findings are consistent with those of the baseline method, fixed effect, and lagged approach. Overall, the four alternative estimation models tackling the endogeneity issue presented in this section assure and confirm the findings obtained by the OLS baseline models, supporting the positive association between CEO power and risk.

Robustness checks are further conducted using three alternative measures of firm risk (the dependent variable) and clustered standard error at the firm level. These are the standard deviation of return on asset (STD-ROA), the bankruptcy risk (Z-score), and the accounting rate of return (ARR). Particularly, while the main measure of total risk (TR) focuses more on the fluctuation of stock values (the overall market value of shareholder's wealth), these three alternative measures of risk capture the accounting risk of firms. The results confirm the main finding that CEO power is positively associated with firm risk. Overall, this robustness test implies that firms awarding CEOs with more power tend to be exposed to higher risks from both book and market aspects.

Another robustness check is implemented with alternative independent variables (CEO power), using clustered standard error at the firm level. The first alternative measure is CEO duality (Lewellyn and Muller-Kahle 2012), which assumes that firms led by CEOs who are also the board chairperson tend to exhibit greater power compared to firms with separate CEOs and chairmen. The results show that firms led by a powerful CEO (proxied by CEO–chairperson duality) are exposed to higher risk than firms led by non-powerful CEOs. Consistently, this association is driven by idiosyncratic risk rather than systematic risk. Clearly, CEO power tends to influence firm-specific risk, primarily. Second, a firm's level of board independence is employed as another alternative measure of CEO power, which refers to the proportion of board members that are independent directors. This measure is a reverse proxy of CEO power, such that the higher the board independence value, the less power CEOs possess. The negative coefficients of the board independence variable across the three risk types support the positive effect of CEO power on firm risk, as found in the main findings and other tests. Nevertheless, the associations are statistically insignificant. Last, the study constructs an index for CEO power, which is the sum of three CEO-power dummy proxies: CEO pay slice (Cpower_D), CEO duality, and board independence. The results indicate that a one unit increase in the CEO power index will lead to an increase in total risk, idiosyncratic risk, and systematic risk. Overall, these findings confirm all the tests performed above, which support H1. All these results are not presented here to save space, but they are available from the authors.

3.8.4 GARCH and Fama and French 3-factor models[5]

To provide further assurance to the findings obtained from the baseline method, three additional risk measures are employed by using time-series characteristics (GARCH) for total risk and the Fama–French three-factor model for idiosyncratic risk and systematic risk following the literature (Bollerslev 1986; Fama and French 1993; Bello 2008; Ashley and Patterson 2010; Cotter et al. 2015; Li and Luo 2017).

The associations between CEO power and total risk (TR), idiosyncratic risk (Risk_Idio), and systematic risk (Risk_Sys) are captured in Columns 1–3 containing all variables described in Appendix (Table 9): CEO characteristics, firm characteristics, board characteristics, and microeconomics variables. The results confirm the main finding that CEO power is positively associated with firm risk. Decomposing total risk into idiosyncratic risk and systematic risk, the results in Columns 2 and 3 indicate that CEO power's positive influence on firm risk is mainly driven by its influence on firm-specific risk rather than on market risk. This can be drawn from the economic significance of the CEO power association with the two risk components. Overall, this robustness test implies that firms awarding CEOs with more power tend to be exposed to higher risks (Table 4).

3.8.5 Difference-in-difference approach (DiD)

For further insight into the association between CEO power and firm risk, we also investigate whether it may hold or differ during turbulences, such as the financial crisis of 2007 and the COVID-19 health crisis of 2020 (H2). The difference-in-difference (DiD) approach is employed for all three risk measures: total risk, idiosyncratic risk, and systematic risk, as explained earlier. The results are shown in Table 5. Looking at the coefficients of the two crisis dummies (Crisis_C and Crisis_F for the COVID crisis and the financial crisis), the positive and statistically significant coefficients indicate that firm risk tends to be higher during both crises by approximately 10–13% for total risk and idiosyncratic risk (Columns 1 and 2). This is understandable because, during turbulent times, corporations are exposed to greater uncertainty and, hence, their stock price fluctuates, symptomatic of firm risk. The economic significance of these two variables has two indications: (1) the risk level of firms is different (particularly, higher) in crisis compared to non-crisis and (2) the differences in firm risk between crisis and non-crisis are almost the same for both types of crises.

Nevertheless, when it comes to whether crises influence the association between CEO power and firm risk, a different interpretation is obtained. First, the Cpower_D yields consistently positive coefficients for all three risks. This indicates that firms run

[5] We sincerely thank the reviewer for the valuable suggestion to use the GARCH model for total risk and the Fama–French three-factor model for idiosyncratic and systematic risk.

by powerful CEOs are exposed to 2.5% greater risk compared to that of firms run by non-powerful CEOs (for total risk and idiosyncratic risk). This confirms the impact of CEO power on firm risk, which the study has confirmed thus far using different analyses. The interaction terms between the COVID crisis and CEO power and between the global financial crisis and CEO power are statistically insignificant. This implies that both financial and health crises do not exhibit statistically significant influences on the association between CEO power and risk. In other words, firms run by powerful CEOs remain exposed to 2.4% higher risk than firms run by non-powerful CEOs regardless of whether the firms are operating in crisis or non-crisis periods (either health or financial). The findings show that, if CEOs have great power and control over their firms, they are likely to exercise it in the same way, and perhaps their views and inclinations within risk-related decision making also remain the same (optimistic and overlooking uncertainty) during both normal operating and turbulent periods. Consequently, the economic, financial, or public health conditions behind the markets would not influence the association between CEO power and firm risk.

3.8.6 Subsample approach[6]

The study also repeats the tests with four subsamples to check for changes in the results. The OLS models with clustered standard error at the firm level (Eq. 3) are performed on four subsamples: financial crisis, non-financial crisis, COVID, and pre-COVID samples. By performing on crisis and non-crisis subsamples, four coefficients of CEO power (CPS) in each subsample are obtained. Subsequently, Chow's test is performed to examine whether those CEO power coefficients are statistically different across different subsamples. The results are provided in Table 6.

Regarding the association between CEO power and risk, between financial crisis and non-financial crisis, two CPS coefficients, 0.132 and 0.085 (p value <0.1 and 0.05, respectively), indicate that during the financial crisis periods, everyone per cent increase in CEO power leads to a 13.2% increase in firm total risk. However, during the non-financial crisis period, such an impact fall to 8.5%. Clearly, the positive impact of CEO power on firm risk remains relatively similar across both financial and non-financial crises. This finding is consistent with the DiD approach.

However, findings obtained for the health crisis show that CEOs seem to only exercise their power to increase firm risk during pre-COVID times ($\beta_{CPS}=0.101$, p value <0.01, Table 5, Column 4). However, during the pandemic, CEO power lost its influence on firm risk ($\beta_{CPS}=0.015$, insignificant, Table 6, Column 3). According to Chow's test, the difference in the relationship between CEO power and firm risk during COVID and pre-COVID periods is statistically significant.

Overall, using the subsample method, H2 is supported in that the positive effects of CEO power on firm risk are negatively moderated by crises. However, the effects are different between the global financial crisis of 2007 and the global health crisis of 2020. Particularly, CEO power loses its effect on firm risk during the COVID crisis but remains

[6] We performed an additional analysis considering two years before the COVID-19 pandemic started (2018 and 2019) and during the pandemic (2020 and 2021). We obtained consistent results that further support our main findings that CEOs seem to only exercise their power to increase firm risk during pre-COVID times. This suggests that CEOs may practice with more caution during a novel crisis such as COVID-19, compared to normal times. All these results are not presented here to save space, but they are available from the authors.

Table 4 Alternative measures of risk: GARCH and Fama and French 3-factor models

Variable	(1) TR TR	(2) Risk_Idio Risk_Idio	(3) Risk_Sys Risk_Sys
CPS	0.0309***	0.0465***	0.0016***
	(0.012)	(0.017)	(0.000)
Controls	Yes	Yes	Yes
Constant	0.2768***	0.2789***	0.0019
	(0.072)	(0.101)	(0.001)
Year fixed effect	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
country fixed effect	Yes	Yes	Yes
Observations	9,540	10,387	10,387
R-squared	0.189	0.147	0.223

The table presents the results of the associations between CEO power and firm risk using alternative measures of risk inferred from the GARCH and Fama and French 3-factor models. **TR** refers to the firm total risk, i.e., the volatility estimated by GARCH (1,1) model. **Risk_Sys** refers to the market risk, measured by extracting the beta value of the market premium in the Fama–French 3-factor model. **Risk_Idio** refers to the idiosyncratic risk, measured by the standard deviation of the residuals obtained from the Fama–French 3-factor model. **CPS** captures the percentage of a CEO's total compensation to the total compensation of the top five executives in each firm. **CEO_Age** is the biological age of the CEO (in years). **CEO_ female** equals 1 if the CEO is female, and 0 otherwise. **Delta** is the natural logarithm of the change in dollar value of a CEO's wealth for a one percentage point change in stock price. **CEO_Tenure** is the natural logarithm of the number of years the CEO has held the position. **CEO_Edu** is equal to 1 if the CEO has a Master's degree or higher, and 0 otherwise. **Size** refers to the logarithm of firm total asset. **Growth** captures the percentage annual growth rate in sales. **Profit** is the ratio of earnings before interest payments and income taxes to total assets. **R&D%** is the R&D expenses to total assets. **Growth_oppo** is the market-to-book ratio. **CAPEX** captures the percentage of net fixed asset to total asset. **Div_cut** is a dummy equal to 1 if there is a reduction in annual dividend payout, and 0 otherwise. **Board_size** is the number of directors on the firm's board of directors. **%Female is** the proportion of female directors on the board. **Financial and COVID crisis** is equal to 1 if the firm-year observations fall in the period 2007–2009 and 2020–2021, and 0 otherwise. **GDP_growth** measures the percentage growth in GDP of each country, while **Inflation_rate** is the percentage annual change in the consumer price index (CPI) of each country. **Foreign_Inv** measures the percentage of GDP that is foreign direct investment for each country, and **Trade (% of GDP)** measures the percentage of each country's GDP derived from trade

unchanged during financial crisis and non-financial crisis. As explained above, CEOs with more power tend to be more optimistic and underestimate the uncertainty involved with their risk-related decision making, leading to riskier decisions and, hence, higher risk outcomes. Nevertheless, it is sensible that, during turbulence, CEOs should be much more cautious with their risk decision making due to the surrounding uncertainty caused by the crisis. As a result, CEOs with more power should be more cautious and conservative in

Table 5 CEO power and firm risk across financial and health crises—difference-in difference (DiD)

Variable	TR	Risk_Idio	Risk_Sys
Cpower_D	.024***	.023***	.002***
	(.007)	(.009)	(0.000)
cpower_covid	− .018	− .016	− .001
	(.468)	(.525)	(.787)
Crisis_C	.119**	.125**	− .009
	(.039)	(.034)	(.107)
cpower_crisis	.018	.016	.002
	(.222)	(.29)	(.186)
Crisis_F	.13***	.127***	.008*
	(.006)	(008)	(.083)
Controls	Yes	Yes	Yes
Constant	− 1.503***	− 1.43***	− 2.377***
		(0.000)	(0.000)
Year fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes
Observations	12,836	12,685	12,685
R-squared	0.244	0.256	0.451

The table presents the results of the associations between CEO power and firm risk during the global financial crisis and COVID crises, in comparison to non-crisis periods using the difference-in-difference (DiD) approach. **TR** refers to the firm total risk measured by the natural logarithm of the standard deviation of an individual firm's daily stock returns yearly, **Risk_Idio** refers to the firm idiosyncratic risk measured by the natural logarithm of the standard deviation of the residuals obtained from the single-index market model, and **Risk_Sys** refers to the market risk measured by the natural logarithm of the difference between TR and Risk_Idio. **Cpower_D** is a dummy variable valued at 1 if the CEO pay slide (CPS) is greater than the median value of the sample, and 0 otherwise. **Crisis_C** and **Crisis_F** capture the financial and COVID crises and are equal to 1 if the firm-year observations fall in the period 2007–2009 and 2020–2021, and 0 otherwise. **CEO_Age** is the biological age of the CEO (in years). **Cpower_covid** is the interaction term between the Cpower_D and the Crisis_C. **Cpower_crisis** is the interaction term between Cpower_D and Crisis_F. **CEO_ female** equals 1 if the CEO is female and 0 otherwise. **Delta** is the natural logarithm of the change in dollar value of the CEO's wealth for a one percentage point change in stock price. **CEO_Tenure** is the natural logarithm of the number of years the CEO has held the position. **CEO_Edu** is equal to 1 if the CEO has a Master's degree or higher, and 0 otherwise. **Size** refers to the logarithm of firm total asset. **Growth** captures the percentage annual growth rate in sales. **Profit** is the ratio of earnings before interest payments and income taxes to total assets. **R&D%** is the R&D expenses to total assets. **Growth_oppo** is the market-to-book ratio. **CAPEX** captures the percentage of net fixed asset to total asset. **Div_cut** is the dummy 1 if there is a reduction in annual dividend payout, and 0 otherwise. **Board_size** is the number of directors on the firm's board. **%Female** is the proportion of female directors on the board. **GDP_growth** measures the percentage growth in GDP of each country. **Inflation_rate** is the percentage annual change in the consumer price index (CPI) of each country. **Foreign_Inv** measures the percentage of GDP that is foreign direct investment for each country, and **Trade (% of GDP)** measures the percentage of each country's GDP arising from trade

their risk-related decision making during the crises. Nevertheless, the moderating effects are only recorded for the COVID crisis but not the financial crisis.

The inconclusive findings between the two methods (DiD OLS and subsample OLS) are partially due to the different analytical methods and measures employed. Particularly, for the DiD, CEO pay slice (CPS) is converted into a dummy, while the subsample methods employ the original CPS. Therefore, additional checks are performed to clarify the findings and draw a conclusion on the matter. Specifically, with the same use of the dummy CEO

Table 6 CEO power and firm risk across financial and Covid crises – Sub-sample regressions

Variable	Financial Crisis versus Non-Financial crisis	COVID and non-COVID crisis		
	(1)	(2)	(3)	(4)
	Financial Crisis	Non-Financial crisis	COVID	Non−COVID
CPS	.132*	.085**	.015	.101***
	(.069)	(.023)	(.889)	(.003)
Controls	Yes	Yes	Yes	Yes
Constant	− 1.543*	− 1.685***	− 1.064***	− 1.595***
	(.081)	(0.000)	(0.000)	(0.000)
Year fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
country fixed effect	Yes	Yes	Yes	Yes
Observations	2671	10,165	967	11,869
R-squared	0.215	0.261	0.292	0.245
Chow test	F (2, 1540) = 13.42***	F (2, 1540) = 7.51***		

The Table presents the results of the associations between CEO power and firm risk during the global financial crisis and COVID-19 crisis, using sub-samples of financial crisis, non-financial crisis, COVID and non-COVID periods (together with Chow's test). The dependent variable employed is **TR** which refers to the firm total risk measured by the natural logarithm of the standard deviation of an individual firm's daily stock returns yearly. **CPS** is the percentage of a CEO's total compensation to the total compensation of the top-five executives in each firm. **CEO_Age** is the biological age of the CEO (in years). **CEO_ female** takes the value 1 if the CEO is female, and 0 otherwise. **Delta** the natural logarithm of the change in dollar value of a CEO's wealth for a one percentage point change in stock price. **CEO_Tenure** is the natural logarithm of the number of years the CEO has held the position. **CEO_Edu** equals 1 if the CEO has a master's degree or higher, and 0 otherwise. **Size** refers to the logarithm of firm total asset. **Growth** captures the percentage annual growth rate in sales. **Profit** is the ratio of earnings before interest payments and income taxes to total assets. **R&D%** is the R&D expenses to total assets. **Growth_oppo** is the market-to-book ratio. **CAPEX** captures the percentage of net fixed asset to total asset. **Div_cut** is a dummy equal to 1 if there is a reduction in annual dividend payout, and 0 otherwise. **Board_size** is the number of directors on the board. **%Female** is the proportion of female directors on the board. **Financial and COVID crisis** is set at 1 if the firm-year observations fall in the period 2007–2009 and 2020–2021, respectively, and 0 otherwise. **GDP_growth** measures the percentage GDP growth of each country, **Inflation_rate** is the percentage annual change in the consumer price index (CPI) of each country. **Foreign_Inv** is the percentage of GDP that is foreign direct investment in each country, and **Trade (% of GDP)** is the percentage of each country's GDP stemming from trade

power, we employ the DiD with propensity score matching (PSM) to retest for both H1 and H2.

3.8.7 Difference-in-difference (DiD) with propensity score matching (PSM)

We further employ the propensity score matching (PSM) approach to re-examine the influences of CEO power on firm risk. PSM tackles sample selection bias. More specifically, according to the logistic test with the CEO power dummy as the dependent variable, the powerful CEO sample tends to be younger, female, and with lower tenure, employed by smaller firms, to mention a few. This implies that the powerful CEO sample may possess distinct characteristics that may contribute to higher firm risk, instead of the CEO power effect per se. Furthermore, we also conduct the same model on the difference subsample: financial crisis, non-financial crisis, COVID, and non-COVID crisis, based on which difference-in-difference statistics are computed to examine the differences in the association between CEO power and risk across different turbulences. The results are presented in Table 7.

First, we test for the ‘balancing property’ of the match using the Rubin’s B and the Rubin’s R (Rosenbaum and Rubin 1985). According to Rubin (2001), for a successful and effective matching, Rubin’s B should be lower than 25% and Rubin’s R lies between 0.5 and 2. Our results were 18.5% for Rubin’s B and 0.84 for Robin’s R. In Panel A, the result indicates that, after matching powerful CEOs with non-powerful CEOs of the same characteristics (matched by propensity score), the average firm risk of the powerful CEO sample is significantly higher than that of the matched non-powerful CEO sample ($\mathbf{\Delta} = 0.0248$, *p*value < 0.01). This confirms the main findings from the baseline OLS estimation and various robustness checks (Sect. 3.8.2, 3.8.3, and 3.8.4). Once again, the PSM result supports H1 in that firms led by powerful CEOs exhibit higher risk than those led by non-powerful CEOs.

Re-examining H2 on the moderating effect of CEO power on firms, we use a DiD approach with PSM. The results are shown in Panels B and C for the financial crisis and for the COVID crisis, respectively. For the financial crisis, firms led by powerful CEOs are associated with higher risk for both crisis and non-crisis periods ($\mathbf{\Delta} = 0.0396$ and 0.0247, *p* value < 0.05). Using the DiD method, the difference in the CEO power effect between crisis and non-crisis is statistically insignificant (Δcrisis–Δnon-crisis = 0.01494, ns). This shows that the effect of CEO power on risk remains unchanged for both crisis periods, which is consistent with the DiD OLS and subsample OLS models. Regarding the COVID health crisis (Table 6, Panel C), consistent with the subsample approach (Sect. 3.8.6), CEO power only increases firm risk during a non-COVID crisis and has no significant effect on firm risk during the COVID crisis ($\Delta_{covid} = 0.0184$, ns; $\Delta_{non\text{-}covid} = 0.0293$, *p* value < 0.01). Computing the DiD t-statistic, the difference in a CEO power effect between health crisis and non-health crisis is statistically significant at the 1% level (Δ_{covid}–$\Delta_{non\text{-}covid} = -0.0109$, *p* value < 0.01).

Overall, after employing several tests on the moderating effects of crises, separating financial from health crises, it is concluded that crises tend to mitigate the effects of CEO power on firm risk. As explained in previous sections, during turbulence, CEOs are less optimistic and confident with market conditions due to excessive uncertainty, and so are more cautious and reluctant to exercise their power to increase firm risk. This supports our second hypothesis.

However, this phenomenon only occurs for the COVID health crisis, which may be because of its sudden, unexpected, and unfamiliar nature to corporations and economies. Without much reference and experience in dealing with such crises, executives faced challenges in predicting uncertainties. This put upward pressure on CEOs in strategic decision making, causing their reluctance in committing to higher risk. For the financial crisis, although the consequences of the crisis were and continue to be prominent and contagious, the nature of the crisis is not a new concept and, in many circumstances, not so unpredictable. Therefore, powerful CEOs’ optimism and confidence remains.

3.8.8 CEO power and firm risk and moderation (BGD): OLS cluster at firm level.

Table 8 shows the results of the influences of CEO power on firm risk and moderation (BGD): that was performed using the OLS model with clustered standard error at the

Table 7 Propensity score matching (PSM) on CEO power and risk—moderating effects of **crises**

			Treated	Control	Δ	S.E	T-stat
Panel A: PSM on CEO power and firm risk							
Full sample	TR	Unmatched	− 2.0445	− 2.0074	− 0.0371***	0.0058	− 6.29
		Matched-ATT	− 2.0444	− 2.0693	0.0248***	0.0090	2.75
Panel B: Difference-in-difference with PSM: financial and non− financial crisis							
Financial Crisis	TR	Unmatched	− 1.9790	− 1.9592	− 0.0199	0.0141	− 1.41
		Matched-ATT	− 1.9792	− 2.0188	0.0396**	0.0195	2.03
Non-financial Crisis	TR	Unmatched	− 2.0558	− 2.0144	− 0.0414***	0.0069	− 5.99
		Matched-ATT	− 2.0558	− 2.0806	0.0247**	0.0102	2.42
DiD (Δcrisis−Δnon-crisis)	0.01494		0.65				
Panel C: Difference-in-difference with PSM: COVID and non− COVID crisis							
COVID Crisis	TR	Unmatched	− 1.9519	− 1.8993	− 0.0527**	0.02676	− 1.97
		Matched-ATT	− 1.9519	− 1.9704	0.01840	0.03781	0.49
Non-COVID Crisis	TR	Unmatched	− 2.0459	− 2.0130	− 0.0329***	0.0064	− 5.17
		Matched-ATT	− 2.0459	− 2.0752	0.0293***	0.0091	3.21
DiD (Δcrisis−Δnon-crisis)	− 0.0109		2.803***				

The table presents the PSM results of the average treatment effects (ATE) and the average treatment effect on the treated (ATT) with 1:1 matching. The ATE and ATT of CEO power on firm risk (Δ) are estimated by the difference between the mean changes of firms with powerful CEOs (Column "Treated") and that of matched firms with non-powerful CEOs (Column "Non-treated"). T-statistics with robust standard errors are in the final column. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

firm level from 2006 through to 2021. The results across the three columns show consistent findings for H3 based on the coefficients of CPS (β1, test for H1), and of CPS_BGD (β2, test for H3). Particularly, coefficient β1 consistently reveals positive values, which are statistically significant at the 1% level or below for total risk, idiosyncratic risk, and systematic risk. This indicates the positive association between CEO power and firm risk, supporting H1. Specifically, based on the β1 of columns(β1 = 0.126, 0.121, and 0.013, respectively), the results indicate that, for every one per cent increase in CEO power (measured by a one per cent increase in the CEO's pay, relative to the total pay of the top five directors), total risk increased by approximately 13%, idiosyncratic risk increased by approximately 12%, and systematic risk increased by approximately 1.3%. This indicates a consistent finding on the positive association between CEO power and firm total risk, consistent with H1.

Regarding H3, the coefficients of the interaction term between CPS × BGD show a significant impact. Specifically, the coefficients of CPS_BGD (β2) are negative and statistically significant at the 10% level or below for total risk, idiosyncratic risk, and systematic risk. The finding supports the agency theory view that the presence of women directors can enhance board independence, improve the effectiveness of oversight functions (Carter et al. 2010), and thus curb the opportunistic, self-serving behavior of managers. The findings also support the assumption that women tend to approach risk assessment more cautiously than men do (Zalata et al. 2018). These points suggest that companies with gender-diverse boards exhibit robust governance and are more inclined to enhance board oversight of CEO decisions. Consequently, in firms where the CEO has power, board gender diversity exhibits a positive association with a reduction in firm risk, as women directors are more likely to reduce risk and improve corporate financial stability through their conservative assessment of CEOs' risk decisions.

3.8.9 Additional analysis: CEO power on firm risk across non-financial and financial firms and CEO power and firm risk across firms with different growth opportunity and R&D expenses

We provide additional analysis. The results are not provided to save space but are available on request from the authors. We provide the differences in the effect of CEO power and firm risk across non-financial firms and financial firms. The results indicate that the association between CEO power and firm risk is statistically significant and positive only in the non-financial firms. In other words, the findings obtained thus far are driven mainly by the non-financial firms. The reason may be that financial firms are strictly followed by analysts and are exposed to considerable regulations and guidelines.

Last, we extend the analysis to examine the effects of CEO power on firm risk across different levels of a firm's current R&D expenses, and growth opportunity. The results show that the positive effects of CEO power on firm risk remain unchanged across high-growth and low-growth firms. Nevertheless, the effect is weakened for high-growth firms, i.e., with lower economic significance. In other words, CEOs exercise their power to increase firm risk more strongly if the firms possess low growth opportunity. This may be because higher risk is often associated with higher returns so CEOs with power are more optimistic and confident that they can increase the growth rate of their low-growth firms by taking on higher risk.

In terms of R&D expense, the positive association between CEO power and firm risk is mainly driven by firms with low R&D expenses. The reason lies in the risk-taking capacity of firms, which is linked to their R&D expenditure (Yung and Chen 2018). Firms having low R&D expenditure signifies a lower risk level (higher risk-taking capacity) in comparison to high R&D spending firms. Therefore, with a greater risk capacity, powerful CEOs can be more confident in employing their power to increase firm risk for higher firm performance.

4 Conclusions

This paper investigates the influence of CEO power on firm risk in an international context during the 2007 global financial crisis and the COVID-19 crisis. The study combined agency theory with the behavioral agency model and the inhibition/approach theory to explain the relationship between CEO power and firm risk using G7-listed firms. Cross-country panel data of 12,836 firm-year observations covering the period from 2006 to 2021 are employed. The study provides empirical evidence of a significant

Table 8 Influences of CEO power on firm risk and moderation (BGD)

Variable	(1) TR	(2) Risk_Idio	(3) Risk_Sys
CPS	0.1256***	0.1206***	0.0136***
	(0.043)	(0.041)	(0.002)
CPS_BGD	− 0.2844*	− 0.2656*	− 0.0544***
	(0.162)	(0.147)	(0.009)
BGD	− 0.0431	− 0.0382	0.0070**
	(0.051)	(0.053)	(0.003)
Controls	Yes	Yes	Yes
Constant	− 1.6236***	− 1.5055***	− 2.4319***
	(0.146)	(0.146)	(0.009)
Year fixed effect	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
country fixed effect	Yes	Yes	Yes
Observations	12,836	12,685	12,685
R-squared	0.251	0.263	0.465

The table presents the results of the estimation of baseline methods (OLS) with clustered standard error at the firm level from 2006 through to 2021. The dependent variables are total risk (TR) presented in column 1; idiosyncratic risk (Risk_idio) presented in Column 2; and systematic risk (Risk_Sys) presented in Column 3. **TR** refers to the firm total risk measured by the natural logarithm of standard deviation of individual firm's daily stock returns yearly, **Risk_Idio** refers to the firm idiosyncratic risk measured by the natural logarithm of standard deviation of the residuals obtained from the single-index market model and, **Risk_Sys** refers to the market risk measured by the natural logarithm of the difference between TR and Risk_Idio**. CPS** captures the percentage of CEO's total compensation to the total compensation of the top five executives in each firm. **CPS_BGD** the interaction term between CEO pay slice and board gender diversity. **CEO_Age** biological age of the CEO (in years). **CEO_ female** denotes 1 if the CEO is female, and 0 otherwise. **Delta** is the natural logarithm of the change in dollar value of CEOs' wealth for one percentage point change in stock price. **CEO_Tenure** the natural logarithm of the number of years the CEO has held the position. **CEO_Edu** 1 if the CEO has a Master's degree or above and 0 otherwise. **Size** refers to the logarithm of firm total asset. Growth captures % annual growth rate in sales. Profit is the ratio of earnings before interest payments and income taxes to total assets. R&D% is research and development expenses to total assets. **Growth_oppo** Market-to-book ratio. **CAPEX** captures % of net fixed asset to total asset. **Div_cut** dummy 1 if there is a reduction in annual dividend payout, and 0 otherwise. **Board_size** the number of directors on the firm board of directors. % **Female** the fraction of female directors on board. **Financial and Covid crisis** 1 if the firm-year observations fall in the period 2007–2009 and 2020–2021, respectively, and 0 otherwise**. GDP_growth** measures the % GDP growth (economic growth) of the countries, **Inflation_rate** is the % annual change in the consumer price index (CPI) of the countries. **Foreign_Inv** measures the % of foreign direct investment of GDP of the countries, and **Trade (% of GDP)** measures the percentage of the countries' trade of their GDP positive relationship between CEO power and three types of firm risk—total risk, idiosyncratic risk, and systematic risk. The economic significance is more pronounced for total risk and idiosyncratic risk, indicating a positive influence of CEO power on firm risk being mainly driven by firm-specific risk. The data were obtained from multiple sources; namely, DataStream, BoardEx, the World Bank, and the International Monetary Fund. Lewellyn and Muller-Kahle (2012) recommended further research into the power of CEOs through developing a measure of possible sources of their compensation and power. Accordingly, this study adopts CEO compensation (CPS) and confirms the results of Lewellyn and Muller-Kahle (2012) and Sheikh (2019).

Our findings confirm these two studies conducted on firm samples, concluding that CEO power is significantly positively correlated with firm risk. Extending their findings, this study also finds that the association between CEO power and risk is stronger in non-crisis periods. This suggests that power may allow and incline CEOs to take more risk in times of financial stability and discourage them (or at least encourage caution) from taking risk during crises. This argument complements the premise of the behavioral agency model together with the inhibition/approach theory, that CEOs' risk-taking behavior increases with power due to their propensity to be optimistic in their perceptions of risk (Anderson and Galinsky 2006). A distinction is made between the 2007 global financial crisis and the 2020 COVID crisis. Particularly, the increased risk with CEO power remains relatively unchanged across financial crises and non-financial crises. However, such an effect only remains during non-COVID crises and disappears during COVID crises. This may be because the optimism and confidence of powerful CEOs is reduced during turbulence that they are unfamiliar with and have no reference to or experience of, which was the case with COVID. Conceivably, CEOs with power are more reluctant to increase firm risk during new or 'strange' occurrences like a pandemic. It is possible that, if there is a similar public health crisis in the future, the association between CEO power and firm risk will be detected since the health crisis then becomes an 'old' phenomenon that they know about. Moreover, this study further investigates the mitigating role of Board Gender Diversity (BGD) on the relationship between CEO power and firm risk. It provides essential insights into corporate governance, revealing how gender diversity within boards can influence governance dynamics and decision-making, particularly in risk management and CEO power.

The findings of this study offer international empirical evidence for the relationship between CEO power and firms' risk-taking, which has several implications in practice, particularly for firms, current and potential investors, and regulators or policymakers. For example, policymakers can use our evidence as a proactive tool to anticipate the impact of crises on investors and markets by analyzing how CEO power affects corporate risk. Regulators may also establish improved rules and regulations to minimize risk and prevent future turbulence. Firms and investors can enjoy deeper insights into how to manage risks associated with powerful CEOs, based on the mentioned recommendations. Hence, this study is helpful for enhancing senior managers' hiring criteria, and understanding the risks associated with powerful CEOs during crises. Furthermore, as shown in this study, power helps to reduce extremely conservative attitudes in the risk-taking of CEOs. Such risk-aversion appears to be detrimental to shareholders' wealth accumulation. As the key findings of this study demonstrate, CEO power is more likely to cause firm risk to increase, in line with the findings of Finkelstein and Hambrick (1996) and Lewellyn and Kahle (2012). In this respect, the board of directors and top management are encouraged to delegate more power to CEOs to achieve positive outcomes and meet firms' objectives. This is because CEO power is expected to work effectively and achieve a reasonable return on investment. However, they should reduce authoritarian CEOs' power and adopt strict corporate governance as appropriate to realize firms' potential and restrict CEOs' risk-based compensation. At the same time, the demonstrated positive relationship between CEO power and risk acts as a wake-up call for any management layers in a corporation—particularly the board of directors—to pay more attention to the risk-taking by powerful CEOs and assure value-enhancing risk-taking strategies, because higher risk can eventually lead to excessive risk, which is detrimental to firms if not under cautious surveillance. Similar signals and alerts are sent to other stakeholders, including shareholders and regulators, that put upward pressure on firms led by powerful CEOs. This is because the evidence provided serves as a stable governance tool that enables firms' top management teams to impose vigilant monitoring to maximize corporate profit and reduce costs related to risk-taking; investors to employ more rigid analyses of firms' risk-taking behaviors; and policymakers to apply relevant and prudential governance regulations related to risk, enhancing the health and sustainability of corporate environments and financial markets (Lewellyn and Muller-Kahle 2012).

Furthermore, the empirical evidence offered in this study enhances international boards and other senior decision makers' awareness and consideration of the relationship between CEO power and firm risk under the influence of worldwide health and financial crises (Sheikh 2019). Policymakers constantly attempt to influence legislation to impose monitoring policies on firm activities, including risk-taking (Sheikh 2019), specifically during or after times of crisis. The 2007 financial crisis and the 2020 COVID-19 pandemic are among the riskiest events since the Great Depression of 1929–1932 (Moschonas 2020) and these two reveal the sheer vulnerability of the global economy and its impact on corporate risk-taking. Therefore, it is more critical to evaluate and critically examine the determinants of firm risk today than ever before. Regarding the third hypothesis (H3), the results presented show a significant impact of the BGD. Specifically, the coefficients for the BGD are negative and statistically significant at the 10% level or higher for total risk, idiosyncratic risk, and systematic risk. These points suggest that companies with gender-diverse boards exhibit robust governance and are more inclined to enhance board oversight of CEO decisions. Consequently, in firms where the CEO has power, board gender diversity exhibits a positive association with a reduction in firm risk, as women directors are more likely to reduce risk and improve corporate financial stability through their conservative assessment of CEOs' risk decisions.

Appendix

See Table 9.

Table 9 Definitions and measures of controlling variables

Variables (abbreviation)	Definitions and measures	Citations
Firm size (SIZE)	Firm total asset = ln(TA)	Yung and Chen (2018), Bernile et al. (2018), Coles et al. (2006)
Sales growth (Growth)	Annual growth rate in sales = $\ln\left(\frac{Sale_T}{Sale_{T-1}}\right)$	Yung and Chen (2018), Fan et al. (2021)
Profitability (Profit)	Corporate earnings = $\frac{Earnings\ before\ interest,\ tax,\ depreciation,\ amortisation}{Total\ asset}$	Yung and Chen (2018), Bernile et al. (2018)
R&D expense (R&D%)	% research and development expense to total asset = $\frac{R\&D\ expense}{Total\ asset}$	Yung and Chen (2018), Bernile et al. (2018), Coles et al. (2006)
Growth opportunity	Market-to-book value ratio	Yung and Chen (2018), Coles et al. (2006), Bernile et al. (2018)
Asset tangibility (CAPEX)	% net fixed asset to total asset = $\frac{Net\ PPE}{Total\ asset}$	Yung and Chen (2018), Bernile et al. (2018), Coles et al. (2006)
Market leverage (Leverage)	% of debt financing to firm market value = $\frac{Short-term\ debt+Long-term\ debt}{Total\ assets\ -\ Book\ equity\ +\ market\ equity}$	Yung and Chen (2018), Bernile et al. (2018), Coles et al. (2006)
Surplus cash (Cash_surp)	% surplus cash to total asset = $\frac{Operating\ net\ cash\ flow-Depreciation\ and\ Amortisation+R\&D\ expense}{Total\ Assets}$	Yung and Chen (2018), Bernile et al. (2018), Fan et al. (2021)
Dividend cut (Div_cut)	Dummy variable taking the value of 1 if there is a reduction in annual dividend payout, and 0 otherwise	Yung and Chen (2018)
Board size (Board_size)	Number of directors on the firm board of directors	Yung and Chen (2018), Fan et al. (2021)
Female representation (%female/BGD)	The fraction of female directors on board	Chen et al. (2019), Liu, Tian, and Zhang (2023)
CEO age (CEO_Age)	The biological age of the CEO (in years)	Coles et al. (2006), Fan et al. (2021), Serfling (2014)
CEO tenure (CEO_Tenure)	Number of years that the CEO has been holding their position	Coles et al. (2006), Hirshleifer et al. (2012), Onali, et al. (2016), Lo and Shiah-Hou (2022)
CEO gender (CEO_fem)	Dummy variable taking the value of 1 if the CEO is female, and 0 otherwise	Fan et al. (2021), Liu, Tian, and Zhang (2023)
CEO wealth delta (Delta)	The change in dollar value of the CEO's wealth for one percentage point change in stock price	Yung and Chen (2018), Coles et al. (2006)
CEO education (CEO_Edu)	Dummy variable taking the value of 1 if the CEO has a Master's or higher, and 0 otherwise	Fan et al. (2021), Kim and Lu (2011)
Financial crisis (Crisis_F)	Dummy variable taking the value of unity if the firm-year observations fall in the GFC period 2007–2009, and 0 otherwise	Demirguc-Kunt et al. (2013)
COVID crisis (Crisis_C)	Dummy variable taking the value of unity if the firm-year observations fall in the COVID-19 crisis period 2020–2021, and 0 otherwise	Garel and Petit-Romec (2021)

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