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How Does Firms ESG Investment Play a Moderating Role between Climate Variability Risk and Enterprise Worth?

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Abstract

In light of the Sustainable Development Goals, businesses are progressively integrating environmental, social, and governance (ESG) factors in their investment planning. Scholars, investors, and politicians frequently examine climate variability risk (CVR) impact on enterprise worth (EW), how certain investing techniques mitigate this impact. In order to investigate these patterns, we quantify the impact of CVR on EW by analyzing data from 1720 US-listed companies throughout 2005 to 2020. To accomplish our goal, we apply GMM approach to consider the regression estimations. The following are our primary findings: Initially, CVR has a substantial detrimental impact on EW. However, enterprise worth is positively and considerably impacted by ESG investments. Similarly, the link between CVR and EW moderated in part by ESG investments. We verify that our estimations hold up well under different methodological conditions. Finally, this study presents a novel viewpoint on risk management with important policy ramification for US managers, investors, and regulators. We contend that US corporations need to use firms ESG investing as a key strategic driver.

Keywords: climate variability risk; firms ESG considerations; enterprise worth

1. Introduction

Risk associated with climate unpredictability is a serious worldwide issue that affects both private citizens and large multinational companies(Adegbite, Guney et al. 2019, Al-Qudah, Al-Okaily and Alqudah 2022). Storms, floods, and sea level rise are examples of extreme weather occurrences that can seriously threaten businesses by destroying property, upsetting supply networks, and lowering demand and productivity (Alessandri, Tong and Reuer 2012). Many businesses have experienced financial instability because of the transition to a low carbon-economy, which may call for changes to current regulations, market practices, and technological advancement in order to lessen the effects of climate change firms (Al Ahbabi and Nobanee 2019). Furthermore, study shows a strong correlation between political instability and climate variability, which affects the operational and strategic choices made by businesses(Anderson and Garcia-Feijoo 2006, Aouadi and Marsat 2018). Consequently, scholars, policy makers, and researchers have given climate variability risk a great deal of intention.

The US economy significantly affects by global climate variability, which also poses a serious risk to the security of its citizens and enterprises(Arellano and Bond 1991). Current occurrences, such as vineyard hazards and dam breaches, as reported by the Phys.org, Boston Globe, Kathmandu Post, and the Forbes, emphasize the far-reaching effects. The repercussions of climate change are real and urgent, even in the face of criticism. In spite of skeptics, the irrefutable urgency of addressing climate variability demands crucial considerations, influencing both indigenous and foreign enterprises (Aerts, Cormier and Magnan 2008, Adegbite, Guney et al. 2019). As per scientific assessments, the US GDP could decrease by 10% if global warming do not address. Extreme weather events are the main

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global hazards to enterprises, according to the World Economic Forum. The cost of climate risk estimated to be around 1 trillion US dollars, fifty percent of which may happen in the coming 5 years (Bansal and Song 2017). The United States pledge to consider $1.7 trillion in terms of investing in climate variability mitigation over the next ten years, with the goal of halving greenhouse gas emissions by 2030, is noteworthy. Comparably, the European Green Deal proposed by the European Commission seeks to achieve pollution a free zone (GHG emissions) in all EU economies by 2050 (Boulhaga, Bouri et al. 2023). Companies heavily expose to climate concerns as they seek out investment opportunities. These hazards include costs associated with integrating new technology and possible legal repercussions for breaking ecological standards (Broadstock, Chan et al. 2021). Because sustainability is becoming more and more important to stakeholders, leading to boost research focus on the impact of climate variability hazard on investment approaches, pricing dynamics, and hedging practices (Camilleri 2018, Adegbite, Guney et al. 2019, Awaysheh, Heron et al. 2020).

Previous studies have looked into how macro-level climate variability risk affects company performance, financial policy uncertainty, and economic growth performance(Camilleri 2018, Boulhaga, Bouri et al. 2023). Additional research has looked at the risk of climate variability at the company level, how it relates to change in leverage and information efficiency, how it relates to financing decisions made by enterprises, and how it relates to political instability(Cormier and Magnan 2007). Furthermore, research has done to determine whether CSR can reduce stock return and risk factor, ex-ante litigation risk, firm-level climate change exposure and CVR liaison with CEO equity returns and CVR in the event of climate disaster (Elsayed and Paton 2005, Anderson and Garcia-Feijoo 2006, Estrada, De La Fuente and Martín-Cruz 2010, Aouadi and Marsat 2018). Although the impact of CVR on many corporate characteristics is a topic of constant discussion, the precise relationship between CVR and enterprise worth (EW) has not well studied so far. Therefore, the first purpose of this study is to look into how CVR affects US publicly listed enterprise worth.

Academics are constantly debating the influence of ESG initiatives on corporate worth, even though investors generally perceive these investments favorably (Fafaliou, Giaka et al. 2022). Corporate sustainability is becoming more and more in demand from society, partly due to regulatory pressures, UN sustainable development goals (SDGs) and initiatives like the Paris Agreement. The link between ESG investments and enterprise worth is still up for dispute, though. Some researchers present a range of viewpoints from recommending a nonlinear relationship to pointing to a positive correlation (Figge 2005, Flammer 2015, Ortiz Almeyda and Velasco González 2021). While some studies even suggest a financial underperformance, others found no statistically significant correlation (Galbreath 2010, Garcia-Castro, Ariño and Canela 2010). In light of this, the second objective is to investigate how investments regarding ESG affect the enterprise worth of US publicly traded companies.

We argue that making ESG investments can be very beneficial for controlling the risks related to climate change costs. ESG investments, in contrast to typical CSR methods, offer a comprehensive method of addressing elements essential to long-lasting performance and risk reduction (Godfrey 2005, Gillan, Koch and Starks 2021). There is great potential that including ESG factors will reduce climate related expenses while also increasing enterprise worth. This potential comes from proactive risk management practices, financial savings, enhanced reputation, capital accessibility, innovation stimulation, and alignment with sustainability goals. Thus, we propose that the link between climate pertinent expenses and enterprise worth maybe influenced by investments regarding ESG. Within this context, examining how ESG investments affect the relationship between CVR and EW in the US is the third goal of this study. It is critical to realize that, in terms of nominal GDP, the US economy is the largest in the world. Owing to its substantial economic sway over the world stage, the United States is an indispensable player in resolving growth, stability, and environmental issues. Pollution is one of the most urgent environmental issues, particularly with regard to greenhouse gas emissions. The nation must take the lead in reducing its carbon footprint and reducing the effects of pollution on a national and worldwide scale.

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Our three primary areas of inquiry in this article are: (1) Enterprise worth (EW) and climate variability risk (CVR); (2) Environmental, social, and governance indicators and enterprise worth (EW); (3) Investments regarding ESG and its moderating effect on the liaison between CVR and EW. In order to accomplish these goals, we examine an extensive data set that includes 1720 US-listed companies and annual data from 2005 to 2020. We considered both dynamic panel data and static approaches to conduct analysis. The main conclusions drawn from our research are as follows: (1) CVR has a statistically negative influence on EW; (2) Investments regarding ESG has a positive impact on enterprise worth; (3) Investments regarding ESG strengthens the correlation between CVR and EW. Additionally, we also do several sensitivity and robustness tests using different estimators to guarantee the accuracy of our findings. We also improve our analysis by breaking down CVR into three parts: physical, regulatory, and opportunity hazards. We also take into account issues related to ecological, social, and governance (ESG) that are associated with climate risk. Such deep down analyses support the legitimacy and truth worthiness of our study conclusion.

This article makes numerous noteworthy advances to the body of existing literature. First, by analyzing the relationship between CVR and EW in the context of the United States, it presents fresh empirical data. Previous research has predominantly focused on extensive evaluations at the national level, often utilizing CO2 emissions and traditional performance measures. It also investigates how investments in ESG affect enterprise worth. Thirdly, by incorporating investments regarding ESG into the analytical model and explaining how it modifies the CVR-EW relationship, it offers a more thorough approach than CSR. Fourth, this study takes a more thorough approach than earlier research, which was limited by accounting constraints and mostly concentrated on steady current progress indicators like ROA and ROE. In particular, we employ two important stand-ins for enterprise worth: growth option value (GOV), which derives from an option approach, and the Tobin Q model. Moreover, we address statistical challenges by employing FGLS and GMM approaches. To put it briefly, this study presents a novel approach to risk management that has important policy ramifications for US managers, investors, and regulators. We suggest that businesses can benefit greatly from ESG investing as a strategic enabler.

This pattern used throughout the remainder of the paper. Section 2 represents hypotheses, provides a theoretical viewpoint, and examines previous research. The data and methodology section 3 provides an overview of the research methodology. Robustness checks and empirical findings are included in section four “results and discussion”. Lastly, the article summarized, flaws pointed out, and recommendations for more research made in the “conclusion” section 5.

Empirical and Theoretical Literature Review

Scholarly interest in corporate environmental responsibility has increased significantly in the last few decades, especially in works that look at the liaison between environmental jeopardy more especially, climate variability risks (CVR) and enterprise worth (EW) (Hart and Milstein 2003, Godfrey, Merrill and Hansen 2009, Boulhaga, Bouri et al. 2023, Cohen 2023). Examining how climate variability affects enterprise worth is a key area of research in this area. The findings of the Intergovernmental Panel on Climate Change clearly show that human activity is the main contributor to global warming. Consequently, there is growing pressure on businesses worldwide to reduce their greenhouse gas (GHG) emissions and get ready for the challenges that come with climate variability (Hausman 2015, Hartzmark and Sussman 2019, Cui, Wang et al. 2023). Researchers looked at how organizations' information efficiency and leverage adjustments affected by the danger of climate variability. Their research indicates that companies have a more favorable association with countries that have stronger environmental protection laws and better policies (Cormier and Magnan 2007). Furthermore, employing a sample of 42 developing countries, they discovered a substantial correlation between the risk of climate change and the volatility of monetary policy (Cohen 2023). In a study that focused on US firm-year data from 2002 to 2018, regression-based modeling utilized to find that corporate social responsibility (CSR) initiatives help lower the risk of climate change. Several econometric validation tests, including as system GMM, entropy balancing, and propensity score

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matching, difference-in-difference, and modified regression approaches, validated this finding. The results of the study support the notion that corporate social responsibility (CSR) adds value (Aksom and Tymchenko 2020). A new study examined how companies modify their ESG disclosures in response to natural disasters. According to the study, businesses deliberately raise their ESG disclosures in order to sway investor opinions in the wake of natural disasters (He, Ding et al. 2023). Furthermore, a number of researchers have looked into the connection between bond returns and news on climate variability. While some research has revealed a mixed connection with different consequences (Jia and Li 2020), other investigations have produced different findings.

Researchers used data from publicly traded US companies from 2012 to 2021 to investigate the impact of CVR on enterprise worth (EW) in a recent study (Khan, Riaz et al. 2022). Their findings indicate a negative relationship between CVR and EW. Comparable research in the energy sector revealed similar results (Khan, Serafeim and Yoon 2016), with panel data from 2010 to 2020 demonstrating a negative relationship between market capitalization and CVR and a positive association between dividend yield and EW. However, the connection between CVR and EW is still largely unexplored, which emphasizes how crucial it is to look at this more. Our research uses a novel CVR metric created by Ref. (Aerts, Cormier and Magnan 2008) that evaluates a firm's susceptibility to climate-related advantages, environmental consequences, and legal obstacles. Furthermore, as our literature study makes clear, rather than focusing directly on EW, earlier research has primarily concentrated on a firm's current performance measurements, such as Return on Equity (ROE) and Return on Assets (ROA), which are limited by accounting constraints (Kim, Kim and Qian 2018). This study uses two metrics to assess corporate value. Tobin's Q, which often utilized as a forecast of future investment possibilities (Kim, Lee and Kang 2021, Fafaliou, Giaka et al. 2022), firstly employed. Secondly, we employ a more straightforward method of measuring growth worth (GV). This method borrows from the real options approach and computes the total value of a company as the total of its current business value plus the value allocated to its growth potential (De Andrés-Alonso, Azofra-Palenzuela and De La Fuente-Herrero 2006, Klingebiel 2012, Koller, Nuttall and Henisz 2019, Fafaliou, Giaka et al. 2022). In order to fill the first research gap, we put our first hypothesis in this form.

Sustainable finance is the process of incorporating ESG investments into a business's overall business plan. Investors who value social responsibility highly assess a company's investment potential by looking at how well it conforms to ESG standards. This strategy, which is frequently referred to as ESG investment or practices in the literature (Li, Gong et al. 2018, Khan, Riaz et al. 2022, Kong, Zhang et al. 2022), allows investors to evaluate a company's commitment to sustainable economic development and meeting its social duties. A company's ability to manage its environmental impact gauged by the environmental aspect of ESG, which considers things like emissions, energy efficiency, renewable energy use, pollution control, greenhouse gas emissions, reliance on fossil fuels, and biodiversity preservation (Liang and Renneboog 2017, Kong, Zhang et al. 2022). However, the governance component (G) encompasses a wide variety of activities, including risk management practices, diversity on the board, corporate governance processes, and compliance with disclosure laws, audit-related practices, management structure, and transparency (Lins, Servaes and Tamayo 2017, Magrizos, Apospori et al. 2021).

Despite investors' positive opinions, there is still a great deal of academic debate regarding the impact of ESG investments on enterprise worth (EW) (Fafaliou, Giaka et al. 2022). There is also a great deal of disagreement regarding the relationship between ESG investments and enterprise worth, with studies demonstrating a range of results from a positive correlation (Figge 2005, Flammer 2015) to a nonlinear relationship (Ortiz Almeyda and Velasco González 2021). Moreover, while some studies indicate a lack of statistically significant correlation (Galbreath 2010), others even suggest that there may be financial underperformance (Garcia-Castro, Ariño and Canela 2010). The concept of growth option value (GOV) comes from prestigious financial economics publications (Magrizos, Apospori et al. 2021, Mohieldin, Wahba et al. 2022). These publications suggest that an enterprise's worth made up of its current assets as well as the potential value that comes with its future growth opportunities.

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These seminal works gave rise to real options theory, which provides a strategy framework that may be used to ESG practices. This theory emphasizes how crucial it is for ESG strategies to be flexible, allowing businesses to modify their initiatives in reaction to unforeseen circumstances and shifting market conditions. The real options theory advises businesses to launch initiatives when circumstances are most advantageous, which highlights the strategic timing of ESG practices (Myers 1977).

Businesses may effectively manage the uncertainties associated with complex ESG concerns by implementing the concepts of real options theory, which promotes resilient and sustainable decision-making (Adegbite, Guney et al. 2019). The extant body of research highlights the strategic importance of incorporating ESG practices, as evidenced by studies that highlight its crucial function in bolstering fundamental business operations (Naseer, Khan et al. 2024). However, the impact of ESG on a company's growth options has not received as much attention. However, empirical data indicates that many important techniques depend on this specific value component (Kim, Kim and Qian 2018). In conclusion, empirical research on the correlations between business financial performance and ESG or CSR has produced contradictory findings, with studies indicating positive, negative, and neutral relationships (Ozkan, Temiz and Yildiz 2023). This study attempts to assess a company's ESG performance by utilizing Refinitiv ESG Scores. These scores are renowned for their strong data integration capabilities e.g., MSCI, and Bloomberg. These ratings offer useful information to stakeholders, companies, and investors, facilitating well-informed decisions about sustainability (Rahi, Akter and Johansson 2021). Given that, ESG investments have the ability to influence a company's long-term prospects and possibilities; it expected that they have a substantial impact on enterprise worth. In light of this conversation, the following is the formulation of our second hypothesis.

There are other risk-reducing tactics related to these risk factors that go outside the purview of corporate social responsibility (CSR) and should be looked into further (Aksom and Tymchenko 2020). Corporate social responsibility (CSR) takes the shape of environmental, social, and governance (ESG) investments, which evaluate the significance of these factors in a portfolio's long-term performance. The negative effects of firm-specific risks may be mitigated by ESG investments (Aksom and Tymchenko 2020, Gillan, Koch and Starks 2021, Boulhaga, Bouri et al. 2023). ESG investing, as opposed to CSR, is an integrated strategy that can lessen the effect of corporate climate change risk on value and performance of the organization. ESG investments can affect an enterprise worth by acting as a moderating factor in the relationship between enterprise worth and CVR. According to this article, making ESG investments can help reduce risks associated with climate change and offer a complete substitute for conventional CSR activities. It proposed that the use of ESG principles could potentially decrease CVR while increasing EW is achieved through innovative approaches, cost-effectiveness, enhanced reputation, proactive risk management, capital availability, and sustainability target alignment. The article makes the case that ESG investments could have an effect on the relationship between CVR and EW because the US has the largest economy in the world. Therefore, we build a third hypothesis.

The interdisciplinary character ESG investments with regard to CVR and its effect on EW forms the basis of this study's theoretical framework. Numerous studies that draw results from various theoretical perspectives, including the institutional theory, stakeholder theory, and resource-based view (RBV), lend support to the examination of these relationships (Richardson and Welker 2001). The application of institutional theory enables the examination of the ways in which a firm's performance is impacted by its reaction to environmental concerns, namely climate change (Schuler and Cording 2006). According to this view, it is crucial to give in to pressure from regulations and outside expectations. The resource-based perspective also emphasizes how important it is to adjust to environmental changes in order to maintain prosperity (Shiu and Yang 2017, Shahzad, Shah et al. 2023). This study attempts to provide a thorough understanding of the intricate interactions between ESG investment, CVR, and EW by integrating various theoretical frameworks. According to stakeholder theory, companies that are skilled at fostering connections with a variety of

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stakeholders—including those who are worried about climate change—can have a beneficial impact on their enterprise worth (Luo and Liao 2023). Furthermore, by utilizing well-established studies on climate variability, we look into how CVR affects EW. The success of businesses and climate risk are negatively correlated, as previous research (Godfrey, Merrill and Hansen 2009, Hausman 2015, Boulhaga, Bouri et al. 2023) has highlighted. We want to fill in the gaps in the literature by analyzing the effect of CVR on EW by utilizing an original CVR measure (Aerts, Cormier and Magnan 2008) and evaluating EW using Tobin's Q and GOV.

Additionally, this study examines the connection between ESG investments and EW by utilizing stakeholder theory and sustainable finance (Snoeren 2015, Tahmid, Hoque et al. 2022). By using this strategy, we hope to shed light on the intricate relationships that exist between enterprise worth, CVR, and ESG investment. It is critical to indicate an inverse liaison between CVR and ESG aspects in order to support EW and assure continued profitability. The literature, which includes a variety of research (Figge 2005, Lins, Servaes and Tamayo 2017, Fafaliou, Giaka et al. 2022), offers a wide range of conclusions about the relationship between EW and ESG investments. Moreover, this comprehension can be consumed for efficient jeopardy management, since scholars have maintained that funding Corporate Social Responsibility (CSR) involvement functions in terms of insurance-like safeguard in contradiction of firm-specific peculiar risks, eventually leading to improved EW. Together, these theories highlight how crucial it is for companies to actively manage the risks associated with climate change in order to be competitive (Teng, Wang et al. 2021). ESG investments are thought of as comprehensive risk alleviating strategies and have the potential to intermediate the relationship between CVR and EW, according to the literature (Aksom and Tymchenko 2020).This is in addition to corporate social responsibility (CSR). This hypothesis, which is well supported theoretically, serves as the starting point for the rest of the research. An overview of the theoretical foundations is provided in Figure 1. ESG considerations are thought of as comprehensive risk alleviating strategies and have the potential to intermediate the relationship between CVR and EW, according to the literature (Aksom and Tymchenko 2020). This is in addition to CSR. This hypothesis, which is well supported theoretically, serves as the starting point for the rest of the research.

3. Material and Methods

The research included 1,720 publicly traded companies in the US as a sample from 2005 to 2020. As the greatest economy in the world (Aksom and Tymchenko 2020), the United States undoubtedly plays a crucial role in the expansion and stability of the global economy (Khan, Riaz et al. 2022). The United States is also a vital beginning point for comprehending and resolving environmental issues because it is one of the biggest polluters, especially when it comes to yearly CO2 emissions. This recognition stems from the fact that it serves as the principal home base for a sizable number of polluting organizations, highlighting the significance of investigating the relationship between business operations, environmental hazards, and sustainable practices in this important economic environment. To guarantee a solid dataset, we imposed particular sampling standards. In order to do this, companies with stated governance scores, corporations that took part in latest business conference calls on CVR. In order to lessen survivorship bias, we also eliminated dysfunctional businesses and utility or financial organizations with unique capital structures governed by various bodies. The dataset was additionally cleared of outliers. CompStat, the World Development Indicators (WDI), and Refinitiv's Eikon platform provided the data for this study.

3.1. Variable Details

We employed machine learning techniques[2] to examine climate variability risk (CVR) information taken from Ref. (Aerts, Cormier and Magnan 2008)'s earnings conference calls. This can be written as the following equation:

Climate Variability Risk = $CVR_{i,t} = \frac{1}{B_{i,t}} \sum_{b}^{B_{i,t}} (1[b \in C] \times 1[b, r \in S])$ 1

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As per Sautner et al., Equation (1) shows that a greater CVR score corresponds to a higher risk of climate change. The climate variability dynamics at a given point in time are captured by CVR using a full set of climate variability bigrams, represented by the letter C. Moreover, "r" stands for uncertainty or a relevant notion.

Regarding enterprise worth (EW^2), we utilize two metrics. The first statistic is the Tobin's Q ratio (TR), which is frequently employed in financial analysis. Our approach to determining the TR, as shown in equation (2), is consistent with earlier research (Tong and Reuer 2006, Trigeorgis and Lambertides 2014, Kim, Lee and Kang 2021, Fafaliou, Giaka et al. 2022, Khan, Riaz et al. 2022).

$$Tobin'\ s\ Q_{i,t} = \frac{Equity\ MV_{i,t} + Liabilities\ MV_{i,t}}{Equity\ BV_{i,t} + Liabilities\ BV_{i,t}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 2$$

Second, based on the genuine options approach, the value of a company's current endeavors is added to the potential value of upcoming development prospects to calculate the total valuation of the company. This provides a more direct indicator of a company's growth options (GO) (De Andrés-Alonso, Azofra-Palenzuela and De La Fuente-Herrero 2006, Klingebiel 2012, Koller, Nuttall and Henisz 2019, Fafaliou, Giaka et al. 2022). We evaluate the growth option value (GOV) using the real-options paradigm in line with earlier research (Klingebiel 2012, Trigeorgis and Reuer 2017, Koller, Nuttall and Henisz 2019, Fafaliou, Giaka et al. 2022). According to the approach of (Trigeorgis and Reuer 2017), the calculation of GOV involves deducting the market capitalization of the company from its assets-in-place attributable to equity and dividing the result by the market capitalization.

Using equation (3), we first ascertain the value of the assets that are in place and attributable to equity.

$$Value\ of\ assets\ in\ place_{i,t} = \frac{Net\ Income_{i,t}}{Ke_{i,t}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3$$

In the subsequent stage, we compute the Growth Option Value (GOV) using the following equation (4):

$$GOV_{i,t} = \frac{Market\ Capitalization_{i,t} Value\ of\ assets\ in\ place_{i,t}}{Market\ Capitalization_{i,t}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 4$$

To calculate the value of a company's equity assets-in-place, we compute the present value of earnings (net income) for a given year (t), assuming perpetual continuation, and discount it at the cost of equity (Ke). Since the Capital Asset Pricing Model (CAPM) accounts for market risk, we opt to use it for calculating the cost of equity (Trigeorgis and Reuer 2017). In terms of ESG investing, we use the company's ESG overall index based on the Refinitiv ESG score, as per the studies by Refs. (Rahi, Akter and Johansson 2021, Fafaliou, Giaka et al. 2022). The categories that apply to the scoring range are as follows: A score of 0 to 25 (0–0.25) indicates subpar relative ESG performance and a lack of transparency in the disclosure of relevant ESG information. Scores between 51 and 75 (0.51–0.75) imply good relative ESG performance and above-average transparency in presenting relevant ESG data. Not to mention, scores between 76 and 100 (0.76–100) show outstanding relative ESG performance in addition to a high degree of openness in disclosing relevant ESG data. Standardized values are used in our study to make sure those variables with various scales and units are on the same scale. Furthermore, we include firm and macroeconomic factors in all model settings, in line with recent literature. Appendix A contains information on the variables in detail.

Econometrics Models and Empirical Approach

Equations (5) through (9) below show how the following exact dynamic panel two-stage GMM models are built to assess the study hypothesis in order to investigate the association between CVR and EW with an emphasis on ESG investment:

$$TR_{i,t} = \alpha_0 + \beta_1 \mathrm{TR}_{i,(t-2)} + \beta_2 \mathrm{CVR}_{i,t} + \delta_1 FOCF_{i,t} + \delta_2 SGR_{i,t} + \delta_3 \mathrm{TAG}_{i,t} + \delta_4 SZE_{i,t} + \delta_5 FLEV_{i,t} + \delta_6 \mathrm{INFR}_{i,t} + \delta_7 \mathrm{GDPP}_i + \partial_1 dum\ year + \partial_1 dum\ industry + \varepsilon_{i,t} \dots\dots\dots\dots 5$$

$$GOV_{i,t} = \alpha_0 + \beta_1 \mathrm{GOV}_{i,(t-2)} + \beta_2 \mathrm{CVR}_{i,t} + \delta_1 FOCF_{i,t} + \delta_2 SGR_{i,t} + \delta_3 \mathrm{TAG}_{i,t} + \delta_4 SZE_{i,t} + \delta_5 FLEV_{i,t} + \delta_6 \mathrm{INFR}_{i,t} + \delta_7 \mathrm{GDPP}_i + \partial_1 dum\ year + \partial_1 dum\ industry + \varepsilon_{i,t} \dots\dots\dots\dots 6$$

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$$TR_{i,t} = \alpha_0 + \beta_1 \mathrm{TR}_{i,(t-2)} + \beta_2 \mathrm{VCR}_{i,t} + +\beta_3 \mathrm{ESG\ Index}_{i,t} + \delta_1 FOCF_{i,t} + \delta_2 SGR_{i,t} + \delta_3 \mathrm{TAG}_{i,t} + \delta_4 SZE_{i,t} + \delta_5 FLEV_{i,t} + \delta_6 \mathrm{INFR}_{i,t} + \delta_7 \mathrm{GDPP}_i + \partial_1 dum\ year + \partial_1 dum\ industry + \varepsilon_{i,t} \ldots\ldots 7$$

$$TR_{i,t} = \alpha_0 + \beta_1 \mathrm{TR}_{i,(t-2)} + \beta_2 \mathrm{CVR}_{i,t} + \beta_3 \mathrm{ESG\ Index}_{i,t} + \beta_4 \mathrm{CVR}_{i,t} + \beta_5 \mathrm{ESG\ Index}_{i,t}) + \delta_1 FOCF_{i,t} + \delta_2 SGR_{i,t} + \delta_3 \mathrm{TAG}_{i,t} + \delta_4 SZE_{i,t} + \delta_5 FLEV_{i,t} + \delta_6 \mathrm{INFR}_{i,t} + \delta_7 \mathrm{GDPP}_i + \partial_1 dum\ year + \partial_1 dum\ industry + \varepsilon_{i,t} \ldots\ldots 8$$

$$GOV_{i,t} = \alpha_0 + \beta_1 \mathrm{GOV}_{i,(t-2)} + \beta_2 \mathrm{CVR}_{i,t} + \beta_3 \mathrm{ESG\ Index}_{i,t} + \beta_2 \mathrm{CVR}_{i,t} + \mathrm{ESG\ Index}_{i,t}) + \delta_1 FOCF_{i,t} + \delta_2 SGR_{i,t} + \delta_3 \mathrm{TAG}_{i,t} + \delta_4 SZE_{i,t} + \delta_5 FLEV_{i,t} + \delta_6 \mathrm{INFR}_{i,t} + \delta_7 \mathrm{GDPP}_i + \partial_1 dum\ year + \partial_1 dum\ industry + \varepsilon_{i,t} \ldots\ldots 9$$

In subscripts, firms are represented by [i], while time is represented by [t]. A statistic called Tobin's Q ratio, or TR, is used to determine the market worth of a business. In contrast, lag-dependent variables are indicated by subscripts [t-2], while GOV stands for growth option value. The variables used in this analysis have the following acronyms: GDPP for gross domestic product; INFR for inflation; δ for dummy variable; SZE for firm size; SGR for sales growth; FLEV for financial leverage; GDPP for climate variability risk; TAG for assets tangibility; FOCF for firm operating cash flow; and ε for error term.

After utilizing descriptive statistics and correlation to begin our empirical investigation, we turned our attention to baseline regression. The Feasible Generalized Least Squares (FGLS) (Velte 2017)is a robust framework that we used to address heteroskedasticity, cross-sectional dependence, and serial/auto-correlation problems. To further lessen the chance of omitted variable bias brought on by data heterogeneity, we further adjusted for other factors that might be connected to the predictors but are not easily observable, accessible, or measurable (Wai Kong Cheung 2011). As far as addressing endogeneity and maintaining accuracy and consistency are concerned, the Generalized Method of Moments (GMM) has proven to be the most dependable econometric technique (Aksom and Tymchenko 2020). Endogeneity and reverse causality are eliminated by GMM, which automatically creates instrumental variables (Wang, Barney and Reuer 2003). In order to account for heterogeneity in our study, we also employed quantile regression, splitting the variables into high and medium quantiles (90th, 75th, and 50th, respectively), as utilized by Ref. (Weber 2014).

4. Findings Discussion

The variables' standard statistical characteristics, such as the mean, standard deviation, and total number of observations, are shown in Table 1. It shows a substantial fluctuation in the data, which is necessary to evaluate how firm-level climatic variability risk (CVR) affects enterprise worth (EW), as determined by growth options value (GOV) and Tobin's Q. Our main explanatory variable is CVR; the explained variable is EW; and the moderator is ESG investment. There is no multicollinearity among the variables, as shown by our correlation coefficients and variance inflation factor (VIF), both of which fall within acceptable bounds. Appendix Table A has comprehensive explanations of the variables. Additional information is provided by correlations and VIF estimates in Table 2, which further support the lack of multicollinearity.

The outcomes of stationarity testing using first and second-generation unit root frameworks are shown in Appendix Table 2. Assuming total independence among cross-sectional units, the Augmented Dickey-Fuller (ADF)-Fisher and Im-Pesaran-Shin (IPS) tests for stationarity are appropriate for imbalanced panel datasets (Wen, Ho et al. 2022). Cross-sectional reliance on unit root results is addressed by the second-generation PCIPS test, which solves a particularly cross-sectional problem. The results confirm the predicted integration order for the research variables. Instead of using the cointegration approach, we choose to use the Ordinary Least Squares (OLS) model.

Table 1. Descriptive Statistics.

Variable	Obs.	Mean	Std.Dev	Min	Max	VIF	1/VIF
TQR	19,443	2.6001	2.0013	0.5101	9.2018		

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GV	19,443	0.8625	0.7081	0.1053	8.3401		
FCCR	19,443	0.0420	0.0370	0.0000	0.0748	2.11	0.474
ESG Index	19,443	0.4069	0.1949	0.0000	0.9412	1.09	0.917
TANG	19,443	6.5401	5.0052	2.1011	8.1077	1.03	0.971
OCF	19,443	0.0919	0.0801	0.0814	0.4052	2.55	0.392
SIZE	19,443	8.0235	6.0907	6.1001	23.3012	1.32	0.758
SAG	19,443	2.3104	1.0053	0.8401	7.0108	1.39	0.719
LEV	19,443	0.2511	0.2402	0.0000	0.8103	2.03	0.493
INF	19,443	3.82	2.41	1.40	7.00	1.22	0.820
GDP	19,443	− 0.05	3.13	2.08	5.90	2.01	0.498
Mean VIF						1.97	

Table 2. Correlations Matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) FCCR	1.000								
(2) ESG Index	0.018	1.000							
(3) TANG	0.012	0.588	1.000						
(4) OCF	−0.003	− 0.005	− 0.005	1.000					
(5) SIZE	−0.011	0.001	0.004	0.043	1.000				
(6) SAG	0.010	− 0.076	− 0.097	− 0.033	− 0.016	1.000			
(7) LEV	0.007	0.032	0.023	− 0.032	0.013	− 0.001	1.000		
(8) INF	−0.004	0.008	0.010	0.002	0.001	− 0.010	− 0.002	1.00	
(9) GDP	−0.002	− 0.022	− 0.010	− 0.003	0.016	− 0.117	0.050	− 0.105	1.000

4.1. Regression Techniques

To make sure that all conditions meet and to avoid false regression, the study runs the diagnostic and post-estimation tests listed in Table 3 before moving on to the baseline estimation. We begin with baseline estimation as part of the assessment of the hypotheses. Assuming no influence, we run the Breusch–Pagan (LM) test to see if panel effect estimation or Ordinary Least Squares (OLS) is a better fit. The substantial p-value of the Breusch–Pagan test indicates that the LM test is significant and recommends the panel estimation method over alternative alternatives. After the Hausman test hypothesis refuted, we chose a fixed effect model and carried out calculations of both fixed and random effects. The results of the Modified Wald and Wooldridge tests show that our models are serially or auto correlated heteroskedastic. We use a strong fixed effect model to account for heteroskedasticity.

Table 3, which presents the statistics of the fixed effect robust approach, provides significant insights into the correlation between firm-level climatic variability risk (CVR) and enterprise worth (EW), as ascertained by TR and GOV. The empirical findings, which demonstrate a significant negative effect of CVR on enterprise worth and an average fall in EW because of CVR, support H1. Columns 1–2 illustrate the correlation between a one-unit rise in CVR and a −0.0503 and −0.0406 unit

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decrease in TR and GOV, respectively, when all other variables are held constant. These real results support the conclusions made by Reference (He, Ding et al. 2023).

We then look into how ESG investments affect EW. The data are summarized in Table 3 columns (3–4) and show that ESG investment generally increases EW as determined by TR and GOV. These are positive, statistically significant impacts. These results are in line with earlier studies conducted by Refs. (Rahi, Akter and Johansson 2021, Fafaliou, Giaka et al. 2022, Shahzad, Shah et al. 2023). So, we validate our H2 using our data. Next, in order to assess our third hypothesis, we include the interaction term (CVR*ESG index) in columns 5–6. The results show that the interaction term has a favorable impact on EW, supporting our hypothesis (H3) that the interaction of CVR and ESG investments will minimize negative consequences on EW.

Table 3. Fixed Effect Robust: Direct and Moderating Affect.

FE robust Estimation	Direct effect				Moderating Effect	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	TQR	GV	TQR	GV	TQR	GV
FCCR	− 0.0503***	− 0.0406**	− 0.0551***	− 0.0526**	− 0.0447***	− 0.0492**
	(0.0179)	(0.0203)	(0.0218)	(0.0213)	(0.0138)	(0.0246)
ESG Index			0.0681***	0.0456**	0.0674***	0.0615***
			(0.0143)	(0.0228)	(0.0131)	(0.0208)
FCCR* ESG Index					0.0064**	0.0047*
					(0.0032)	(0.0025)
TANG	− 0.0348*	− 0.0602**	− 0.5106***	− 0.0026**	− 0.0521***	− 0.0705
	(0.0025)	(0.0301)	(0.0202)	(0.0013)	(0.0033)	(0.4207)
OCF	0.1809***	2.5023	2.5002	0.0294***	0.0565***	0.0952
	(0.0297)	(2.0809)	(2.0804)	(0.0099)	(0.0271)	(0.0523)
SIZE	− 0.0783***	− 2.5010***	0.5709***	0.0079***	0.0023***	− 0.3089***
	(0.0032)	(0.2400)	(0.0080)	(0.0011)	(0.0002)	(0.0111)
SAG	0.1170***	0.6550***	0.563***	0.0173***	0.0042	0.0003***
	(0.0049)	(0.0405)	(0.0414)	(0.0015)	(0.0044)	(0.0000)
LEV	− 0.0301***	0.0370	0.2608	− 0.0137***	0.126***	− 0.0223
	(0.0103)	(0.7207)	(0.7025)	(0.0036)	(0.0094)	(0.0234)
INF	− 0.0045	− 1.1430	0.7407	− 0.0030	− 0.0101	− 0.0834***
	(0.0063)	(1.1460)	(0.5433)	(0.0055)	(0.0149)	(0.4401)
GDP	0.6004***	− 8.643***	−10.1911***	− 0.1053***	− 0.0700***	2.1001***
	(0.0239)	(1.680)	(1.6834)	(0.0080)	(0.0219)	(0.596)
Constant	0.693	− 0.602	− 0.0007***	− 0.050***	− 0.0242**	− 0.0813***
	(1.0119)	(0.049)	(0.0000)	(0.0000)	(0.0121)	(0.0362)
Obs.	19,443	19,443	19,443	19,443	19,443	19,443
Industry/year cluster	Yes	Yes	Yes	Yes	Yes	Yes
adj. R2	0.159	0.221	0.286	0.214	0.259	0.289
F-test	35.03***	27.13***	47.44***	17.74***	117.01***	467.75***

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Breusch–Pagan $\chi 2$	434.46***	934.06***	534.96***	1134.46***	834.48***	1434.46***
Hausman Test $\chi 2$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Modified Wald test	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wooldridge test	F=314.42***	F=513.21***	F=453.25***	F=627.22***	F=109.42***	F=541.37***
Wald test	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Explanation

Our findings highlight the benefits that ESG investing may provide to companies that are more vulnerable to climate risk and show how it can increase company value through active participation in ESG activities (Khan, Riaz et al. 2022, Boulhaga, Bouri et al. 2023). Moreover, we include control variables in each empirical formulation. The results show that some variables have a statistically significant negative impact on equity, including asset tangibility (TAG), firm size (SZE), leverage (FLEV), and inflation (INFR); on the other hand, some variables have a positive impact on equity, including sales growth (SGR), firm operating cash flow (FOCF), GDP growth (GDPP), and firm tangibility (TAG). On all factors, CVR typically has a negative effect on the value of the company.

Furthermore, the considerable F-test results for each fixed effect model specification show that the study models are well specified. A corporate finance research (Fafaliou, Giaka et al. 2022). lists a number of factors that affect a company's value, including climate risk. Consequently, our econometric modeling is consistent with recent studies in the field by taking into consideration both firm specific and macroeconomic aspects (Kim, Lee and Kang 2021). Our study lowers possible confounding variables, which improves dependability. All the variables have undergone a one-year time shift, and the clustering standard errors are shown in parenthesis.

The remarkable results from the modified Wald and Wooldridge approach, which indicated issues with serial/autocorrelation and heteroskedasticity in our fixed effect models, led us to adopt a more robust approach. Fixed effect models with robust functions, despite the fact that they partially address these problems, do not adequately account for cross-sectional dependence. As a result, we switched to generalized models, more precisely FGLS, which provide a more thorough solution by concurrently addressing heteroskedasticity, cross-sectional dependency, and serial/autocorrelation (Velte 2017). The FGLS results, which are shown in Table 3 columns (1–2), are consistent with the earlier findings. First, our hypothesis (H1) is supported by the negative and significant coefficients (-0.0621 and -0.0570) for CVR in the first stage, which, on average, show a decline in EW as determined by TR and GOV (He, Ding et al. 2023). Next, we looked at how ESG investments directly affected EW. In accordance with earlier research (Rahi, Akter and Johansson 2021, Fafaliou, Giaka et al. 2022, Shahzad, Shah et al. 2023), The ESG index's positive and substantial correlations in Table 3 columns (3–4) suggest that investing in ESG enhances TR and GOV. In the third stage, we included the interaction term (CVR*ESG index). The noteworthy and statistically significant coefficient values of 0.0121 and 0.0102 in Table 3 columns 5–6 provide substantial support for our hypothesis. This implies that the positive and significant relationships between CVR and EW are routinely and considerably moderated by the interaction term. Our study supports H3 by showing how important it is for ESG activities to lessen the negative effects of CVR on EW. Furthermore, as previous studies have demonstrated (Boulhaga, Bouri et al. 2023), our findings emphasize the strategic significance of ESG initiatives in fostering resilience and value creation, especially for businesses operating in areas seeing a rise in climate-related issues.

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Table 4. Feasible Generalized Least Square (FGLS) Estimation.

FGLS estimation:	Direct effect				Moderating Effect	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	TQR	GV	TQR	GV	TQR	GV
FCCR	− 0.0621***	− 0.0570**	− 0.0509***	− 0.0459***	− 0.0524***	− 0.0344***
	(0.0242)	(0.0305)	(0.0231)	(0.0071)	(0.0191)	(0.0017)
ESG index			0.0780***	0.0642***	0.0712***	0.0470***
			(0.0126)	(0.0216)	(0.0222)	(0.0229)
FCCR* ESG Index					0.0121***	0.0102***
					(0.0024)	(0.0019)
TANG	− 0.0090***	− 0.0006***	− 0.0813***	0.0080***	− 0.0010***	− 0.0026***
	(0.0037)	(0.0000)	(0.0362)	(0.0062)	(0.0000)	(0.0011)
OCF	− 0.0026***	− 0.0006***	− 0.0305	− 0.0040**	− 0.0004**	− 0.0091***
	(0.0006)	(0.0000)	(0.0061)	(0.0020)	(0.0002)	(0.0029)
SIZE	0.0042**	0.0108**	− 0.0090	− 0.0300***	− 0.0006**	− 0.0108***
	(0.0021)	(0.0004)	(0.0093)	(0.0003)	(0.0003)	(0.0054)
SAG	0.0013***	0.0038***	0.0008**	0.0043***	0.0214	0.0108
	(0.0004)	(0.0017)	(0.0004)	(0.0081)	(0.0228)	(0.0157)
LEV	− 0.0008**	− 0.0040**	− 0.0301***	− 0.0090***	− 0.0108	− 0.0031***
	(0.0004)	(0.0020)	(0.0061)	(0.0037)	(0.0115)	(0.0013)
INF	− 0.0511***	− 0.0090***	− 0.0007***	− 0.0007***	− 0.050***	− 0.0242**
	(0.0058)	(0.0007)	(0.0100)	(0.0000)	(0.0000)	(0.0121)
GDP	0.0304**	− 0.0018	− 0.0309***	− 0.0003***	− 0.0004	− 0.0065***
	(0.0152)	(0.0011)	(0.0083)	(0.0001)	(0.0004)	(0.0031)
Constant	− 3.689***	− 0.0060**	0.693	− 0.602	− 1.909***	− 0.0652
	(1.036)	(0.0030)	(1.0119)	(0.049)	(0.2304)	(3.0188)
Year/industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm cluster	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	19,443	19,443	19,443	19,443	19,443	19,443
Wald chi2	37.13***	17.19***	77.01***	47.04***	54.12***	74.12***

4.2. Generalized Method of Moment

We acknowledge the possibility of endogeneity and reverse causation in our empirical estimates. It is possible that anything was missed in our exploratory investigation, even with several control variables included. This oversight may entail neglecting factors like macro-level climate variability risk or behavioral effects e.g., attitudes toward climate variability that could have an impact on both CVR and EW. We use the generalized two-step method of moments, a robust econometric technique

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that is well-known for resolving endogeneity and reverse causality concerns as well as for developing instrumental variables on its own, to minimize the potential bias in our initial approximations.

The results of the generalized two-step method of moments (GMM) are displayed in Table 5 columns 1-2, and they indicate negative and statistically significant CVR coefficient values. Nevertheless, this supports our initial hypothesis that TR and GOV typically decrease. Additionally, Table 5 columns (3–4) demonstrate the remarkable and favorable influence of ESG investment on EW, hence supporting our hypothesis and highlighting the potential benefits of ESG for EW. Furthermore, the interaction term favorably and significantly moderates the relationship between CVR and EW. This supports the correctness of our hypothesis by further verifying our initial model (H3), as seen in Table 5 columns 5–6. Furthermore, the Autoregressive (AR) (2) test is used to verify residual autocorrelation of the second order. In summary, our analysis uses strong econometric techniques like GMM to solve the acknowledged problems of endogeneity and reverse causation, offering significant insights into the links between CVR, EW, and ESG investments.

To sum up, our research highlights three important points: (1) there is a notable and adverse correlation between CVR and EW. (2) The investment in ESG has a noteworthy and favorable effect on EW. (3) The relationship between CVR and value is moderated by ESG investment, improving EW. These findings validate our assumptions H1, H2, and H3. Our empirical results are represented visually in Figure 3.

First, the impact of firm-level climatic variability risk (CVR) on enterprise worth (EW) of US-listed enterprises is investigated in this study. We validate the prediction in H1 by repeatedly observing an inverse influence of CVR on enterprise worth through the application of FGLS, GMM, and fixed-effect robust estimating techniques. The current findings support the hypothesis put forth by Ref. (Zhang and Shuang 2021) that the environmental expenses related to climate change concerns may lower corporate value. These findings are consistent with previous research by Refs. (Xie, Nozawa et al. 2019, Khan, Riaz et al. 2022, Boulhaga, Bouri et al. 2023). Next, the effect of investments in ESG on company value is discussed in the context of US-listed companies. Using fixed-effect robust, FGLS, and GMM estimate approaches, we consistently discover a positive impact of ESG investments on company value, as expected by H2 and corroborated by other research (Rahi, Akter and Johansson 2021, Sautner, Van Lent et al. 2023, Shahzad, Shah et al. 2023). A company's value can be impacted by ESG in a variety of ways, such as by improving its reputation, luring customers and investors in, and promoting productivity and creativity.

In the final component of our study, we look at the moderating role that ESG investment plays in the link between CVR and EW. The results indicate a strong moderating effect, with the interaction term CV*ESG index having a positive and significant influence on the connection between CVR and EW. This demonstrates how ESG investments can lessen the detrimental effect that the danger of climate change has on a company's value. In particular, ESG investments boost corporate value and decrease CVR. These findings suggest that climate finance policies, such green tax credits and subsidies, can facilitate the transition of investors to more environmentally friendly options.

Refs. (Godfrey 2005, Gillan, Koch and Starks 2021) demonstrate the significant benefits of risk management from ESG investing involvement in lowering the costs associated with climate-related hazards. ESG investments provide a comprehensive alternative to traditional CSR, successfully addressing the significance of ESG factors to long-term performance and risk reduction.

Above all, the outcomes demonstrate the advantages of ESG programs. Engaging in these kinds of activities can be advantageous for companies that put their stakeholders first because environmental, social, and governance (ESG) factors support enhanced public trust, financial support, brand awareness, reputation, and a competitive edge that can result in higher sales and a higher corporate valuation.

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Table 5. Two-Steps Dynamic panel System Generalized Method of Movements estimation.

Two-stage GMM estimations	Direct effect				Moderator's effect	
VARIABLES	(1) TQR	(2) GV	(3) TQR	(4) GV	(5) TQR	(6) GV
L2.TQR	−0.0364***		−0.0336***		− 0.0264***	
	(0.0102)		(0.0114)		(0.0112)	
L2.GV		−0.0764***		−0.0036**		0.0564***
		(0.0312)		(0.0014)		(0.0212)
FCCR	−0.0451***	−0.0361***	−0.0463***	−0.0319***	− 0.0445***	0.0331***
	(0.0221)	(0.0111)	(0.0125)	(0.0108)	(0.0221)	(0.0092)
ESG index			0.0691***	0.0523***	0.0541***	0.0474**
			(0.0310)	(0.0181)	(0.0138)	(0.0237)
FCCR* ESG Index					0.0292***	0.0138***
					(0.0042)	(0.0067)
TANG	−0.0027***	−0.0038***	− 0.0008	− 0.0065	− 0.0301***	−0.0104**
	(0.0016)	(0.0001)	(0.0008)	(0.0041)	(0.0071)	(0.0057)
OCF	0.3717***	−0.0033***	−0.0086***	0.0091***	0.00926***	0.0092***
	(0.0445)	(0.0001)	(0.0010)	(0.0004)	(0.00088)	(0.0008)
SIZE	−0.0923***	−0.1250***	−0.0574***	−0.0444***	− 0.0153***	−0.0108***
	(0.0102)	(0.0258)	(0.0121)	(0.0144)	(0.0008)	(0.0049)
SAG	0.0124***	0.0095***	0.0011	0.0029	0.0579***	0.0008
	(0.0058)	(0.0031)	(0.0012)	(0.0018)	(0.0024)	(0.0057)
LEV	−0.0096***	0.1011***	0.0202***	−0.0182***	− 0.0127***	0.0041***
	(0.0016)	(0.0105)	(0.0019)	(0.0007)	(0.0095)	(0.0015)
INF	−0.0122***	−0.1081***	− 0.0035	−0.0132***	− 0.0581	− 0.0136
	(0.0042)	(0.0194)	(0.0040)	(0.0026)	(0.0358)	(0.0208)
GDP	−0.0122***	0.0123	0.0169***	− 0.0048*	− 0.0334***	− 0.1300*
	(0.0042)	(0.0261)	(0.0065)	(0.0025)	(0.0067)	(0.0786)
Constant	0.0579***	−7.0915***	0.0072	1.0072***	− 3.689***	−4.0658***
	(0.0024)	(0.0397)	(0.0140)	(0.0145)	(0.2033)	(0.0183)
Year/industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Number of ids	1771	1771	1771	1771	1771	1771
AR (1)-1st differences	−23.217***	−13.201***	−21.211***	−11.201***	−12.201***	−15.201***

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AR (2) – 1st differences	2.115	3.101	3.015	3.147	4.201	0.985
Sargan Test p-value	0.081	0.120	0.198	0.101	0.149	0.123
Hansen test (p-value)	0.155	0.111	0.149	0.123	0.109	0.088

5. Conclusion and Policy Recommendations

This study looked at the relationship between an enterprise worth (EW) and climate variability risk (CVR), highlighting the moderating effect of ESG investments in this relationship. We conducted our analysis using a sample of 1720 US-listed companies from 2005 to 2020. We use machine learning to produce climate variability risk data. We computed firm value using the TR ratio and GOV. We made our ESG investment decisions based on Refinitiv's overall score. The estimate procedure made use of feasible generalized least square, dynamic-panel GMM, and panel fixed effect estimators. The following succinctly summarizes our main findings: (i) CVR significantly and negatively affects EW. (ii) Investments in ESG show a considerable and favorable influence on both GOV and EW. (iii) By moderating the CVR-value link, ESG investment increases EW. We used alternative estimating methods to do a thorough robustness analysis in order to guarantee the validity of our main conclusions. Significantly, quantile regression analysis showed that in the high and medium percentiles (the 90th and 75th, respectively), CVR reduces EW and exhibits higher variation and stability than at the low percentile. We also used the Driscoll Kraay standard error clustering method to make sure our main specification result would hold up over time, and the results were reliable.

This research has important policy ramifications for US legislators and business executives. First off, decision-makers can use our findings to get strategic insights. The detrimental impact of CVR on EW emphasizes how crucial proactive risk reduction techniques are. Additionally, the gains that EW has reaped from ESG investments highlight the real advantages of incorporating ESG principles into business decision-making procedures. Second, businesses can use these results to support their sustainability initiatives. The CVR-FV link is positively moderated by ESG investment, indicating that engaging in ESG activities helps mitigate the financial impact of climate change concerns. Thirdly, by using these insights, investors can choose investments with greater knowledge. The detrimental impact of CVR on EW draws attention to the financial risks that these businesses face because of climate change. Investors may also think about incorporating assessments of companies' ESG and climate risk management into their investment strategy.

From an academic perspective, this work advances our knowledge of the implications of CVR on EW, which enhances the body of scholarly literature. A thorough approach to climate risk assessment is provided by the methodological innovation of using machine-learning algorithms to generate corporate conference call climate change risk data. The empirical findings give climate finance models empirical support, particularly when taking US-listed corporations into account. The found negative and considerable impact of CVR on EW is consistent with established theoretical frameworks and adds empirical evidence to the body of research demonstrating the deleterious effects of climate change risk on financial indicators. Ultimately, the study demonstrates how investments in ESG mitigate the CVR-EW relationship, suggesting that ESG initiatives could mitigate the adverse effects of climate risk on firm value.

References

1. Adegbite, E., et al. (2019). "Financial and corporate social performance in the UK listed firms: the relevance of non-linearity and lag effects." Review of Quantitative Finance and Accounting **52**: 105-158.

 doi:10.20944/preprints202507.1197.v1

2. Aerts, W., et al. (2008). "Corporate environmental disclosure, financial markets and the media: An international perspective." Ecological economics **64**(3): 643-659.
3. Aksom, H. and I. Tymchenko (2020). "How institutional theories explain and fail to explain organizations." Journal of Organizational Change Management **33**(7): 1223-1252.
4. Al-Qudah, A. A., et al. (2022). "The relationship between social entrepreneurship and sustainable development from economic growth perspective: 15 'RCEP'countries." Journal of Sustainable Finance & Investment **12**(1): 44-61.
5. Al Ahbabi, A. R. and H. Nobanee (2019). "Conceptual building of sustainable financial management & sustainable financial growth." Available at SSRN 3472313.
6. Alessandri, T. M., et al. (2012). "Firm heterogeneity in growth option value: The role of managerial incentives." Strategic Management Journal **33**(13): 1557-1566.
7. Anderson, C. W. and L. Garcia-Feijoo (2006). "Empirical evidence on capital investment, growth options, and security returns." The journal of finance **61**(1): 171-194.
8. Aouadi, A. and S. Marsat (2018). "Do ESG controversies matter for firm value? Evidence from international data." Journal of business ethics **151**: 1027-1047.
9. Arellano, M. and S. Bond (1991). "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations." The review of economic studies **58**(2): 277-297.
10. Awaysheh, A., et al. (2020). "On the relation between corporate social responsibility and financial performance." Strategic Management Journal **41**(6): 965-987.
11. Bansal, P. and H.-C. Song (2017). "Similar but not the same: Differentiating corporate sustainability from corporate responsibility." Academy of Management Annals **11**(1): 105-149.
12. Boulhaga, M., et al. (2023). "Environmental, social and governance ratings and firm performance: The moderating role of internal control quality." Corporate Social Responsibility and Environmental Management **30**(1): 134-145.
13. Broadstock, D. C., et al. (2021). "The role of ESG performance during times of financial crisis: Evidence from COVID-19 in China." Finance research letters **38**: 101716.
14. Camilleri, M. A. (2018). "Closing the loop for resource efficiency, sustainable consumption and production: A critical review of the circular economy." International Journal of Sustainable Development **21**(1-4): 1-17.
15. Cohen, G. (2023). "The impact of ESG risks on corporate value." Review of Quantitative Finance and Accounting **60**(4): 1451-1468.
16. Cormier, D. and M. Magnan (2007). "The revisited contribution of environmental reporting to investors' valuation of a firm's earnings: An international perspective." Ecological economics **62**(3-4): 613-626.
17. Cui, X., et al. (2023). "Economic policy uncertainty and green innovation: Evidence from China." Economic Modelling **118**: 106104.
18. De Andrés-Alonso, P., et al. (2006). "The real options component of firm market value: The case of the technological corporation." Journal of Business Finance & Accounting **33**(1-2): 203-219.
19. Elsayed, K. and D. Paton (2005). "The impact of environmental performance on firm performance: static and dynamic panel data evidence." Structural change and economic dynamics **16**(3): 395-412.
20. Estrada, I., et al. (2010). "Technological joint venture formation under the real options approach." Research Policy **39**(9): 1185-1197.
21. Fafaliou, I., et al. (2022). "Firms' ESG reputational risk and market longevity: A firm-level analysis for the United States." Journal of Business Research **149**: 161-177.
22. Figge, F. (2005). "Value-based environmental management. From environmental shareholder value to environmental option value." Corporate Social Responsibility and Environmental Management **12**(1): 19-30.
23. Flammer, C. (2015). "Does corporate social responsibility lead to superior financial performance? A regression discontinuity approach." Management science **61**(11): 2549-2568.
24. Galbreath, J. (2010). Sustainable development in business: a strategic view. Theory and practice of corporate social responsibility, Springer**:** 89-105.
25. Garcia-Castro, R., et al. (2010). "Does social performance really lead to financial performance? Accounting for endogeneity." Journal of business ethics **92**: 107-126.

 doi:10.20944/preprints202507.1197.v1

26. Gillan, S. L., et al. (2021). "Firms and social responsibility: A review of ESG and CSR research in corporate finance." Journal of Corporate Finance **66**: 101889.
27. Godfrey, P. C. (2005). "The relationship between corporate philanthropy and shareholder wealth: A risk management perspective." Academy of management review **30**(4): 777-798.
28. Godfrey, P. C., et al. (2009). "The relationship between corporate social responsibility and shareholder value: An empirical test of the risk management hypothesis." Strategic management journal **30**(4): 425-445.
29. Hart, S. L. and M. B. Milstein (2003). "Creating sustainable value." Academy of Management Perspectives **17**(2): 56-67.
30. Hartzmark, S. M. and A. B. Sussman (2019). "Do investors value sustainability? A natural experiment examining ranking and fund flows." The Journal of Finance **74**(6): 2789-2837.
31. Hausman, J. (2015). "Specification tests in econometrics." Applied Econometrics **38**(2): 112-134.
32. He, F., et al. (2023). "ESG performance and corporate risk-taking: Evidence from China." International Review of Financial Analysis **87**: 102550.
33. Jia, J. and Z. Li (2020). "Does external uncertainty matter in corporate sustainability performance?" Journal of Corporate Finance **65**: 101743.
34. Khan, M., et al. (2016). "Corporate sustainability: First evidence on materiality." The accounting review **91**(6): 1697-1724.
35. Khan, M. A., et al. (2022). "Does green finance really deliver what is expected? An empirical perspective." Borsa Istanbul Review **22**(3): 586-593.
36. Kim, K.-H., et al. (2018). "Effects of corporate social responsibility on corporate financial performance: A competitive-action perspective." Journal of management **44**(3): 1097-1118.
37. Kim, S., et al. (2021). "Risk management and corporate social responsibility." Strategic Management Journal **42**(1): 202-230.
38. Klingebiel, R. (2012). "Options in the implementation plan of entrepreneurial initiatives: Examining firms' attainment of flexibility benefit." Strategic Entrepreneurship Journal **6**(4): 307-334.
39. Koller, T., et al. (2019). "Five ways that ESG creates value." The McKinsey Quarterly.
40. Kong, X., et al. (2022). "China's historical imperial examination system and corporate social responsibility." Pacific-Basin Finance Journal **72**: 101734.
41. Li, Y., et al. (2018). "The impact of environmental, social, and governance disclosure on firm value: The role of CEO power." The British Accounting Review **50**(1): 60-75.
42. Liang, H. and L. Renneboog (2017). "On the foundations of corporate social responsibility." The Journal of Finance **72**(2): 853-910.
43. Lins, K. V., et al. (2017). "Social capital, trust, and firm performance: The value of corporate social responsibility during the financial crisis." the Journal of Finance **72**(4): 1785-1824.
44. Luo, Y. and W.-C. Liao (2023). "Does ESG Guide Chinese Stock Investment with Economic Policy Uncertainty in Trade War." Available at SSRN 4631649.
45. Magrizos, S., et al. (2021). "Is CSR the panacea for SMEs? A study of socially responsible SMEs during economic crisis." European Management Journal **39**(2): 291-303.
46. Mohieldin, M., et al. (2022). SDGs and the 2030 Agenda: On Crisis and Opportunity. Business, Government and the SDGs: The Role of Public-Private Engagement in Building a Sustainable Future, Springer**:** 1-17.
47. Myers, S. C. (1977). "Determinants of corporate borrowing." Journal of financial economics **5**(2): 147-175.
48. Naseer, M. M., et al. (2024). "Firm climate change risk and financial flexibility: Drivers of ESG performance and firm value." Borsa Istanbul Review **24**(1): 106-117.
49. Ortiz Almeyda, M. and M. d. P. Velasco González (2021). "The value of a firm's engagement in ESG practices: Are we looking at the right side?".
50. Ozkan, A., et al. (2023). "Climate risk, corporate social responsibility, and firm performance." British Journal of Management **34**(4): 1791-1810.
51. Rahi, A. F., et al. (2021). "Do sustainability practices influence financial performance? Evidence from the Nordic financial industry." Accounting Research Journal **35**(2): 292-314.
52. Richardson, A. J. and M. Welker (2001). "Social disclosure, financial disclosure and the cost of equity capital." Accounting, organizations and society **26**(7-8): 597-616.

 doi:10.20944/preprints202507.1197.v1

53. Sautner, Z., et al. (2023). "Firm-level climate change exposure." The Journal of Finance **78**(3): 1449-1498.
54. Schuler, D. A. and M. Cording (2006). "A corporate social performance–corporate financial performance behavioral model for consumers." Academy of management Review **31**(3): 540-558.
55. Shahzad, K., et al. (2023). "Exploring the nexus of corporate governance and intellectual capital efficiency: from the lens of profitability." Quality & Quantity **57**(3): 2447-2468.
56. Shiu, Y. M. and S. L. Yang (2017). "Does engagement in corporate social responsibility provide strategic insurance-like effects?" Strategic management journal **38**(2): 455-470.
57. Snoeren, P. (2015). Does stakeholder engagement increase the capability to achieve profitable firm growth? Academy of Management Proceedings, Academy of Management Briarcliff Manor, NY 10510.
58. Tahmid, T., et al. (2022). "Does ESG initiatives yield greater firm value and performance? New evidence from European firms." Cogent Business & Management **9**(1): 2144098.
59. Teng, X., et al. (2021). "Environmental, social, governance risk and corporate sustainable growth nexus: Quantile regression approach." International Journal of Environmental Research and Public Health **18**(20): 10865.
60. Tong, T. W. and J. J. Reuer (2006). "Firm and industry influences on the value of growth options." Strategic organization **4**(1): 71-95.
61. Trigeorgis, L. and N. Lambertides (2014). "The role of growth options in explaining stock returns." Journal of Financial and Quantitative Analysis **49**(3): 749-771.
62. Trigeorgis, L. and J. J. Reuer (2017). "Real options theory in strategic management." Strategic management journal **38**(1): 42-63.
63. Velte, P. (2017). "Does ESG performance have an impact on financial performance? Evidence from Germany." Journal of global responsibility **8**(2): 169-178.
64. Wai Kong Cheung, A. (2011). "Do stock investors value corporate sustainability? Evidence from an event study." Journal of business ethics **99**: 145-165.
65. Wang, H., et al. (2003). "Stimulating firm-specific investment through risk management." Long range planning **36**(1): 49-59.
66. Weber, O. (2014). "Environmental, social and governance reporting in China." Business Strategy and the Environment **23**(5): 303-317.
67. Wen, H., et al. (2022). "The fundamental effects of ESG disclosure quality in boosting the growth of ESG investing." Journal of International Financial Markets, Institutions and Money **81**: 101655.
68. Xie, J., et al. (2019). "Do environmental, social, and governance activities improve corporate financial performance?" Business Strategy and the Environment **28**(2): 286-300.
69. Zhang, J. and Z. Shuang (2021). "Socially responsible investment and firm value: The role of institutions." Finance Research Letters **41**: 101806.