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Firm climate change risk and financial flexibility: Drivers of ESG performance and firm value

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This study investigates how a firm's climate change risk (FCCR) and financial flexibility (FIFL) affect its value and environmental, social, and governance (ESG) performance. We use data from publicly listed US firms for 2012–2021. We employed four estimation methods: bootstrap quantile regression, feasible generalised least squares, a generalised method of moments, and fixed effects with Driscoll-Kraay standard errors. Our main findings indicate that climate change risk has a negative effect on firm value and a positive effect on ESG performance and that financial flexibility moderates these effects by reducing risk and enhancing value. These results are robust against alternative measures and estimation techniques. Our study provides novel insights into the influence of climate risk and financial flexibility on firm value and ESG performance. We also discuss the implications of our results for academics, practitioners, and policymakers.

1. Introduction

Recent publications indicate that extreme climate change is among the most pressing global concerns (World Economic Forum, 2019), with a projected financial burden of approximately $1 trillion for firms due to climate risk (Roston, 2019). The US economy is at significant risk, with potential negative impacts of up to 10% by the end of the century (Huang & Lin, 2022). To address these risks, Corporate Social Responsibility (CSR) initiatives, such as environmental sustainability efforts and also environmental, social, and governance (ESG) rating improvement, are gaining importance (Huang & Lin, 2022; Naeem et al., 2022). Recently, sustainable investments have experienced remarkable growth, increasing by over 269% worldwide since 2016 (GSIA, 2018). According to the US Sustainable Investment Foundation's (SIF) 2020 report, sustainable investing assets will account for $17.1 trillion in the total US assets under professional management in 2020, a remarkable increase of more than 40% from the start of 2018. Financial markets demonstrate an apparent positive consideration of ESG scores in investors' capital allocation decisions (Hartzmark & Sussman, 2019). Despite this favourable perception, investors and academia are still engaged in an ongoing debate regarding the impact of a firm's participation in ESG practices and its overall value (Fuente et al., 2022). Recent research emphasises the need for more refined theoretical efforts to understand the insurance mechanisms underlying this firm strategy and its connection to firm value (Wang et al., 2020).

In this context, financial flexibility (FIFL) is crucial for companies navigating uncertain climates. Firms with greater FIFL can invest in expansion opportunities, withstand economic shocks, and achieve sustainable growth (Teng et al., 2021). It is considered a critical factor in resolving firms' climate change risk (FCCR) and achieving long-term value. However, empirical evidence on the relationship between FCCR, FIFL, firm value, and ESG performance is lacking (Li et al., 2022). Existing research has focused mainly on ESG and financial performance in equity markets, leaving room to explore the relationship between risk and ESG performance.

Nevertheless, research shows that highly sustainable enterprises are

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more resilient during turbulent times (Broadstock et al., 2021). However, the complex nature of climate change impacts presents challenges in assessing specific business vulnerabilities, and individual differences in accepting climate change risks remain, with some doubts regarding the existence of global warming (Huang & Lin, 2022). To address this gap, Sautner et al. (2023) develop time-varying metrics for firm-level climate risk exposure, reflecting management and analyst perceptions gathered from earnings conference call transcripts. Because climate change poses significant challenges for firms, understanding the relationship between FCCR and FIFL, firm value, and ESG performance is crucial. Empirical studies and pioneering metrics are vital for advancing knowledge and guiding sustainable business strategies. Recently, significant research has explored the impact of climate risk on corporations, financial institutions, and national governments, and the pricing and hedging of climate-related risks (Shea et al., 2020). Several studies have contributed to the growing body of literature on climate finance by emphasising the importance of ESG in enhancing product differentiation and corporate risk management (Lins et al., 2017; McWilliams & Siegel, 2001). The literature suggests that increasing environmental and social initiatives can help companies navigate economic downturns and build moral and social capital as 'insurance' against unique risks (Deng et al., 2013; Ferrell et al., 2016; Griffin et al., 2021; Walker et al., 2019). However, further research is needed to explore the relationship between FCCR, ESG, and firm value (Ozkan et al., 2022; Starks, 2023). Consequently, there is a potential gap for future researchers to delve deeper into these areas and conduct further studies. Considering this opportunity, this study was driven by several factors. Corporate sustainability is a complex and frequently discussed topic that has attracted significant attention from researchers and policymakers (Guo et al., 2020; Hartzmark & Sussman, 2019; Hossain & Masum, 2022; Lins et al., 2017; Magrizos et al., 2021; Ozkan et al., 2022; Shahzad et al., 2022). Therefore, it is crucial to address these challenges. Second, investors rely on market parameters for their investment decisions (Fuente et al., 2022). Although traditional performance measures have been extensively used, they can also be influenced by accounting philosophies. Incorporating an ESG matrix with firm value is essential for a more comprehensive view. Finally, recent scholarly investigations have advocated examining the moderating factors that influence this association in varying ways among different organisations (Fuente et al., 2022; Magrizos et al., 2021).

This study addresses this gap by investigating the impact of FCCR on firm value and ESG performance. We also examined the influence of the FIFL on firm value and ESG performance. Furthermore, we explore the potential moderating role of the FIFL in the relationships between FCCR, firm value, and ESG performance. The primary objective of our study is to enhance the understanding of how FCCR and FIFL influence company value and ESG performance. Through our analysis, we seek to shed light on the strategic use of FIFL to address the challenges posed by FCCR effectively. To achieve our objectives, we analysed a sample of 1529 publicly listed US companies from 2012 to 2021. Our results indicate a negative and statistically significant relationship between FCCR and firm value, and a positive relationship with ESG performance. Moreover, FIFL positively affects firm value and ESG performance. Notably, FIFL is a moderating factor that reduces FCCR and enhances a firm's overall performance.

Our paper makes significant contributions to the existing literature in several ways.

- We investigate the impact of FCCR on both firm value and ESG performance.
- We analyse how FIFL influences the firm value and ESG performance.
- We explore the moderating effect of FIFL on the relationship between FCCR, firm value, and ESG performance.

To ensure the robustness of our analysis, we employ various estimation techniques, including feasible generalised least squares (FGLS) and simultaneous quantile regression, at different levels (high, medium, and low). Additionally, we address the endogeneity issue using a two-step system-generalised method of moments (GMM) approach. We conduct a series of rigorous robustness assessments to obtain accurate results. These assessments involve using alternative metrics for FCCR and employing alternative measurements for both dependent and independent variables. By utilising diverse estimation techniques, we strengthened the credibility of our conclusions. Overall, our research provides valuable insights into the complex relationships among FCCR, FIFL, firm value, and ESG performance. Through a comprehensive approach and thorough assessment, we hope to contribute to advancing the knowledge in this field and offer practical implications for researchers and practitioners.

The remainder of this paper is organised as follows. Section 2 reviews significant literature and formulates the hypotheses. Section 3 deals with data tracking and methodology. Section 4 reports our results and discussion and we conclude and consider the implications of our study in section 5.

2. Literature review and hypotheses development

First, we explain why the FCCR is expected to influence firm value and ESG performance. Next, we explore the role of FIFL in the relationship between firm value and ESG performance. Therefore, the moderating benefits of FIFL are emphasised to reduce the detrimental consequences of FCCR on firm value. Our primary approach is to develop a framework for evaluating the impact of FCCR and FIFL on firm value and ESG performance. Subsequently, we investigate how FIFL influences the strength and direction of these relationships.

2.1. Climate change risk, firm value and ESG performance

Instrumental stakeholder theory provides a theoretical basis; for example, corporations are rewarded (punished) for successfully (unsuccessfully) addressing stakeholder issues. Corporations have duties for a wide range of stakeholders, including employees, customers, suppliers, and larger communities. Extreme environmental catastrophes are the most critical danger for companies worldwide (World Economic Forum, 2019). The climate risk cost to firms is predicted to be over $1 trillion, with one-half of that cost expected to be spent in the next five years (Roston, 2019). Climate change is also projected to affect global supply chains with bad weather conditions causing major interruptions in the delivery of products and services. Various studies also indicate that climate change is strongly connected to unstable political conditions, which is likely to have an influence on a company's operational outcomes and also strategic decisions (Li et al., 2018; Ozkan et al., 2022). With growing knowledge of the severe repercussions of climate change, initiatives to mitigate such have dominated policymakers' agendas globally. The US has committed $1.7 trillion in climate change investments over the next ten years, intending to cut US greenhouse gas (GHG) emissions to half of the levels in 2005 b y 2030 (Ozkan et al., 2022). Studies have been conducted on the implications of climate threats for companies (Berkhout et al., 2006; Gasbarro & Pinkse, 2016; Linnenluecke et al., 2013) yet few examine the direct impact of FCCR on corporate performance (Ozkan et al., 2022; Starks, 2023; Yu et al., 2016).

Companies engaged in sustainable practices and adapted to climate change risks are more appealing to consumers who prioritise sustainability and are better positioned to retain staff who are concerned about the effects of climate change. Companies face greater regulatory compliance vulnerabilities when current and prospective climate-related laws and regulations limit their profit potential by raising compliance expenses, placing them in a less competitive position (Aupperle et al., 1985). Lenders view climate exposure as a significant risk-enhancing element in their portfolios and impose higher risk premiums on borrowers with a significant carbon footprint to offset heightened emission-related risk (Jung et al., 2018). Increased financial costs can push businesses into financial distress. Additionally, companies with high carbon emissions are more susceptible to reputational damage due to stakeholders' environmental awareness, possibly resulting in revenue loss and a decline in market share (Kabir et al., 2021).

The connection between corporate actions and their impact on climate change performance is a central part of the ongoing debate regarding whether adopting environmentally friendly practices is financially beneficial (i.e. 'it pays to be green'). Hoffman (2005) notes that US companies often participate in GHG emission reduction initiatives aimed at short-term economic gains while reducing regulatory risks in the long term. Okereke and McDaniels (2012) report that the steel industry in EU countries may not be as affected by competitive losses due to climate policies. Sudhakara Reddy and Assenza (2009) advocate for integrating climate policies with development goals to ensure positive economic and environmental outcomes. Traditionally, environmental protection efforts were believed to hinder business operations because of the associated costs and challenges. However, research spearheaded by Porter and van der Linde (1995) challenges this notion. They argue that investments in environmental protection positively influence operational performance by reducing waste. This supports the idea that being environmentally conscious can lead to a win-win situation, benefiting both the environment and the company's operations (Yu et al., 2016).

On counterpart based on the 'traditional economic trade-off argument', studies suggest negative or no relationship (Dixon-Fowler et al., 2013; Freedman & Jaggi, 1988), enhancing environmental performance resulted in greater costs for businesses than financial benefits (Friedman, 2007; Ruggiero & Lehkonen, 2017).

Lins et al. (2017) study the relationship between CSR and firm performance in the context of a crisis. Sautner et al. (2023) study the FCCR and reports a negative association with firms' financial market outcomes. Ozkan et al. (2022) empirically investigate the influence of climate-related risks on businesses' financial outcomes using a large sample size encompassing 2063 registered organisations from multiple nations from 2010 to 2017. The results indicate a positive, insignificant relationship between climate risk and Tobin's Q. Similarly, Hossain et al. (2022) study the relationship between FCCR and CEO equity incentives for 1540 firms from 2002 to 2018 and contributed to the FCCR literature. Siddique et al. (2021) examine the relationship between climate risk (carbon disclosure) and firm performance. They found a negative association in the short term and a positive association in the long term. Mbanyele and Muchenje (2022) studies climate risk and CSR performance, concluding that climate risk triggers the decision to invest in environmentally friendly projects. Lee and Raschke (2023) studies stakeholder legitimacy with the financial and ESG performance of 39 firms in 2019, concluding that stakeholder legitimacy is an antecedent to ESG and financial performance. We posit this is based on the theoretical and empirical literature discussed above.

H-1. FCCR negatively impacts firm value.

In the context of climate change, the risk-management hypothesis posits that firms with higher environmental and social performance are better positioned to adapt to changing conditions and regulations. Consequently, they are less vulnerable to the adverse effects of climate change and are more likely to maintain their competitive advantage and long-term financial performance.

Companies can enhance their long-term viability and create value for their stakeholders by actively managing climate-related risks and embracing sustainable practices. This approach enables firms to mitigate potential climate-related risks and capitalise on emerging opportunities in the evolving business landscape. Building on the risk management hypothesis, our second hypothesis is as follows.

H-2. FCCR positively impacts ESG performance.

2.2. Financial flexibility, firm value and ESG performance

In the context of FIFL and FCCR, stakeholder theory suggests that organisations that successfully manage climate change risks while maintaining FIFL are better equipped to meet their long-term duties to stakeholders. Research on FIFL is scarce (De Jong et al., 2012). DeAngelo and DeAngelo (2007) create an FIFL-based capital structure theory, while Gamba and Triantis (2008) describe how FIFL affects business value. There are divergent perspectives on the conceptualisation of FIFL (Hao et al., 2022). One school of thought places significant emphasis on the traits of 'prevention' and 'utilisation' concerning FIFL, specifically from the financing standpoint. Another school adopts a more comprehensive approach that includes financial management and business policies (Hao et al., 2022). According to Cherkasova and Kuzmin (2018), FIFL is the ideal distribution of financial resources, strategic investment of valuable assets during crises, and the effective management of financial risks. Organisations' FIFL can promptly react to external financial disturbances and mobilise or acquire additional financial assets to mitigate adverse consequences. Empirical data suggest that enterprises with more FIFL are more likely to endure economic downturns (Arslan-Ayaydin et al., 2014; Bancel & Mittoo, 2011; DeAngelo & DeAngelo, 2007; Gamba & Triantis, 2008; Marchica & Mura, 2010). Firms with a greater degree of FIFL should be valued more than those with lower levels of FIFL (Gamba & Triantis, 2008; Marchica & Mura, 2010). In an unpredictable climate, FIFL is critical for company strategy adjustment. It refers to an enterprise's natural ability to mitigate financial risks and make optimal use of financial resources in the face of volatile changes in the financial environment (Teng et al., 2021). Firms with greater FIFL can invest in prospects for expansion, such as expanding into new markets or creating new products, leading to increased financial performance (Bilyay-Erdogan, 2020; Marchica & Mura, 2010; Teng et al., 2021). Furthermore, FIFL enables organisations to withstand short-term economic shocks or downturns, which may help preserve long-term financial success. Firms with less FIFL are more confined in their capacity to explore growth opportunities or respond to economic shocks, potentially resulting in poorer financial performance (Bancel & Mittoo, 2011; Teng et al., 2021). Our hypotheses are based on theoretical prospects and empirical findings from previous studies.

H-3. Financial flexibility positively impacts firm value.

In the context of sustainable development theory, ESG performance is a comprehensive evaluation of a firm's ability to pursue sustainability. Instrumental stakeholder theory suggests that firms can enhance their ESG performance by considering the rights and interests of stakeholders, such as by actively protecting the environment, taking social responsibility, and improving corporate governance. These measures can help firms obtain scarce resources, improve their competitive advantages, and strengthen their profitability (Jones, 1995; Pesqueux and Damak-Ayadi, 2005). In Resource-Based View (RBV) theory, firms are viewed as possessing unique resources and capabilities that can lead to sustained competitive advantage. One such valuable resource is the FIFL, which refers to a firm's ability to manage its financial resources effectively, access capital, and respond to unexpected financial challenges. This gives firms the agility and capacity to adapt to changing market conditions and invest in strategic initiatives (Hao et al., 2022; Marchica & Mura, 2010). A stronger financial position allows companies to invest in sustainable practices, technologies, and initiatives to reduce their environmental footprints, promote social welfare, and improve corporate governance practices. FIFL enables companies to invest in corporate governance practices that foster transparency, accountability, and ethical behaviour. These practices build trust with investors and stakeholders and reduce the risk of governance-related controversies, which can adversely affect a firm's reputation (Barry et al., 2022). By strategically allocating financial resources, FIFL firms can align their business strategies with sustainability goals. Consequently, they can improve their ESG performance; positively influence their reputation among investors, consumers, and other stakeholders; and achieve competitive advantage in an increasingly sustainable market. Therefore, based on the RBV perspective and recognising FIFL as a valuable resource, we hypothesised the following.

H-4. Financial flexibility positively impacts ESG performance.

Guo et al. (2020) examine the impact of CSR on firm value, finding that CSR increases systematic risk and lowers firms' idiosyncratic risk and Tobin's Q. FIFL moderates the negative correlation between CSR and firm value by reducing the positive relationship between CSR and systematic risk. The RBV suggests that firms with more resources are better equipped to achieve their goals (Barney, 1991, 1995; Barney et al., 2021; Dierickx and Cool, 1989; Wernerfelt, 1984). In the context of climate change, FIFL can be considered as a resource that can help firms achieve their goals. This is because FIFL can help firms withstand the financial shocks caused by climate change and invest in ESG initiatives. FIFL allows companies to withstand financial shocks from climate change by providing them with more options, such as raising capital or selling assets. This enables them to continue operating, even in the face of climate-related challenges. Moreover, FIFL empowers companies to invest in ESG initiatives, reducing their environmental impact, and improving their social and governance practices. With more significant resources, they can mitigate climate risk and enhance their reputation among investors and consumers. Usually, FIFL firms can adapt better to climate change, invest in sustainability, and positively impact firm value and ESG performance.

H-5. Financial flexibility moderates the relationship between climate change risk and firm value.

FIFL, a company's capacity to manage its finances, moderates the link between FCCR and ESG performance. This enables greater resource allocation for sustainability initiatives and risk management. FIFL firms can strategically invest in ESG-focused projects to foster improved ESG performance. FIFL also supports adaptability to regulatory changes and long-term sustainability.

H-6. FIFL moderates the relationship between climate change risk and ESG performance.

2.3. Theoretical framework

To understand the interplay between FCCR, FIFL, firm value, and ESG performance, we developed a comprehensive theoretical framework encompassing six hypotheses that guide our investigation and understanding of the complex relationships among these crucial variables.

Hypothesis H-1: FCCR negatively affects firm value. As firms face an increasing number of environmental challenges, their exposure to climate-related risks may adversely affect their overall value and financial performance.

Hypothesis H-2: FCCR positively affects ESG performance. Firms facing higher climate change risks may be motivated to proactively engage in environmentally and socially responsible practices. As these companies seek to reduce challenges related to climate change, they are more likely to invest in ESG initiatives to mitigate risks and improve their overall sustainability performance.

Hypothesis H-3: Financial flexibility positively affects firm value. Firms equipped with higher financial flexibility can navigate uncertain economic conditions, enhance investment opportunities, and strengthen their overall value.

Hypothesis H-4: Financial flexibility positively affects ESG performance. The availability of financial resources allows firms to invest in sustainable initiatives, bolster their ESG performance, and align their business strategies with societal and environmental concerns.

Hypothesis H-5: Financial flexibility moderates the relationship between climate change risk and firm value. As a valuable resource, FIFL may mitigate the impact of FCCR on firm value, thus enabling firms to respond more strongly to environmental challenges.

Hypothesis H-6: Financial flexibility moderates the relationship between climate change risk and ESG performance. Through strategic resource allocation, FIFL can influence the relationship between FCCR and ESG performance, allowing firms to invest in sustainable practices and improve their social and environmental impact.

By integrating these hypotheses, our theoretical framework enriches our understanding of the intricate dynamics of FCCR, FIFL, firm value, and ESG performance. This foundation guides our empirical investigation, contributing to broader knowledge of sustainable business practices and their implications for companies and stakeholders. Fig. 1 presents the theoretical framework of the study.

Subsequent sections detail the research methodology and data analysis used to validate and refine our theoretical framework. Through empirical exploration, we aspire to contribute to the ongoing discourse on sustainable business strategies and their implications for long-term value creation and software.

3. Data sample and research design

3.1. Sample, data, and sources

We created a panel dataset with a sample size of 1529 publicly listed US firms for 2012 through 2021. Data availability determined the sample period. The main ideas of this study were taken from previous publications. Data availability determined the sample period. We created a sample based on annual financial data from Refinitiv Eikon and Compustat for the empirical analysis. From the Refinitiv Eikon database, we retrieved ESG data. Refinitiv's financial markets database includes sources for approximately 70% of worldwide company market capitalisations. The ESG scores by Refinitiv transparently and objectively measure an organisation's relative ESG performance, commitment, and effectiveness based on more than 500 comparable metrics in ESG and other controversial categories (Lee & Raschke, 2023). Data on firms' exposure to climate change were taken from (Sautner et al., 2023).[1]

3.2. Variables definition and measurement

We employed Tobin's Q as an indicator of a firm's value. Brainard and Tobin (1968),Tobin (1969) explain it as a firm's ratio of market value and replacement cost of its capital stock, suggesting that this ratio be utilised to measure the firm's 'incentive to invest in capital' and has become identified as 'Tobin's average Q' (Bolton et al., 2011). Hayashi (1982) illustrates scenarios in which the 'average Q' is equivale)nt to the 'marginal Q'. Abel and Eberly (1994) developed a 'unified theory of investment' in neoclassic settings. Abel and Eberly (1993); Chung and Pruitt (1994); Lindenberg and Ross (1981); Lucas and Prescott (1971); Perfect and Wiles (1994) show prominent early developments in Tobin's Q.

This ratio illustrates the link between the market and book value/ replacement costs and assesses a company's potential for development. Unfortunately, computing the Q ratio is challenging due to its denominator, 'the replacement cost of a firm's assets', which is unspecified. Estimating this value is challenging, owing to the absence of active markets for numerous assets (Butt et al., 2023). Chung and Pruitt (1994) provide a simple approximation of Tobin's Q and state that the book value of total assets is treated as a replacement cost, which cannot be

[1] Detailed methodology at Sautner, Z., Van Lent, L., Vilkov, G., & Zhang, R. (2023). Firm-Level Climate Change Exposure. *The Journal of Finance*. https://doi.org/10.1111/jofi.13219.

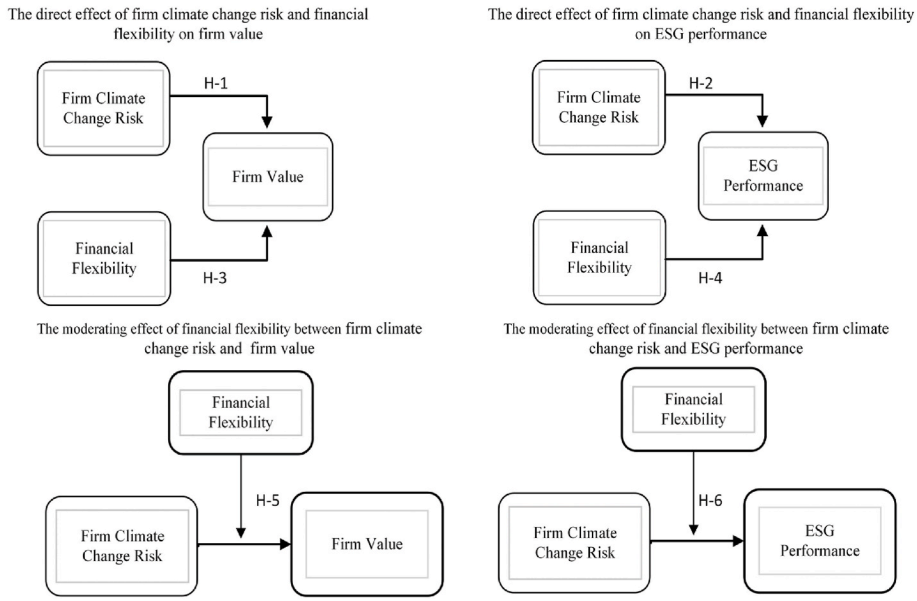

Fig. 1. Theoretical framework.

directly measured. We utilise a measure similar to Chung and Pruitt (1994), using Equation (1).

$$Tobin's\ Q_{i,t} = \left(PRCC\_F_{i,t} * CSHO_{i,t}\right) + AT_{i,t} - CEQ_{i,t} \,/\, \mathrm{AT}_{i,t} \tag{1}$$

where PRCC_F indicates the annual closing share price, CSHO indicates common shares outstanding, CEQ is total ordinary/common equity, AT is total assets, i is the company, and t is the year.

In previous literature, a large number of studies Busch and Hoffmann (2011); Chortareas and Noikokyris (2021); Chung and Pruitt (1994); Fafaliou et al. (2022); Jin and Jorion (2006); Mackay and Moeller (2007) employed similar measures for Tobin's Q calculations. Although the Tobin's Q ratio has also been criticised in the literature, we use it to study the impact of climate change risk and financial flexibility on firm value for several reasons. First, the Tobin's Q ratio is a comprehensive measure of firm value that considers both tangible and intangible assets. Climate change risk can affect both tangible and intangible assets substantially. For instance, climate change can damage physical assets such as buildings and equipment. Climate change can also damage intangible assets such as brand reputation and customer relationships (Busch & Hoffmann, 2011; Jin & Jorion, 2006). Second, the Tobin's Q ratio is a market-based measure of firm value. Thus, it considers investors' expectations regarding a firm's future cash flow (Guenster et al., 2011). Climate change risk and financial flexibility can significantly impact investors' expectations of a firm's future cash flow.

Numerous studies underscore the significance of attaining financial flexibility through strategies involving low leverage or maintaining substantial cash reserves (Bancel & Mittoo, 2011; Billett & Garfinkel, 2004; Bilyay-Erdogan, 2020). These studies argue that companies equipped with ample cash reserves or those operating with low leverage are better equipped to manage income shortfalls, thereby averting underinvestment. For example, DeAngelo and DeAngelo (2007) explicitly incorporates leverage and cash holdings to define financial flexibility. They contend that an optimal approach to flexibility involves low leverage, moderate cash holdings, and high dividend distributions. In line with this perspective, Gamba and Triantis (2008) demonstrate that financial flexibility can arise from a firm's strategic decisions regarding its capital structure, liquidity, and investment choices. Furthermore, considering heightened economic risk, Bates et al. (2009) propose that high cash reserves are associated with low debt levels. Consequently, the concurrent adoption of these policies enables firms to prevent financial distress and defaults.

As there is no unanimously accepted metric for financial flexibility, existing studies predominantly use single or multiple, or a combination of multiple indicators. In the single-indicator approach, financial flexibility is assessed using metrics such as cash holdings or debt capacity (Billett & Garfinkel, 2004; Marchica & Mura, 2010). Meanwhile, the multi-indicator combination method assesses financial flexibility by considering a combination of financial leverage and cash holdings (Arslan-Ayaydin et al., 2014; DeAngelo & DeAngelo, 2007; Gamba & Triantis, 2008).

In this article, we refer to the studies of Al-Slehat (2019); Arslan-Ayaydin et al. (2014); Chang and Wu (2021); Teng et al. (2021) to evaluate enterprises' financial flexibility using two financial indicators: cash holdings and debt levels. The calculation of firms' FIFL is based on Equation (2):

$$Financial\ flexibility(FIFL) = Cash\ flexibility + Debt\ flexibility \tag{2}$$

Cash flexibility refers to an enterprise's ability to utilise internal funds. It is calculated as Cash + Cash equivalent)/total assets, whereas debt flexibility means that a firm's ability to obtain external financial resources is calculated as a 1-corporate debt ratio.

Firm value and ESG served as dependent variables. FCCR and FIFL are the main variables of interest. We use a variety of controls at the firm level that may have an impact on firm value and ESG. To select the control variables, we refer to the standard literature, particularly articles pertinent to risk discourse such as (Albuquerque et al., 2019; Arslan-Ayaydin et al., 2014; Davis et al., 2020; Hossain et al., 2022; Huang & Lin, 2022; Li et al., 2022; Ozkan et al., 2022). These control variables include firm size, leverage, tangible assets, cash flow, growth, and fixed assets. Table 1 presents the descriptions, measurements, and data sources of the variables.

3.3. Model setting

Our model utilises multiple regression models for fundamental connection testing, which reduces the susceptibility to omitted variable bias (Allison, 2009; Hossain & Masum, 2022). These models control for other variables such as firm size, leverage, asset tangibility, cash flow, growth, and fixed assets. Using the multiple regression model, the following equations were constructed:

Table 1
Variables descriptions and measurement.

Name	Acronym	Description	Data Sources
Dependent Variables			
Firm Value	Tobin's Q	Equation 1	Computed by using Compustat Data
ESG Score	ESG	Environmental, Social, and Governance combined score	Refinitiv Eikon
Independent Variables			
Firms' Climate Change Risk	FCCR	Based on earnings conference calls	(Sautner et al., 2023) Data available at https://osf.io/fd6jq/files/osfstorage
Financial Flexibility	FIFL	Equation 2	Computed by using Compustat Data
Control Variables			
Leverage	LEV	Debt to equity	Compustat
Firm Size	FIS	N Log of sales	Compustat
Fixed Assets	FAS	N Log of Property Plant and Equipment	Compustat
Cash Flows	CAF	Net Cash flows	Compustat
Assets Tangibility	AST	Fixed Assets/Total Assets	Compustat
Growth	Growth	% change in total assets	Compustat

This table lists the study variables, their measurements, and the data sources.

$$Firm\ Value_{i,t} = \alpha_1 + \beta_1 FCCR_{i,t} + \beta_2 FIFL_{i,t} + \gamma_1 \sum Control_{i,t} + Year_t + Industry_i + \varepsilon_{i,t} \tag{3}$$

$$ESG_{i,t} = \alpha_1 + \beta_1 FCCR_{i,t} + \beta_2 FIFL_{i,t} + \gamma_1 \sum Control_{i,t} + Year_t + Industry_i + \varepsilon_{i,t} \tag{4}$$

where FCCR is a firm's climate change risk, FIFL is financial flexibility, and the control variables include asset tangibility, cash flow, fixed assets, firm size, growth, and leverage. ε is the error term, i is for firm and t for year.

After initial testing, the analysis was carried out using bootstrap quantile regression at various quantile levels. Simultaneous quantile regression was conducted to assess the consistency of the findings across different quantiles (25, 50, 75, and 95) of data distribution. This technique provides insights into the relationships between FCCR, FIFL, firm value, and ESG performance at various levels.

The ordinary least square relies on certain assumptions regarding the stochastic disturbance term, assuming homoscedasticity, no cross-sectional correlation, and no autocorrelation within panels. However, when these assumptions are violated, the feasible generalised least squares (FGLS) model becomes more appropriate for parameter estimation. In the next step, FGLS is employed. Endogeneity can introduce bias into the estimation results, potentially leading to unreliable findings. A two-step generalised method of moments (GMM) approach was employed, incorporating a finite sample adjustment to the covariance matrix, as proposed by Windmeijer (2005). The instruments used in Arellano and Bond (1991) dynamic panel estimate are lagged levels of the first difference in the variables. However, lagged levels frequently create inadequate instruments for the first differences, as stated by (Arellano & Bover, 1995). They thus advise using a 'system GMM' estimator created by Arellano and Bover (1995); Blundell and Bond (1998) to lessen this issue. In this improved form, introduced by Roodman (2009), lagged differences in the dependent variable are used as instruments for equations in levels, and the lagged levels of the series are used as instruments for equations in the first differences. We assessed the strength and validity of these instruments using diagnostic tests, including the autoregressive (AR) 1, AR2, Sargen, and Hansen tests, for overidentifying restrictions.

3.4. Robustness

Rigorous robustness analyses were conducted to validate the results. The different models employ alternative measures and estimation techniques to support the robustness of their conclusions. First, we use an alternative measure called 'climate change sentiments' as the independent variable for FCCR. The second alternative measure of 'ROA' (return on assets) and 'stock returns' are employed as the dependent variable for firm value, and CSR is used as an alternative measure for ESG. Third, we replace both the independent variable 'FCCR' and the dependent variables 'firm value' and ESG performance with alternative measures. Fourth, we employ an alternative estimation technique known as 'Fixed Effect Driscoll-Kraay' to estimate the relationships between the variables. These analyses were essential for validating the integrity and reliability of our findings.

4. Empirical results and discussion

4.1. Descriptive statistics and correlation

Table 2 presents the correlations, variance inflation factors, and descriptive statistics of the study variables. Columns (1)–(8) show the pairwise correlations, indicating that the independent variable is not subject to multicollinearity issues. To clarify this further, Column (9) shows the VIF values within an acceptable range. Columns (10)–(11) show the descriptive statistics, means, and standard deviations.

4.2. Quantile regression results

A simultaneous quantile regression analysis with bootstrap standard errors was employed to further estimate the relationship. The lower levels signify the 25th and 50th quantiles, the medium level represents the 75th quantile, and the upper level signifies the 95th quantile. The estimates shown in Table 3, columns (1)–(4) indicate firm value, and columns (5)–(8) indicate ESG performance with relevant independent and control variables. The results indicate the relationship between the variables under consideration across different quantile levels.

FCCR coefficients show a negative association with firm value across all quantile levels (25th, 50th, 75th, and 95th), indicating that higher climate change risk is generally linked to lower firm value. The coefficient values become more negative as we move from the lower to the upper quantile levels. FIFL exhibits a positive association with firm value across all quantiles, indicating that higher financial flexibility is associated with greater firm value. This positive relationship is consistent across quantile levels.

However, regarding the impact of FCCR on ESG performance, the coefficient values are positive for the 25th to 75th quantiles, suggesting a positive relationship between climate change risk and ESG performance. However, the significance decreases as we move towards higher quantile levels. Regarding the impact of FIFL on ESG performance, the coefficient values are positive for all quantile levels, suggesting that financial flexibility is positively associated with ESG performance. Notably, the positive impact strengthens as we move from lower to higher quantile levels.

Overall, these results provide insights into the varying impacts of climate change risk and financial flexibility on firm value and ESG performance across different quantiles.

Standard linear regression assumes homoscedasticity, no cross-sectional correlation, and no panel autocorrelation for the stochastic disturbance factors. To address endogeneity problems in the next stage, the FGLS and GMM models were used for parameter estimations.

4.3. Endogeneity concerns and instrumental variables

In our analysis, we use the Arellano-Bond dynamic panel model approach to control for potential endogeneity issues, implementing it

Table 2
Correlations, variance inflation factors, and descriptive statistics.

Variables	(1) FIFL	(2) FCCR	(3) AST	(4) CAF	(5) PPE	(6) FIS	(7) Growth	(8) LEV	(9) VIF	(10) Mean	(11) S.D.
(1) FIFL	1.000								1.07	.87	.85
(2) FCCR	−0.038	1.000							1.00	.005	.87
(3) AST	0.185	−0.061	1.000						3.22	7.09	3.09
(4) CAF	0.020	−0.015	0.011	1.000					1.00	.012	.22
(5) FAS	0.205	−0.015	0.731	0.002	1.000				2.23	4.75	3.07
(6) FIS	−0.085	0.019	0.819	−0.001	0.739	1.000			4.54	7.36	1.79
(7) Growth	−0.135	0.047	−0.34	−0.049	−0.240	−0.129	1.000		1.02	−1.57	1.55
(8) LEV	−0.033	0.012	0.027	−0.018	0.042	0.027	0.010	1.000	1.00	.053	.71
Tobin's Q										.44	.39
ESG										.46	.19
Mean VIF									1.89		

Notes: The primary model variables are presented in this table with pairwise correlation, variance inflation factor (VIF) and descriptive statistics. The dataset is composed of years 2012–2021, with 15,620 firm-year observations.

through the xtabond2[2] command in Stata. As discussed by Roodman (2009), this approach deals with endogeneity using internal instruments based on the lags of the endogenous variables. The GMM model, typically employed for panel data analysis, yields reliable outcomes even when confronted with various forms of endogeneity, including 'unobserved heterogeneity, simultaneity, and dynamic endogeneity' (Wintoki et al., 2012, p. 588). Specifically, it allows for the use of GMM-style instruments in which longer lags of the endogenous variables are used as instruments for the shorter lags included in the regression. The assumption is that these longer lags are correlated with endogenous regressors but not directly with idiosyncratic errors. We use two lags of endogenous variables as instruments in the GMM model. Wintoki et al. (2012) employ two lags of dependent variables, asserting that this choice adequately captures the persistence of the dependent variable. We followed Ullah et al. (2018) in the operationalisation of the GMM in our analysis. Two-step system GMM helps to address the potential endogeneity concerns regarding the relationships between Refinitiv ESG scores, log sales, and other variables in the model. The lags of these variables serve as internal instruments to isolate the exogenous components of the endogenous regressors. We assessed the strength and validity of these instruments using diagnostic tests, including the AR1, AR2, Sargen, and Hansen tests for overidentifying restrictions. We used the following commands from Stata:

$$\text{xtabond2 y l.y x1 x2, x3twosteprobust nomata iv(x1 x2, x3) gmm(l.ylag(\# \#), collapse)},$$

where the lagged values (l, y) in the example above and the two-step dynamic framework are added as regressors. The lagged levels of the estimator for the dependent variable serve as an instrumental variable to address endogeneity. Additionally, the expression 'lag (# #)' refers to the desired number of lags that investigators intend to incorporate into the model. The utilisation of the system GMM reduces the number of observations owing to the internal transformation process. To obtain post-estimation outcomes, the estat sargan command was employed to compute the Sargan test values, while the estat abond command was utilised to conduct the Arellano-Bond test for the first order.

[2] Detailed methodology available at Roodman, (2009). How to do Xtabond2: An Introduction to Difference and System GMM in Stata. *The stata journal*, *9*(1), 86–136. https://doi.org/10.1177/1536867X0900900106.

4.4. Main results for climate risk and financial flexibility with firm value and ESG

The baseline results are subject to endogeneity, resulting in biased estimates. To deal with endogeneity, models such as the GMM and FGLS provide better estimates. As Mehta (2001) stated, 'If the independent variable were regressed on the instrumental variable, the residual would contain all unobserved sources of variability that determine treatment assignment and influence the outcome variable. As a result, the existence of an instrumental variable identifies or isolates the average direct effect of the treatment on the outcome independent of the unobserved sources of variability'. Applying models such as the GMM and FGLS reduces the risk of biased results. Table 4 shows the FGLS and GMM results for firm value in columns (1) and (2) and for ESG in columns (3) and (4). Columns (5) and (6) show the moderating effect of the FIFL on FCCR and firm value, whereas columns (7) and (8) show the moderating effect of FIFL between FCCR and ESG performance.

Across both estimation techniques, FCCR maintains a negative association with firm value, which is consistent with **H-1**. Similar outcomes were reported by (Siddique et al., 2021), supporting the notion that climate change-related risks might reduce corporate value because of expenses linked to environmental damage (Walker & Wan, 2012).

FCCR shows a positive association with firm ESG performance, consistent with **H-2**. Similar results were reported by (Mbanyele & Muchenje, 2022; Ozkan et al., 2022), supporting the risk management hypothesis, suggesting that companies with high environmental and social performance perform better. This finding also supports the idea that enterprises with greater exposure to climate change risks are more inclined to implement environmentally responsible activities.

FIFL demonstrates a positive relationship with firm value, aligning with previous findings (Hao et al., 2022; Liu & Chang, 2020), which ground this positive relationship in resource dependency theory. Firms with greater cash reserves, greater access to external financing, and fewer financial constraints tend to have a higher market value. The FIFL results were consistent with **H-3**.

Similarly, FIFL shows a positive relationship with ESG performance, concomitant with **H-4**. This suggests that financially flexible corporations engage in more socially responsible initiatives.

Our results indicate that FIFL and FCCR are vital in driving corporate value and ESG performance, whereas the other control variables have a smaller impact.

Table 3
Quantile regression results at lower, medium and upper quantiles.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	q25	q50	q75	q95	q25	q50	q75	q95
	Firm Value				ESG Performance			
FCCR	−0.0190***	−0.0382***	−0.0435***	−0.0279*	0.0144***	0.0098***	0.0056**	−0.0013
	(0.0033)	(0.0031)	(0.0054)	(0.0153)	(0.0023)	(0.0025)	(0.0026)	(0.0040)
FIFL	0.0839***	0.1092***	0.0938***	0.0315*	0.0036	0.0172***	0.0249***	0.0230***
	(0.0166)	(0.0250)	(0.0248)	(0.0183)	(0.0071)	(0.0050)	(0.0070)	(0.0051)
AST	−0.8558***	−1.3098***	−1.7445***	−1.7907***	0.2967***	0.2787***	0.2050***	0.1145**
	(0.0276)	(0.0547)	(0.0890)	(0.2137)	(0.0236)	(0.0160)	(0.0394)	(0.0556)
CAF	−0.0408***	−0.0490***	−0.0563***	−0.0249*	−0.0047	−0.0028	−0.0066**	−0.0064**
	(0.0042)	(0.0048)	(0.0063)	(0.0141)	(0.0031)	(0.0023)	(0.0033)	(0.0031)
FAS	0.0209	0.0302*	0.0055	−0.0066	−0.0476***	−0.0093	−0.0006	−0.0007
	(0.0213)	(0.0158)	(0.0112)	(0.0708)	(0.0085)	(0.0099)	(0.0078)	(0.0132)
FIS	0.6390***	1.0247***	1.4544***	1.6428***	0.3222***	0.4105***	0.4830***	0.4632***
	(0.0359)	(0.0540)	(0.0622)	(0.1616)	(0.0216)	(0.0265)	(0.0359)	(0.0662)
Growth	−0.0217**	−0.0373**	−0.0777***	−0.0787***	0.0359***	0.0472***	0.0405***	0.0336**
	(0.0101)	(0.0153)	(0.0185)	(0.0253)	(0.0094)	(0.0067)	(0.0082)	(0.0142)
LEV	0.0189***	0.0217***	0.0198***	0.0310**	0.0045	0.0036*	0.0030	0.0020
	(0.0028)	(0.0033)	(0.0044)	(0.0137)	(0.0029)	(0.0022)	(0.0023)	(0.0029)
Constant	0.4228***	0.6097***	0.9204***	1.4288***	−0.8274***	−0.9590***	−0.9055***	−0.5938***
	(0.0812)	(0.0897)	(0.1398)	(0.1333)	(0.0661)	(0.0393)	(0.0474)	(0.0463)
Observations	15,585	15,585	15,585	15,585	9821	9821	9821	9821
Pseudo R^2	0.1371	0.1601	0.1197	0.0652	0.1372	0.2007	0.2067	0.1563

Note: All estimations include lower quantiles at 25 and 50, medium quantiles at 75, and upper quantiles at 95. Below the estimated coefficients, the standard errors are shown in parentheses. Asterisks indicate statistical significance at the 10% one-star, 5% two-star, and 1% three-star levels, respectively. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 4
FGLS and GMM results with firm's value and ESG performance.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Direct Effect				**Moderating Effect**			
	FGLS	GMM	FGLS	GMM	FGLS	GMM	FGLS	GMM
	Firm Value		ESG Performance		Firm Value		ESG Performance	
L. Firm Value		0.2622***				0.2576***		
		(0.0525)				(0.0523)		
L.ESG Performance				0.0492				0.0556
				(0.0500)				(0.0495)
FCCR	−0.0345***	−0.0152***	0.0084***	0.0109***	−0.0345***	−0.0163***	0.0085***	0.0107***
	(0.0038)	(0.0048)	(0.0020)	(0.0040)	(0.0038)	(0.0049)	(0.0020)	(0.0041)
FIFL	0.0702***	0.0620**	0.0150***	0.0538***	0.0589***	0.0528**	0.0150***	0.0571***
	(0.0086)	(0.0290)	(0.0044)	(0.0200)	(0.0087)	(0.0239)	(0.0044)	(0.0196)
FCCR × FIFL					0.0820***	0.0801***	0.0071	0.0128
					(0.0128)	(0.0171)	(0.0083)	(0.0110)
AST	−1.2211***	−0.9174***	0.2370***	0.1691***	−1.1808***	−0.8824***	0.2366***	0.1755***
	(0.0389)	(0.0844)	(0.0220)	(0.0563)	(0.0392)	(0.0811)	(0.0221)	(0.0570)
CAF	−0.0477***	−0.0209***	−0.0050***	−0.0029	−0.0471***	−0.0210***	−0.0050***	−0.0030
	(0.0035)	(0.0031)	(0.0019)	(0.0029)	(0.0035)	(0.0031)	(0.0019)	(0.0028)
FAS	0.0329**	−0.0021	−0.0122	−0.0030	0.0351**	0.0015	−0.0122	−0.0028
	(0.0154)	(0.0221)	(0.0095)	(0.0262)	(0.0153)	(0.0221)	(0.0095)	(0.0262)
FIS	0.9832***	0.7736***	0.3902***	0.4593***	0.9519***	0.7455***	0.3904***	0.4529***
	(0.0417)	(0.0843)	(0.0238)	(0.0686)	(0.0419)	(0.0818)	(0.0238)	(0.0683)
Growth	−0.0460***	−0.0094	0.0401***	0.0280***	−0.0435***	−0.0080	0.0401***	0.0280***
	(0.0112)	(0.0102)	(0.0063)	(0.0090)	(0.0112)	(0.0101)	(0.0063)	(0.0089)
LEV	0.0226***	0.0054*	0.0030	0.0024	0.0220***	0.0054*	0.0030	0.0024
	(0.0034)	(0.0031)	(0.0018)	(0.0021)	(0.0034)	(0.0030)	(0.0018)	(0.0021)
Constant	0.6231***	0.5259***	−0.8289***	−0.7914***	0.6092***	0.5059***	−0.8278***	−0.7975***
	(0.0628)	(0.1180)	(0.0364)	(0.1137)	(0.0626)	(0.1131)	(0.0364)	(0.1141)
Observations	15,585	14,947	9821	9543	15,585	14,947	9821	9543
Number of firms	1529	1529	1444	1444	1529	1529	1444	1444
Arellano-Bond AR (2) p value		0.0963		0.1980		0.522		0.521
Arellano-Bond AR (1) p value		0.0000		0.0480		0.0010		0.0011
Sargan (p-value)		0.1935		0.4100		0.1894		0.1891
Hansen (p-value)		0.5340		0.3350		0.5222		0.5200

Note: Estimations include feasible generalised least squares (FGLS) and generalised method of moments (GMM). Below the estimated coefficients, the standard errors are shown in parentheses. The Arellano–Bond AR1 & AR2 test assesses serial correlation of order i by employing residuals in first differences, with an asymptotic distribution of N (0,1) under the null hypothesis, indicating the absence of serial correlation. The Sargan and Hansen test evaluates over-identifying restrictions, with an asymptotic distribution following the chi-squared ($\chi 2$) distribution under the null hypothesis, indicating no correlation between the instruments and the error term. Asterisks denote statistical significance at the 10% one-star, 5% two-star, and 1% three-star levels, respectively. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

The interaction term coefficient (FCCR × FIFL) is positive and significant, indicating that FIFL mitigates the impact of FCCR and improves market value. This relationship is consistent with our fifth hypothesis, **H-5**. Financial flexibility is a valuable resource that allows firms to respond more adeptly to environmental challenges, thereby reducing the impact of FCCR on firm value.

However, the coefficient of the interaction term (FCCR × FIFL) is positive and non-significant, indicating that FIFL does not moderate the relationship between FCCR and ESG performance. This finding is inconsistent with our sixth hypothesis, **H-6**.

4.5. Robustness analysis

A series of robustness analyses were conducted to validate the findings of this study and test the reliability and consistency of the main results. Different models employ various alternative measures and estimation techniques to ensure the robustness of their conclusions.

Model 1 used an alternative measure called 'climate change sentiments' as the independent variable for FCCR. In Model 2, an alternative measure of 'ROA' was employed as the dependent variable for firm value. In Model 3, both the independent variable 'FCCR' and the dependent variable 'firm value' were replaced with alternative measures. This approach enabled a comprehensive examination of these relationships. Model 4 utilised an alternative estimation technique known as 'Fixed Effect Driscoll-Kraay' to estimate the relationships between the variables. In Models 5 and 6, we utilised another alternative measure of the dependent variable, 'stock returns', with GMM and Fixed Effect Driscoll-Kraay. Butt et al. (2023) argue that Tobin's Q may provide inflated results; therefore, using stock return [(stock market returns$_{i,t}$ + dividend-stock market returns$_{i,t-1}$)/stock market returns$_{i,t-1}$] as robustness validates the study's findings.

For the analysis of ESG performance, Model 7 and Model 8 employed 'climate exposure score' as the independent variable for climate change risk, and an alternative measure of 'CSR' was used as the dependent variable. The CSR score was calculated based on the average of the firms' environmental and social scores from the Asset4 database of Thomson Reuters. In Model 9, alternative measures were utilised for both the independent variable 'FCCR' and the dependent variable 'CSR performance'. Finally, Model 10 used the 'Fixed Effect Driscoll-Kraay' estimation technique for this part of the analysis.

Table 5
Robustness analysis.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Methods	GMM	GMM	GMM	FE Driscoll-Kraay	GMM	FE Driscoll-Kraay	GMM	GMM	GMM	FE Driscoll-Kraay
Variables	Tobin's Q	ROA	ROA	ROA	Stock Return	Stock Return	ESG	CSR	CSR	CSR
Direct Effect										
Lagged Dependent Variable	0.305***	0.061	0.061		−0.230***		−0.006	0.103	0.818***	
	(0.046)	(0.048)	(0.047)		(0.037)		(0.046)	(0.146)	(0.036)	
FCCR	−6.072***	−0.001*	−0.827***	−0.001**	−0.017***	−0.021***	3.996***	0.022***	2.706***	9.548***
	(1.579)	(0.001)	(0.231)	(0.000)	(0.006)	(0.003)	(1.283)	(0.008)	(0.877)	(2.644)
FIFL	0.061***	0.006***	0.006***	0.003**	0.028**	0.052*	0.065***	0.621**	0.154***	0.008**
	(0.023)	(0.002)	(0.002)	(0.001)	(0.0123)	(0.020)	(0.025)	(0.313)	(0.041)	(0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AR (1) p-value	0.000	0.000	0.000		0.000		0.000	0.021	0.000	
AR (2) p-value	0.489	0.325	0.464		0.233		0.109	0.299	0.760	
Sargan (p-value)	0.484	0.133	0.110		0.313		0.172	0.248	0.267	
Hansen (p-value)	0.547	0.158	0.450		0.707		0.314	0.377	0.286	
Moderating Effect										
Lagged Dependent Variable		0.061	0.061		−0.235***			0.819***	0.103	
		(0.048)	(0.047)		(0.038)			(0.036)	(0.144)	
FCCR		−0.002**	−0.836***	−0.001**	−0.016***	−0.0219***		2.650***	0.023***	9.573***
		(0.001)	(0.231)	(0.000)	(0.006)	(0.0026)		(0.873)	(0.008)	(2.636)
FIFL		0.005***	0.005***	0.001	0.028**	0.0527*		0.152***	0.611**	0.008**
		(0.002)	(0.002)	(0.001)	(0.012)	(0.0204)		(0.042)	(0.305)	(0.003)
FCCR × FIFL		0.006***	0.006***	0.005***	0.047**	0.037		−0.012	0.053	0.004
		(0.002)	(0.002)	(0.001)	(0.023)	(0.021)		(0.012)	(0.072)	(0.003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AR (1) p-value		0.000	0.000		0.000		0.000	0.000	0.015	
AR (2) p-value		0.333	0.474		0.139		0.149	0.791	0.192	
Sargan (p-value)		0.107	0.128		0.824		0.693	0.268	0.204	
Hansen (p-value)		0.158	0.759		0.987		0.815	0.482	0.282	

Note: Estimations include GMM and Fixed Effect Driscoll-Kraay. All control variables are included in estimations. FCCR is a firm climate change risk, and FIFL is financial flexibility. Below the estimated coefficients, the standard errors are shown in parentheses. The Arellano–Bond AR1 & AR2 test assesses serial correlation of order i by employing residuals in first differences, with an asymptotic distribution of N (0,1) under the null hypothesis, indicating the absence of serial correlation. The Sargan and Hansen test evaluates over-identifying restrictions, with an asymptotic distribution following the chi-squared ($\chi 2$) distribution under the null hypothesis, indicating no correlation between the instruments and the error term. Asterisks denote statistical significance at the 10% one-star, 5% two-star, and 1% three-star levels, respectively. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 5 presents the results of robustness analyses. These results reinforce and validate the main findings of this study, thus ensuring the reliability and credibility of the conclusions.

5. Conclusion and implications

Based on the study results, we can conclude that a firm's value and ESG performance are significantly impacted by FCCR and FIFL. Firms with greater degrees of climate risk tend to have lower firm values, which may be ascribed to the possibility of suffering financial losses from increased climate risk exposure. Moreover, firms with greater FIFL are better equipped to react to and reduce the risks associated with climate change, which enhances ESG performance and has a favourable effect on firm value. This study's conclusions have significant implications for businesses that hope to improve their ESG performance and provide shareholders with long-term gains. It recommends that businesses prioritise climate risk management and work to keep their finances flexible in response to the possibilities and difficulties brought about by climate change. Companies must boost their sustainability and resilience, which may eventually result in better financial outcomes and higher shareholder value. The results are based on a specific sample of firms and cannot be applied to all markets or regions. The links between FCCR, FIFL, ESG performance, and corporate value under various circumstances must be further investigated. Nevertheless, this research offers insightful information about how managing FCCR and retaining FIFL may improve company value and ESG performance and should be considered by businesses seeking to deliver sustainable value to their stakeholders.

The theoretical implications of this study are as follows. Our findings contribute to the discussion of how FCCR and FIFL affect ESG performance. Climate risk exposure increases ESG performance, reduces growth opportunities, and reduces the probability of company exit. Our findings show that enterprises are incentivised to serve social purposes because they perform well financially and stay in the market longer. This supports international organisations' (e.g. the UN) efforts to adopt ESG-based investment practices and strategies. Past research has primarily focused on specific economic crises related to climate risk (Ai & Gao, 2023; Davis et al., 2020; Hossain et al., 2022; Hossain & Masum, 2022; Mbanyele & Muchenje, 2022; Ozkan et al., 2022), and less on firm-specific FCCR. These studies neglect climate risk impact on corporate value and ESG performance. We found that climate change threats destroy firms' market value and influence ESG performance. FIFL mitigates risk and improves market value. Firms with a greater FIFL can better withstand the costs associated with FCCR and capitalise on new opportunities created by the transition to a low-carbon economy. From a theoretical viewpoint, this study contributes to the literature on corporate financing, environmental sustainability, and stakeholder theory.

These findings have direct implications for management. Our research indicates that FCCR and FIFL significantly impact the value of businesses. Second, we demonstrate that climate risk is an essential factor that has a negative effect on the market value of companies, and FIFL improves value and ESG performance. Firms should prioritise maintaining a healthy balance sheet, building cash reserves, and diversifying their sources of financing to ensure that they have the financial resources needed to respond to unexpected events and pursue new opportunities. Third, our findings have implications for asset managers committed to incorporating sustainability into their capital allocation decisions. Climate-related hazards may be instructive for investors, indicating financial and growth opportunities, and market value. FCCR and FIFL are highly dependent on managerial choices. Therefore, our findings can assist executives in formulating strategies to enhance the value and ESG performance of their firms. Overall, this study provides managers with a comprehensive understanding of the effects of climate risk and financial flexibility on business value and social performance.

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