Corporate climate change exposure and renewable energy consumption

by

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Abstract

This study examines the relationship between firm's climate change exposure and renewable energy consumption. Using a panel of 5,853 firm-year observations from the USA for the period 2007–2022. We find a positive and significant relationship between firms' exposure to climate risks and their increased use of renewable energy. We also find that firms that face higher scrutiny from stakeholders regarding their environmental, social, and governance (ESG) practices are also more likely to invest in renewable energy. In particular, these external pressures not only encourage firms to adopt renewable energy but also improve their ESG and environmental performance. The results are robust across alternative econometric specifications and measures of renewable energy consumption. These findings highlight the role of firm exposure to climate change as a key driver for corporate sustainability efforts and strategic energy transitions, with implications for both policymakers and firms aiming to mitigate environmental risks.

Keywords: Climate change exposure**;** renewable energy consumption**;** ESG media coverage**;** corporate sustainability

JEL Classification: G30, M14, Q56

Data Availability Statement: The data used in this study are publicly available from recognized sources.

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1. Introduction

"To keep the 1.5°C temperature target alive, the world needs to cut 2030 emissions by 42 per cent".

(Emissions Gap Report, United Nations Environment Programme, 2022)

The increasing severity of climate change is posing significant threats to ecosystems, economies, and societies worldwide. According to the Intergovernmental Panel on Climate Change (IPCC)[1], global average temperatures have already risen by approximately 1.2°C above pre-industrial levels, contributing to more frequent and severe weather events such as hurricanes, floods, and heatwaves (IPCC, 2018). The economic costs of these events are staggering, with the World Bank estimating that climate-related disasters have cost the global economy over $2.5 trillion since 2000 (World Bank, 2020)[2].

As climate risks intensify, the need for comprehensive strategies to mitigate and adapt to these impacts becomes ever more critical. WEF (2020)[3] highlights that doing nothing is the biggest corporate climate risk of all and argue that there is a need for determined action to reduce greenhouse gas emissions. To reduce such emissions, it is essential to replace fossil fuels with clean or renewable energy sources[4]. The increase of renewable energy use heavily relies on

[1] https://www.ipcc.ch/sr15/

[2] https://www.worldbank.org/en/topic/climatechange

[3] https://www.weforum.org/agenda/2020/01/doing-nothing-may-be-the-biggest-climate-risk-of-all/

[4] Renewable energy sources refer to the energy derived from solar, wind, hydro, geothermal, ocean tide, biomass. These resources are considered sustainable as they are inexhaustible and continuously available, unlike fossil fuels which are finite and contribute to environmental pollution (IEA, 2020).

corporate initiatives, as companies are major energy consumers and significant contributors to greenhouse gas emissions (see Figure 1 and 2). However, for these companies the question is whether there is a business case for engaging in pro-environmental activities, including tackling climate change. As it stands, the literature is divided on the magnitude and the causes of the problem and how to address it. Research on corporate climate risk exposure reveals a complex landscape where companies must navigate both physical risks, such as damage from extreme weather events and transition risks associated with shifting to a low-carbon economy (TCFD, 2017). This study contributes to latter stream by identifying a context in which the association between corporate climate risk exposure and renewable energy consumption is more likely to be positive.

A vast literature has shown that regulatory compliance and risk management are significant drivers for sustainability, as adhering to environmental regulations helps organizations avoid legal penalties and mitigate environmental risks (Dechow, 2023; Thammaraksa et al., 2024). The literature consistently demonstrates that sustainable practices lead to various organizational benefits. Cost savings from energy efficiency and waste reduction are well-documented (Atif et al., 2021), fosters innovation by encouraging the development of new products, services, and business models (Porter & Kramer, 2011) and enhance corporate reputation and brand loyalty, attracting consumers who value corporate responsibility (Peloza & Shang, 2011).

One such sustainability practice for businesses is to fulfill their stewardship role is by investing in energy-efficient technologies and renewable energy sources. Such investments are essential for reducing carbon emissions and mitigating climate change and can also be profitable.

Energy efficiency improvements can range from upgrading equipment and optimizing processes to implementing advanced building designs that minimize energy consumption. Renewable energy investment, such as solar, wind, and geothermal power, further reduces reliance on fossil fuels and decreases greenhouse gas emissions. Rashid et al. (2008) highlight that these measures not only lower operational costs but also signify a company's commitment to environmental sustainability (Atif et al., 2021; Shin et al., 2018). For example, financially, companies can achieve significant cost savings by reducing energy consumption and utilizing more stable and predictable energy sources. Environmentally, these actions contribute to the reduction of carbon footprints, helping to mitigate the adverse impacts of climate change. Socially, companies that prioritize sustainable practices enhance their reputation and build stronger relationships with stakeholders who increasingly value environmental responsibility (e.g., Dechow, 2023; Gibson et al., 2021; Ilhan et al., 2023; Kaplan & Ramanna, 2021; Pankratz et al., 2023)

To the best of our knowledge, this is the first study to investigate the impact of firm climate change exposure on renewable energy consumption. We explore this issue by addressing the following question: *Does a firm's exposure to climate change affect its renewable energy consumption?* It is important to understand the effect of firm's climate change exposure on a firm's renewable energy consumption for three reasons. First, climate change has a significant impact on corporate operations, productivity, and overall economic stability. Over recent decades, climate-related disasters have steadily increased in frequency and severity, leading to significant financial and operational risks for firms (Huang et al., 2018; Shin et al., 2018; WMO, 2023)[5]. According to the World Meteorological Organization, between 1970 and 2021, there

[5] World Meteorological Organization (WMO) https://wmo.int/publication-series/atlas-of-mortality-and-economic-losses-from-weather-climate-and-water-related-hazards-1970-2021

were over 12,000 climate disasters globally, resulting in more than 2 million deaths and USD 4.3 trillion in economic losses. As the threat of climate change intensifies, it is essential to systematically evaluate its consequences on the corporate sector, especially regarding energy consumption and sustainability practices.

Second, climate change impacts firms in multiple dimensions, including physical damage to assets, regulatory changes, and market transitions toward lower carbon emissions (Battiston et al., 2017; Berkman et al., 2024; Dietz et al., 2016; Stroebel & Wurgler, 2021). These pressures require firms to adapt by integrating renewable energy into their operations, not only to mitigate climate risks but also to comply with increasingly stringent environmental regulations. Firms that fail to make this transition are likely to face heightened risks to their financial performance and long-term viability. Third, the findings of this study provide valuable insights into corporate sustainability practices and have important implications for firm stakeholders especially investors, and policymakers to make informed decisions.

The empirical analysis of this study uses a panel data from 1,075 firms in the USA over the period 2007-2022, totaling 5,853 firm-year observations. The main test in this study employs a firm-specific measure of climate change exposure, following the methodology proposed by Sautner et al. (2023), which uses word combinations from firm earnings call transcripts to capture climate change risks at the firm level. We also employ an alternative measure for climate change exposure by incorporating ESG-related negative media coverage. This approach captures external pressures and public scrutiny faced by firms concerning their ESG practices. Consistent with theoretical predictions, the empirical relationship between a firm's climate change exposure and its renewable energy consumption is positive. This result is intuitive, as firms with greater exposure to climate change are more likely to adopt sustainable energy practices. This suggest

that firms may seek to mitigate their environmental footprint, align with evolving consumer and investor preferences for greener operations, and comply with increasingly stringent climate-related regulations. Additionally, firms exposed to the direct effects of climate change such as increased energy costs due to carbon pricing, or the threat of operational disruptions caused by climate events are likely to view renewable energy adoption as both a risk management strategy and a means to enhance their long-term resilience. Finally, our results are robust to the use of alternative econometric specifications, as well as alternative measures for renewable energy consumption and firm climate change exposure.

Our paper makes significant contributions to the literature by applying the "physical–transitioning–regulatory risk paradigm" on firm's climate change exposure, renewable energy consumption, and corporate sustainability. As firms face increasing climate-related risks, this study highlights the importance of renewable energy as a core strategy for corporate adaptation to mitigate the transition risk associated with climate change. By focusing on how firms respond to climate risks, our study adds new dimensions to the literature, which has traditionally focused on broader environmental metrics such as carbon emissions and environmental disclosures (e.g., Ilhan et al., 2023; Matsumura, Prakash, & Vera-Muñoz, 2014).

Second, our study reveals that external pressures, such as ESG-related negative media coverage, is a key drivers of renewable energy adoption. Firms that are subject to higher levels of scrutiny are more likely to integrate renewable energy into their operations. This adds to the growing body of literature that underscores the role of external influences in corporate decision-making regarding climate risks (e.g., Delmas & Toffel, 2008). Finally, these external pressures not only encourage firms to adopt renewable energy but also improve their environmental and

ESG performance indicating that the green energy transition enhances overall corporate sustainability performance.

The remainder of the paper is organized as follows: Section 2 provides a review of the relevant literature and formulates the hypotheses. Section 3 outlines the research design and methodology. Section 4 presents the empirical results. Section 5 conducts a series of robustness checks, identification strategies, and additional analyses. Finally, Section 6 concludes with a discussion of the main findings and their implications, limitations and direction for future research.

2. Literature review and hypothesis

2.1. Organizations and sustainability

The growing urgency of climate change has intensified the scrutiny of corporate behavior concerning environmental sustainability. The literature argues that corporate engagement in environmental activities is a moral imperative, as it contributes to the well-being of society by mitigating the adverse effects of climate change. It challenges companies to consider their role within the broader context of society and the natural world, urging them to act in ways that promote the common good, respect the intrinsic value of nature, and uphold their duties as stewards of the environment (Cho et al., 2015; Gray, 2010; Haigh & Hoffman, 2014; Hart & Zingales, 2017; Kaplan & Ramanna, 2021; Weitzman, 2014).

This moral obligation calls for businesses to adopt practices that prioritize the long-term sustainability of both society and the planet, rather than focusing solely on short-term profits. In a similar direction, Gray (2010) argues that corporate responsibility encompasses proactive measures such as reducing carbon footprints, enhancing energy efficiency, and engaging in sustainable resource management. These efforts not only benefit the environment by reducing harmful emissions and conserving natural resources but also improve the long-term sustainability of businesses by reducing operational risks and potentially lowering costs associated with resource scarcity and regulatory compliance. Similarly, Hart & Zingales, (2017) argue that companies should aim to maximize shareholder welfare, which includes financial returns as well as non-monetary considerations, such as environmental sustainability, ethical business practices, and social impact.

Furthermore, the adoption of sustainable energy practices aligns with broader ethical frameworks that emphasize respect for all living entities and ecosystems (Haigh & Hoffman,

2014). Recognizing the intrinsic value of nature requires corporations to move beyond utilitarian views and consider the broader impact of their operations on the environment. This ethical stance promotes the idea that natural resources should be preserved and respected for their own sake, not merely for their economic utility. Kaplan and Ramanna (2021) further expand on this by suggesting that corporate sustainability initiatives must integrate ethical considerations into their core strategies, acknowledging that companies have a responsibility to future generations. By embracing sustainable practices such as renewable energy adoption, corporations not only contribute to the mitigation of climate change but also align themselves with societal expectations for ethical leadership. This approach ensures that they are seen as contributors to the common good, fostering trust and legitimacy in the eyes of stakeholders, including consumers, investors, and regulatory bodies (Delmas & Toffel, 2008; Kaplan, 2023).

Ultimately, these ethical perspectives challenge businesses to redefine success, not solely by financial performance, but by their ability to balance profitability with their obligations to protect the environment and contribute to the greater societal good (Dyllick & Muff, 2016). In a similar direction, Eccles et al. (2014) argues that companies that prioritize sustainability gain a competitive advantage by reducing operational risks, accessing new markets, and responding to shifts in consumer demand for eco-friendly products and are often viewed as more resilient and attractive to investors (Giglio et al., 2021; Shin et al.,2018). In a similar direction, Porter and Kramer (2011) argue that the pursuit of sustainability often requires firms to rethink traditional business models, leading to innovations in supply chains, product design, and resource management. These innovations not only enhance a firm's environmental performance but can also lead to cost savings and new revenue streams. For example, reducing waste or improving energy efficiency often results in operational cost reductions, while the development of

sustainable products or services can open new avenues for growth and differentiation (Atif et al., 2021; Ilhan et al., 2023; Shin et al.,2018; Semieniuk et al. 2021).

Following the above discussion this study employs the *"physical–transitioning–regulatory risk paradigm"* theoretical perspective, to hypothesize the effects of firm climate change exposure on renewable energy consumption and the mechanisms that shape this relationship. This paradigm highlights the direct and indirect impacts of climate change on corporate sustainability strategies. According to the *"physical–transitioning–regulatory risk paradigm",* increased exposure to physical risks (e.g., natural disasters, extreme weather), transitioning risks (e.g., shifting toward low-carbon technologies), and regulatory risks (e.g., stricter climate regulations) and societal expectations for ethical leadership can pressure firms to adopt more sustainable energy practices (Doh et al., 2021; Semieniuk et al. 2021). Faced with increasing operational costs, regulatory penalties, and shifting market expectations for environmental responsibility, firms find renewable energy adoption a viable strategy for mitigating transitioning risks (Semieniuk et al. 2021) and maintaining operating profitability and complying with environmental regulations and improving their environmental performance (Atif et al., 2021; Giglio et al., 2021; Shin et al., 2018) and meeting stakeholder expectations of environmental sustainability, ethical business practices, and social impact (Bolton & Kacperczyk, 2023; Dechow, 2023; Hart & Zingales, 2017).

Moreover, this paradigm aligns with UN sustainable development goal (SDG, 13: Climate Action). Achieving this objective requires a comprehensive shift in the corporate sector from dependence on brown, fossil-based energy sources to the adoption of sustainable, green energy

alternatives (IPCC, 2022)[6]. By adopting renewable energy, firms can mitigate transition risks related to climate change and align with societal expectations for ethical and responsible leadership. Drawing on this theoretical paradigm, research hypotheses are formally proposed in the following sections.

[6]**IPCC** Climate Change 2022: Mitigation of Climate Change https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/

2.2. Hypothesis Development

2.2.1. Firm climate change exposure and renewable energy consumption

Building on the above discussion, the relationship between firms' exposure to climate change and their sustainable practices has gained significant attention in sustainability research (Delmas & Toffel, 2008; Kaplan, 2023 Stroebel & Wurgler; 2021). Climate change is one of the most pressing societal challenges, and firms increasingly face pressure from stakeholders to mitigate their environmental impact by adopting sustainable energy practices (Giglio et al., 2021; Pedersen et al., 2021; Weitzman, 2014;). Firms exposed to higher levels of climate risk are more likely to adopt renewable energy as a strategic response to mitigate potential adverse effects on their operations, reputation, and financial performance (Lash & Wellington, 2007; Kolk & Pinkse, 2005; Yoon et al., 2024). These firms face growing risks such as regulatory shifts, physical impacts from extreme weather, and evolving consumer preferences toward environmentally responsible practices (CDP, 2023[7]; MSCI, 2022[8]).

Recent research suggests that firms exposed to greater climate risks tend to take proactive measures to reduce their reliance on fossil fuels (Delmas & Montes-Sancho, 2011; Amore & Bennedsen, 2022). These firms recognize that adopting sustainable practices not only mitigates climate-related risks but also helps them align with regulatory requirements, market demands, and investor expectations (Gibson et al., 2020; Dechezleprêtre et al., 2022). In a similar direction Kolk & Pinkse (2005) and Griffin et al. (2021) shows that firms that integrate sustainable

[7] **CDP. (2023)** The Road to Net Zero Starts with Your Core Business https://www.cdp.net/en/climate
[8] **MSCI. (2022)** ESG and Climate Trends to Watch for 2022 https://www.msci.com/research-and-insights/2022-esg-trends-to-watch#:~:text=ESG%20Trends%20to%20Watch%20for%202022&text=They%20range%20from%20evolving%20regulation,critical%20role%20of%20natural%20capital.

strategy into their operations reduce their carbon footprint and position themselves as sustainability leaders, which enhances their reputation and reduces long-term risks associated with climate change.

Leadership and corporate governance also play pivotal roles in driving renewable energy adoption. Firms with environmentally conscious leadership often characterized by strong corporate social responsibility (CSR) commitments are more likely to prioritize to transition to zero carbon emissions (Eccles et al., 2014; Flammer, 2015; Oehmichen et al., 2022). These companies typically disclose their environmental performance through voluntary CSR reporting, which increases transparency and strengthens trust with stakeholders (Dhaliwal et al., 2011; Krueger et al., 2024) which help attract green investors and meet the demands of ESG-focused stakeholders (Gibson et al., 2021; Pankratz et al., 2023). Firms that transition to renewable energy sources reduce their exposure to the volatility of fossil fuel prices and can lower operational costs over time by improving energy efficiency (Khan et al., 2021; Porter & Kramer, 2011; PWC, 2020). In carbon-intensive industries, failing to adopt renewable energy solutions poses significant financial and reputational risks, especially as global efforts to curb greenhouse gas emissions intensify (Dechezleprêtre et al., 2022; PWC, 2020[9]).

Moreover, the positive correlation between renewable energy adoption and business resilience is well-documented. For example, Shin et al. (2018) found that firms with higher renewable energy consumption demonstrate enhanced operational performance, reduced carbon liabilities, and better risk management strategies in response to climate change. Furthermore,

[9] **PWC. (2020).** The Net Zero Economy: Key Drivers of Business Adaptation
https://www.pwc.co.uk/services/sustainability-climate-change/insights.html

renewable energy adoption can drive innovation, leading to new business models and growth opportunities (Rauter et al., 2017).

In conclusion, the literature suggests that firms with greater exposure to climate change risks are more likely to increase their renewable energy consumption as part of a broader strategy to mitigate environmental risks, improve operational efficiency, and align with stakeholder expectations for sustainability (Khan et al., 2021; Shin et al., 2018; Yoon et al., 2024;). This leads us to our first hypothesis:

H1: Firms with higher exposure to climate change risks are more likely to increase their renewable energy consumption.

2.2.2. ESG-related media coverage and renewable energy consumption

As climate change intensifies, firms are increasingly scrutinized for their environmental practices, and ESG-related media coverage has become a powerful tool that shapes public perception and stakeholder expectations (Wong & Zhang, 2022). Negative ESG media coverage can expose firms to reputational risks, regulatory pressures, and potential financial consequences, prompting them to adopt more proactive sustainability strategies (Fu, 2023; Eccles et al., 2014). For example, Wong and Zhang (2022) provide empirical evidence that corporate reputation is considered a valuable intangible asset by investors and adverse ESG disclosure via media channels have a significant and negative impact on firm valuation. Moreover, Fu (2023) highlights that negative media coverage regarding corporate social irresponsibility can paradoxically benefit firms by pushing them to undertake organizational changes that improve corporate social performance This dynamic is rooted in signaling theory and coercive pressure, which posits that negative media attention acts as costly but effective external feedback, prompting firms to respond with enhanced socially responsible behaviors to rebuild their reputation and mitigate the impact of negative publicity. Firms facing negative ESG-related media coverage may seek to increase their use of renewable energy as part of their response to external pressure, aligning with stakeholder expectations for sustainable practices. By doing so, firms can signal their commitment to reducing their environmental impact, thereby mitigating the negative effects of adverse media coverage on their reputation and valuation. Therefore, in this context, renewable energy consumption represents a tangible indicator of a firm's commitment to environmental sustainability. Thus, renewable energy adoption can serve as a strategic response to ESG criticism, helping firms rebuild trust with investors, regulators, and the broader public

while demonstrating leadership in environmental stewardship. Based on the above discussion, we posit the following hypothesis:

Hypothesis 2: Firms that experience negative ESG-related media coverage are more likely to increase their renewable energy consumption.

****** Insert Figure 1 and 2 about here ******

3. Data and method

3.1. Sample

Our sample is drawn from Compustat North America Fundamentals Annual dataset and Thomson/Refinitiv. Thomson/Refinitiv reports data on firms' total annual energy consumption in gigajoules and includes renewable energy consumption as well as total energy consumption within the USA. Renewable energy data, consistent with the United Nations (UN) definition of renewable energy, includes annual aggregated energy from wind, solar, biomass, and geothermal. Total energy consumption encompasses all energy sources, with traditional (fossil fuel) energy being the main contributor. This comprehensive energy consumption data allows us to accurately measure and analyze firms' environmental practices.

Firms reputational risk related to ESG incidents (ESG_Risk) is sourced from Reprisk, using the number of newspaper articles published about each firm, which indicates the firm's public exposure to environmental, governance and social issues. The sample period is from 2007 to 2022, as this is the only period for which the data on climate change exposure and firms' reputational risk related to ESG are available.

Our data on firm financial characteristics (e.g., leverage, return on assets, Tobin's Q, total assets, and capital intensity) comes from Compustat North America and firm governance characteristics (e.g., environment pillar score, governance pillar score and GHG emissions) comes from Thomson/Refinitiv. We exclude financial institutions and insurance companies by removing all companies with SIC codes of 6000–6999 and winsorize all continuous variables at the 1% level for both tails of the distribution. Table 1 presents the variable definition.

****** Insert Table 1 about here ******

3.2. Measure of climate change exposure

In this study we employ firm-level measure of climate change exposure developed by Sautner et al. (2023)[10]. In their research, Sautner et al. (2023) analyze transcripts from quarterly earnings conference calls of publicly traded companies to construct a metric that reflects managers' perceptions of the impact of climate change on their firms. Over the past two decades, earnings conference calls have emerged as a critical platform for companies to disseminate important information to capital market participants.

Specifically, Sautner et al. (2023) examine sentences related to climate change within these calls, utilizing the machine learning algorithm developed by King et al. (2017) to create a collection of climate change bigrams. They construct the climate change exposure measure by counting the number of climate-related bigrams and scaling it by the total number of bigrams present in the transcript. The climate change exposure for firm *i* during quarter *t* is thus defined as:

$$Climate_EXP_{i,t} = \frac{1}{B_{i,t}} \sum_{b=1}^{B_{i,t}} D\ (b) * 1000 \qquad (1)$$

where $b = 1, 2, \ldots, B_{i,t}$ represents all the bigrams for firm *i* in quarter *t*. $D\ (b)$ is a dummy variable that equals one if the bigram ***b*** is related to climate change, and zero otherwise. For clarity in exposition, this measure is then multiplied by 1000. Given the documented importance of industry in influencing firm climate change exposure we construct an industry-year normalized version of the score (N_Climate_EXP).

[10] The data on firm-level climate change exposure are publicly available at https://osf.io/fd6jq/

3.3. Empirical model

To examine the impact of firm-level climate change exposure and use of renewable energy on renewable energy consumption, we estimate the following baseline models:

$$renewable\ energy\ consumption_{i,t} = \alpha + \beta_1(\text{climate change exposure})_{i,t} + \beta_2(\text{Z})_{i,t} + \beta_3 \sum(industry\ effects)_{i,t} + \beta_4 \sum(year\ effects)_{i,t} \quad (2)$$

We measure our dependent variable in equation 2, i.e., renewable energy consumption, as the log of renewable energy consumption (Log_REN) during year t. We also employ alternative measures of renewable energy consumption, including total renewable energy consumption as a percentage of sales turnover (REN/Sales); a dummy variable equaling one, if the firm uses renewable energy, and zero otherwise (REN_D); and as the percentage of renewable energy in the firm's total energy consumption (REN/TC).

The variable of interest in this study is firm-level climate change exposure. We employ two firm-level measure of climate change exposure developed by Sautner et al. (2023). CC_EXP is the original measure from their study, and we construct an industry-year normalized version of the score (N_Climate_EXP). We also employ a measure for the firm level ESG reputation risk (ESG_Risk) using the number of negative newspaper articles published about each firm, which indicates the firm's public exposure to environmental, governance and social issues.

Z in model 2 represents the vector of control variables as defined in **Table 1.** We use two types of control variables namely corporate governance and firm financial characteristics.

Based on previous literature, we include firm characteristics that may influence renewable energy consumption. These firm characteristics are as follow. Tobin's q as a proxy for growth opportunity, return on assets as a measure of firm ability to generate profitability. Cash/total assets is a proxy for cash reserve. Leverage is measured by the ratio of total debt to total assets. Capital intensity is gross property, plant and equipment scaled by total assets. Asset is measured by the natural logarithm of total assets. Sales is measured by the natural logarithm of total revenue.

To control for the corporate governance characteristics, we include firms Environment Pillar Score (Pillar_ENV) which is the weighted average relative rating of a company based on the reported environmental information. Governance Pillar Score (Pillar_GOV) is the weighted average relative rating of a company based on the reported governance information. Emissions (Log_Emissions) is defined as log of direct (scope1) + indirect (scope 2) + indirect (Scope 3). Audit_CSR is a dummy variable equal to one if the company have an external auditor of its CSR/H&S/Sustainability report, and zero otherwise. SCI a dummy variable equal to one if the if the senior executive's compensation linked to CSR/H&S/Sustainability targets, and zero otherwise. All these variables, along with others, are defined in Table 1.

To estimate our empirical models, we employ ordinary least squares (OLS) as the primary method, incorporating controls for industry (using two-digit GICS sector codes) and year effects. Standard errors are adjusted for clustering at the firm level to address heteroscedasticity and within-firm correlation in the residuals. To mitigate concerns about endogeneity in the relationship between climate change exposure and renewable energy consumption, we also incorporate lagged independent variables in our regressions. Specifically, we replace

contemporaneous variables with two-year (t-2), and three-year (t-3) lagged following (Harford et al., 2008). This approach follows the rationale that firms require time to respond to climate change risks and to implement changes in their renewable energy consumption strategies and it allows us to capture the delayed effects of climate risks on corporate decisions regarding renewable energy consumption.

3.4. Descriptive Statistics

Table 2 presents summary statistics. The mean value of CC_EXP is 1.53, indicating that for the average firm, approximately 0.15% (roughly 1.53 divided by 1000) of the bigrams in the earnings conference call transcripts are dedicated to discussions on climate change-related topics. The mean value for ESG Risk, as measured by the number of newspaper articles published, is 8.209. This indicates that ESG-related issues are increasingly prominent in public discourse and growing importance of ESG topics in shaping firms' reputations and the extent to which stakeholders, including the media, monitor corporate sustainability practices.

The average log of total renewable energy consumption (Log_REN) is 4.136. The mean for renewable energy as a percentage of sales (REN/Sales) is 0.9315, suggesting that, on average, firms allocate less than 1% of their sales toward renewable energy consumption. The mean of the renewable energy dummy variable (REN_D), which equals 1 if a firm uses renewable energy and 0 otherwise, is 0.3873, indicating that around 39% of firms in the sample report using renewable energy. Additionally, the average total renewable energy consumption as a percentage of total energy use (REN/TE) is 58.97, reflecting significant usage of renewable energy for firms that have adopted it.

Turning to the control variables, the descriptive statistics on key corporate governance characteristics related to corporate governance and environmental performance. The average Environmental Pillar Score (Pillar_ENV) is 57.29, and the average Governance Pillar Score (Pillar_GOV) is 61.7. The mean log of emissions (Log_Emissions) is 11.8. Approximately 32% of firms are subject to CSR audits (Audit CSRA mean = 0.3192), and 40% link executive compensation to sustainability targets (SCI mean = 0.3996). These mean values suggest that a

significant portion of firms are incorporating sustainability-related governance practices, particularly in environmental oversight and executive incentives tied to sustainability performance.

The descriptive statistics on key financial characteristics provide insights into firm performance and capital structure. The average leverage ratio is 0.2844, indicating that firms, on average, use 28.44% debt in their capital structure. The mean return on assets (ROA) is 0.051, reflecting a 5.1% return on assets, while the average LogQ is 0.5441, indicating moderate firm valuation. The average capital intensity (Cap_INT) is 0.4835, indicating that approximately 48.35% of firms' total assets are invested in gross property, plant, and equipment. On average, firms hold 12.29% of their assets in cash or cash equivalents (mean = 0.1229). The mean log of total assets is 9.32, reflecting the size of the firms in the sample. The average R&D intensity, calculated as R&D expenditures divided by total assets, is 0.02215, indicating that firms, on average, allocate 2.22% of their total assets toward research and development activities. The mean MB ratio is 4.152, which shows that, on average, firms are valued at over four times their book value.

Table 3 shows the correlations among the variables used in the regression analysis. The correlation coefficients for the variables are all below 0.5, indicating that multicollinearity is unlikely to be a concern in our analysis.

****** Insert Table 2 and 3 about here ******

4. Results

4.1. Firm climate change exposure and renewable energy consumption

First, we examine the impact of Firm climate change exposure (CC_EXP) on renewable energy consumption. **Table 4** presents the results for the baseline regression using OLS. We start our analysis by regressing the renewable energy consumption (measured by the log of renewable energy) on the firm climate change exposure. The regression in Column 1 includes only the variable of interest i.e., firm change exposure as well as the industry and year effects. The regression in Column 2 includes contemporaneous corporate governance and firm financial characteristics, while the regressions in Columns 3 and 4 include the two-year and three-year lagged Firm climate change exposure (CC_EXP), corporate governance and firm financial characteristics, respectively.

All of the above model specifications suggest a significant and positive relationship ($p < 0.01$) between firm climate change exposure and renewable energy consumption. For instance, a one-percentage-point increase in the firm's climate change exposure will leads to an increase in renewable energy consumption of between 0.1646 to 0.2549 percentage points. Hence, the economic significance is also high. In summary, there is consistent evidence that firm's climate change exposure has a significantly positive impact on renewable energy consumption. Firms that face greater climate risks are likely to adopt renewable energy, emphasizing the critical role of climate change awareness in driving corporate sustainability efforts.

For the corporate governance control variables, the coefficients of the Pillar_ENV (environmental score) is positive suggesting that firms with stronger environmental performance are more likely to consume renewable energy, the coefficient of Log_Emissions, is positive,

indicating that firms with higher emissions are more likely to adopt renewable energy to reduce their carbon footprint. In contrast, Pillar_GOV (governance score) does not show a significant effect on renewable energy consumption.

Several firm-specific controls also exhibit strong effects. The regression results suggest that firms with a higher level of financial leverage are actively investing in renewable energy. ROA shows no significant relationship, while Log_Q, Cap_INT, and Assets all display strong positive and significant effects, indicating that larger, more capital-intensive firms with higher growth prospects are more likely to adopt renewable energy. Additionally, Audit_CSRA (CSR audit) shows a positive effect, suggesting that firms with CSR audits are more likely to increase renewable energy consumption. R&D intensity is also strongly and positively related to renewable energy adoption, with significant coefficients, indicating that firms investing in R&D are more inclined to invest in renewable energy technologies.

These results strongly support the ***Hypothesis 1*** that climate change exposure and environmental factors are key drivers of renewable energy consumption, alongside firm-specific financial and governance characteristics.

****** Insert Table 4 about here ******

4.2. Number of newspaper article related to ESG and use of renewable energy

In this section, we investigate the relationship between ESG-related media coverage (ESG_Risk) and renewable energy consumption. **Table 5** presents the results for the baseline regression using OLS. We start our analysis by regressing the renewable energy consumption (measured by the log of renewable energy) on the firm ESG-related media coverage (ESG_Risk). The regression in Column 1 includes only the variable of interest i.e., firm ESG-related media coverage (ESG_Risk) as well as the industry and year effects. The regression in Column 2 includes contemporaneous corporate governance and firm financial characteristics, while the regressions in Columns 3 and 4 include the two-year and three-year lagged firm ESG-related media coverage (ESG_Risk), corporate governance and firm financial characteristics, respectively.

The firm ESG-related media coverage (ESG_Risk) has a significant and positive effect ($p < 0.01$) on the use of renewable energy in Columns 1 to 4. The results suggest that firms with higher ESG-related negative media coverage, as indicated by their ESG risk, are more likely to increase their renewable energy consumption. This suggests that firms facing greater scrutiny due to ESG-related risks are more inclined to adopt sustainable energy practices to mitigate reputational and regulatory risks.

As to the corporate governance control variables Pillar_ENV (Environmental Performance Pillar) and Log_Emissions is positive and significant. Several firm-specific controls also exhibit strong effects. The regression results suggest that firms with a higher level of financial leverage are actively investing in renewable energy. ROA shows no significant relationship, while Log_Q, Cap_INT, and Assets all display strong positive and significant effects, indicating that larger, more capital-intensive firms with higher growth prospects are more

likely to adopt renewable energy. Additionally, Audit_CSRA (CSR audit) shows a positive effect, suggesting that firms with CSR audits are more likely to increase renewable energy consumption. R&D intensity is also strongly and positively related to renewable energy adoption, with significant coefficients, indicating that firms investing in R&D are more inclined to invest in renewable energy technologies.

These results suggest that ESG-related media coverage and ESG risk are significant drivers of renewable energy consumption. Firms that face higher scrutiny from stakeholders regarding their environmental, social, and governance practices are more likely to invest in renewable energy. In addition, firm characteristics such as size, leverage, R&D intensity, and capital intensity also play key roles in influencing renewable energy adoption. This highlights the importance of both external ESG pressure and internal firm resources in shaping corporate sustainability strategies.

****** Insert Table 5 about here ******

5. Robustness checks, identification, and further analysis

5.1. Robustness checks

5.1.1. Alternative measure for the renewable energy consumption

In this section, we conduct a series of sensitivity checks to assess the robustness of our findings.

First, we employ alternative measures of renewable energy consumption. Instead of using Log_REN, we use REN/TC (total renewable energy consumption as a percentage of total energy use), REN/Sales (total renewable energy consumption as a percentage of sales turnover), REN_D, a dummy variable that equals one if the firm uses renewable energy and zero otherwise. Control variables, as specified in models 1 and 2, are included in all the regression specifications.

Table 6 presents the results for the alternative measures of renewable energy consumption. When we use the alternative measures of renewable energy consumption i.e., REN/TC (renewable energy as a percentage of total energy use), REN/Sales (renewable energy as a percentage of sales turnover), and REN_D (a dummy variable indicating whether the firm uses renewable energy or not). The coefficients are 0.4434 for REN/TC, 0.0847 for REN/Sales, and 0.0095 for REN_D, all significant at the 1% level. We can confirm that firm climate change exposure is positively and significantly associated with all three renewable energy consumption measures. This provides further support for ***H1***.

To sum up, the results show a consistent and positive relationship between firm climate change exposure and renewable energy consumption, with significant effects across all alternative measures. Firms that face greater climate risks are more likely to increase their use of renewable energy. Additionally, factors such as firm size, capital intensity, leverage, and environmental performance significantly contribute to renewable energy adoption, indicating that

both external pressures and internal resources drive corporate sustainability efforts. These findings further support the results observed in the main model.

****** Insert Table 6 about here ******

5.1.2. Climate Exposure (Normalized by Industry and Year) and Renewable Energy Consumption

Additionally, for climate change exposure, we use N_Climate_EXP, which represents CC_EXP normalized by industry and year, to account for industry-specific and time-variant effects on climate change risks.

Table 7 presents the regression results assessing the impact of N_Climate_EXP (climate exposure normalized by industry and year) on renewable energy consumption using different measures: Log_REN (log of total renewable energy consumption), REN/TC (renewable energy as a percentage of total energy use), REN/Sales (renewable energy as a percentage of sales), and REN_D (a dummy variable indicating whether the firm uses renewable energy or not). All models include control variables, as well as year and industry effects.

The variable N_Climate_EXP is positively and significantly (at the 1% level) associated with renewable energy consumption across all measures of firm Renewable Energy Consumption. These findings suggest that Firms facing higher climate risks when considered relative to their industry peers and specific time periods are more proactive in adopting renewable energy.

****** Insert Table 7 about here ******

5.1.3. The Impact of Renewable Energy Consumption on Corporate ESG and Environmental Pillar Performance

To gain additional insights, we conduct analyses that focus on firm renewable energy consumption and that may impact firms ESG performance. As firms are increasingly pressured by stakeholders, regulators, and investors to adopt environmentally responsible practices, a trend further amplified by the rising importance of Environmental, Social, and Governance (ESG) performance, which has become a critical factor in evaluating a company's commitment to sustainability (e.g., Dechow, 2023; Gibson et al., 2021; Krueger et al., 2024). The **Table 8** presents the results for firm's use of renewable energy (Log_REN) and its impact on both firms ESG (Environmental, Social, and Governance) performance (Column 1 and 2) and Environmental Pillar performance (Column 3 and 4).

The Log_REN (renewable energy consumption) variable is positive and significant ($p < 0.01$) across all models, indicating a strong association between renewable energy adoption and both ESG scores and Environmental Pillar scores performance. The significance of these coefficients suggests that firms adopting renewable energy are likely to be perceived as more sustainable by stakeholders, investors, and the public, improving their ESG profiles and aligning with environmental performance goals. This reinforces the idea that renewable energy not only helps firms mitigate environmental risks but also boosts their ESG performance and competitiveness by addressing growing demands for corporate responsibility.

Key financial and operational factors such as profitability (ROA), market valuation (Log_Q), and capital intensity are positively linked to ESG and Environmental Pillar scores, implying that financially healthy firms are better equipped to engage in sustainable practices. Additionally,

external audits (Audit_CSRA) and R&D investments further strengthen the firm's ESG performance, highlighting the importance of innovation and transparency in achieving sustainability goals.

These findings demonstrate that renewable energy consumption is a critical factor in improving corporate sustainability and environmental performance, reinforcing the growing trend of firms aligning their strategies with global sustainability standards to meet stakeholder expectations and regulatory requirements.

****** Insert Table 8 about here ******

6. Conclusion

Firms are increasingly pressured to transition toward sustainable energy sources not only to comply with regulatory mandates but also to protect themselves from the potential disruptions caused by climate-related risks (Amore & Bennedsen, 2022; Flammer, 2015; Eccles et al., 2014; WEF, 2020). Accordingly, this study provides valuable insights into the relationship between firm-level climate change exposure and renewable energy consumption, demonstrating a clear and positive association. The findings suggest that firms facing higher climate risks are more likely to adopt renewable energy as part of their sustainability strategy. These findings underscore the role of climate risk in shaping corporate sustainability efforts and strategic energy transitions. As regulatory pressures and stakeholder expectations around environmental responsibility intensify, companies increasingly turn to renewable energy to reduce their carbon footprint, enhance their environmental performance, and align with ESG criteria (Dyllick & Muff, 2016; Eccles et al., 2014; Giglio et al., 2021; Kolk & Pinse, 2005; Shin et al., 2018).

Moreover, the results indicate that stakeholder scrutiny particularly in the form of negative ESG-related media coverage further encourages firms to invest in renewable energy. This approach builds on previous literature that has utilized climate-related disclosures to assess firm-level risk and performance (Giglio et al., 2021; Pankratz et al. 2023; Sautner et al., 2023) and expands the understanding of how firms navigate sustainability challenges amidst rising climate threats. Our findings contribute to the literature by highlighting the role of stakeholders in driving corporate strategies toward renewable energy transitions. In addition, we find that firms investing in renewable energy report higher ESG ratings, reflecting a dual benefit: mitigating environmental risks while enhancing reputational capital. Moreover, these energy transitions are

associated with improved environmental performance, positioning companies as leaders in sustainability.

As with other scholarly works, this study is subject to certain limitations, which suggest opportunities for future research. First, the focus on a single geographic region, the USA, limits the generalizability of the findings, as regulatory frameworks, market conditions, and climate impacts vary across regions. Second, the study does not differentiate between the types of renewable energy adopted by firms, such as solar, wind, or hydropower, which could have distinct financial, operational, and environmental implications. For future research, studies could examine how firm size, industry, and supply chain characteristics influence the relationship between climate risk and renewable energy adoption.

References

Atif, M., Hossain, M., Alam, M. S., & Goergen, M. (2021). Does board gender diversity affect renewable energy consumption? *Journal of Corporate Finance*, *66*, 101665.

Amore, M. D., & Bennedsen, M. (2022). Corporate responses to environmental regulation and climate change: Evidence from boardrooms. *Strategic Management Journal, 43*(6), 1289-1308.

Battiston, S., Mandel, A., Monasterolo, I., Schütze, F., & Visentin, G. (2017). A climate stress-test of the financial system. *Nature Climate Change*, *7*(4), 283-288.

Berkman, H., Jona, J., & Soderstrom, N. (2024). Firm-specific climate risk and market valuation. *Accounting, Organizations and Society*, *112*, 101547.

Bolton, P., & Kacperczyk, M. (2023). Global pricing of carbon-transition risk. *The Journal of Finance*, *78*(6), 3677-3754.

Dechezleprêtre, A., Fabre, A., Kruse, T., Planterose, B., Chico, A. S., & Stantcheva, S. (2022). Fighting climate change: International attitudes toward climate policies (No. w30265). *National Bureau of Economic Research*.

Dechow, P. M. (2023). Understanding the sustainability reporting landscape and research opportunities in accounting. *The Accounting Review, 98*(5), 481-493.

Delmas, M. A., & Toffel, M. W. (2008). Organizational responses to environmental demands: Opening the black box. *Strategic Management Journal, 29*(10), 1027-1055.

Dhaliwal, D. S., Li, O. Z., Tsang, A., & Yang, Y. G. (2011). Voluntary nonfinancial disclosure and the cost of equity capital: The initiation of corporate social responsibility reporting. *The Accounting Review, 86*(1), 59-100.

Dietz, S., Bowen, A., Dixon, C., & Gradwell, P. (2016). 'Climate value at risk'of global financial assets. *Nature Climate Change*, *6*(7), 676-679.

Dyllick, T., & Muff, K. (2016). Clarifying the meaning of sustainable business: Introducing a typology from business-as-usual to true business sustainability. *Organization & Environment, 29*(2), 156-174. https://doi.org/10.1177/1086026615575176

Eccles, R. G., Ioannou, I., & Serafeim, G. (2014). The impact of corporate sustainability on organizational processes and performance. *Management Science, 60*(11), 2835-2857. https://doi.org/10.1287/mnsc.2014.1984

Flammer, C. (2015). Does corporate social responsibility lead to superior financial performance? A regression discontinuity approach. *Management Science, 61*(11), 2549-2568.

Fu, L. (2023). Why bad news can be good news: The signaling feedback effect of negative media coverage of corporate irresponsibility. *Organization & Environment*, *36*(1), 98-125.

Giglio, S., Kelly, B., & Stroebel, J. (2021). Climate finance. *Annual Review of Financial Economics, 13*(1), 15-36.

Gibson, R., Krueger, P., & Mitali, S. F. (2020). The sustainability footprint of institutional investors: ESG driven price pressure and performance. *Swiss Finance Institute Research Paper* No. 17-05.

Gray, R. (2010). Is accounting for sustainability actually accounting for sustainability... and how would we know? An exploration of narratives of organizations and the planet. *Accounting, Organizations and Society, 35*(1), 47-62. https://doi.org/10.1016/j.aos.2009.04.006

Griffin, P. A., Lont, D. H., & Pomare, C. (2021). The curious case of Canadian corporate emissions valuation. *The British Accounting Review, 53*(1), 100922.

Huang, Y., Kerstein, J., & Wang, C. (2018). Climate risk and corporate financial policies: Evidence from the impact of hurricanes. *Journal of Accounting and Public Policy, 37*(2), 92-110. https://doi.org/10.1016/j.jaccpubpol.2018.02.003

Hsu, A. W., Li, D., & Tsou, K. (2023). Climate change exposure and firm investment policies. *Journal of Corporate Finance, 78*, 102108.

Ilhan, E., Krueger, P., Sautner, Z., & Starks, L. T. (2023). Climate risk disclosure and institutional investors. *The Review of Financial Studies, 36*(7), 2617-2650.

Javadi, S., & Masum, M. (2021). Climate risk and corporate bankruptcy. *Journal of Corporate Finance, 67*, 101865.

Kaplan, R. S., & Ramanna, K. (2021). Accounting for climate change. *Harvard Business Review, 99*(6), 120-131. Retrieved from https://hbr.org/2021/11/accounting-for-climate-change

Khan, Y., Oubaih, H., & Elgourrami, F. Z. (2022). The effect of renewable energy sources on carbon dioxide emissions: Evaluating the role of governance, and ICT in Morocco. *Renewable Energy, 190*, 752-763.

Kolk, A., & Pinkse, J. (2005). Business responses to climate change: Identifying emergent strategies. *California Management Review, 47*(3), 6-20.

Krueger, P., Sautner, Z., Tang, D. Y., & Zhong, R. (2021). The effects of mandatory ESG disclosure around the world. *Journal of Accounting Research*.

Lash, J., & Wellington, F. (2007). Competitive advantage on a warming planet. *Harvard Business Review, 85*(3), 94-102.

Matsumura, E. M., Prakash, R., & Vera-Muñoz, S. C. (2014). Firm-value effects of carbon emissions and carbon disclosures. *The Accounting Review, 89*(2), 695-724.

Monasterolo, I. (2020). Climate change and risk in finance. *Nature Climate Change, 10*(1), 33-39.

Oehmichen, J., Thiel, L., & Wolff, M. (2022). Gender diversity in corporate boards and firm environmental engagement: The role of female leadership and female community norms. *Journal of Corporate Finance, 73*, 102180.

Hart, O., & Zingales, L. (2017). Companies should maximize shareholder welfare not market value. *ECGI-Finance Working Paper*, (521).

Pankratz, N., Bauer, R., & Derwall, J. (2023). Climate change, firm performance, and investor surprises. *Management Science, 69*(12), 7352-7398.

Pedersen, L. H., Fitzgibbons, S., & Pomorski, L. (2021). Responsible investing: The ESG-efficient frontier. *Journal of Financial Economics*. https://doi.org/10.1016/j.jfineco.2020.11.001

Porter, M. E., & Kramer, M. R. (2011). Creating shared value: How to reinvent capitalism—and unleash a wave of innovation and growth. *Harvard Business Review, 89*(1/2), 62-77. Retrieved from https://hbr.org/2011/01/the-big-idea-creating-shared-value

Sautner, Z., Van Lent, L., Vilkov, G., & Zhang, R. (2023). Firm-level climate change exposure. *The Journal of Finance*, *78*(3), 1449-1498.

Shin, H., Ellinger, A. E., Nolan, H. H., DeCoster, T. D., & Lane, F. (2018). An assessment of the association between renewable energy utilization and firm financial performance. *Journal of Business Ethics, 151*, 1121-1138.

Semieniuk, G., Campiglio, E., Mercure, J. F., Volz, U., & Edwards, N. R. (2021). Low-carbon transition risks for finance. *Wiley Interdisciplinary Reviews: Climate Change*, *12*(1), e678.

Stroebel, J., & Wurgler, J. (2021). What do you think about climate finance? *Journal of Financial Economics, 142*(2), 487-498.

Yoon, H., Tashman, P., Benischke, M. H., Doh, J., & Kim, N. (2024). Climate impact, institutional context, and national climate change adaptation IP protection rates. *Journal of Business Venturing, 39*(1), 106359.

Weitzman, M. L. (2014). Fat tails and the social cost of carbon. *American Economic Review, 104*(5), 544-546.

Wong, J. B., & Zhang, Q. (2022). Stock market reactions to adverse ESG disclosure via media channels. *The British Accounting Review*, *54*(1), 101045.

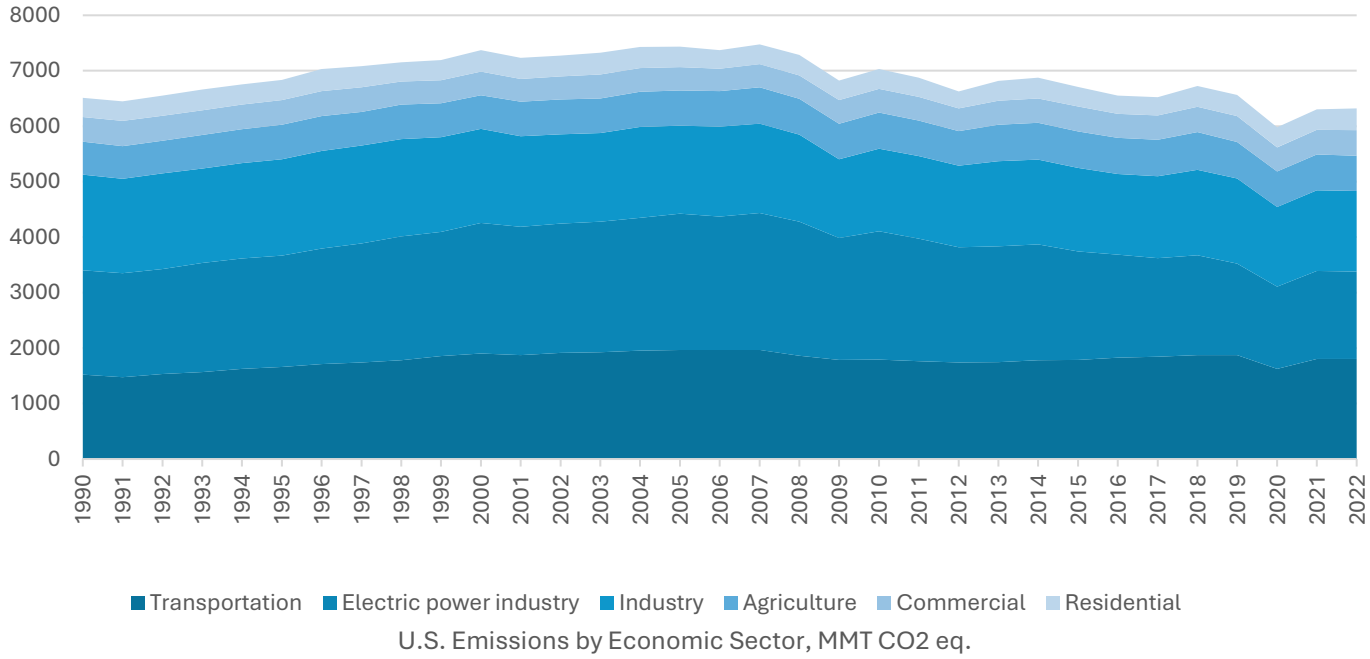


Figure 1: U.S. Carbon Dioxide Emissions, by Economic Sector in Million in Metric Tons of CO2 equivalent (1990-2022)

Data source: U.S. Environmental Protection Agency (EPA), 2024

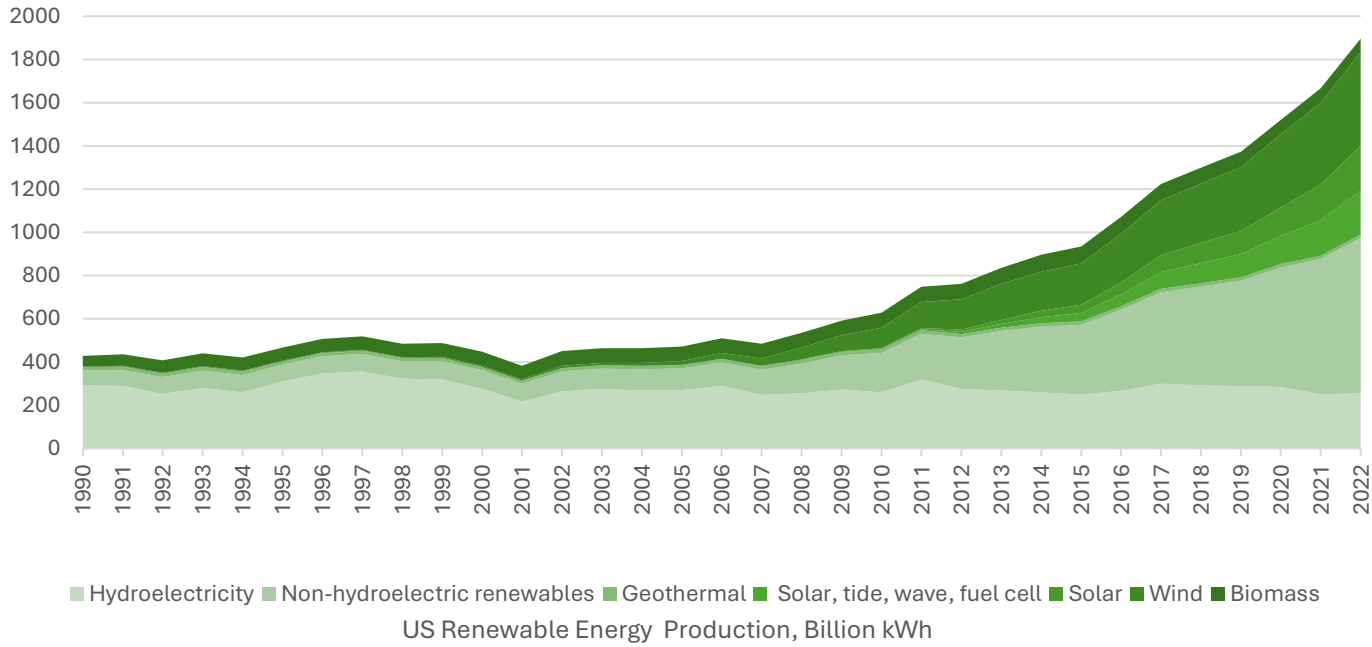


Figure 2: US Renewable Energy Production in Billion Kilowatt Hours (1990-2022)

Data source: The U.S. Energy Information Administration (EIA), 2024

Table 1. Definitions of variables.

Variables	Definition	Source
Log_REN	Log of total renewable energy consumption	Thomson/Refinitiv
REN/Sales	Total renewable energy consumption as a percentage of sales turnover	Thomson/Refinitiv
REN_D	A dummy variable equaling one if the firm uses renewable energy, and zero otherwise	Thomson/Refinitiv
REN/TC	Total renewable energy consumption as a percentage of total energy use	Thomson/Refinitiv
CC_EXP	CC_Exposure developed by Sautner et al. (2023), which is a conference calls-based Climate Risk measure	Sautner et al. (2023)
N_Climate_EXP	Climate_EXP, normalized by industry and year	Sautner et al. (2023)
ESG_Risk	Number of newspaper article published	Reprisk
Pillar_ENV	Environmental pillar score	Thomson/Refinitiv
Pillar_GOV	Governance pillar score	Thomson/Refinitiv
Log_Emissions	Log of ((Scope 1 + Scope 2 + Scope 3) + 1)	ASSET4
Leverage	Long-term debt divided by total assets	COMPUSTAT
ROA	IB/TA	COMPUSTAT
LogQ	Tobin's Q, the log of the sum of market capitalization and the book value of debt, divided by the book value of total assets log ((at-ceq-txdb + csho*prcc_f)/at)	COMPUSTAT
Cap_INT	Capital intensity is gross property, plant and equipment scaled by total assets (ppegt/at)	COMPUSTAT
Cash	Cash and cash equivalents divided by total assets	COMPUSTAT
Assets	Log of total assets (log (at + 1))	COMPUSTAT
Sales	Log of 1+ sales (log (1+sale))	COMPUSTAT
Audit_CSR	Does the company have an external auditor of its CSR/H&S/Sustainability report?	Thomson/Refinitiv
SCI	Is the senior executive's compensation linked to CSR/H&S/Sustainability targets?	Thomson/Refinitiv
MB	Market to Book Ratios at the end of the fiscal year log(prcc_f*csho)/ceq	COMPUSTAT
R&D	R&D expenditures divided by total assets (xrd/at)	COMPUSTAT

Table 2. Descriptive statistics.

	No. of Obs.	Mean	Std. Dev.	Pctl. 25	Pctl. 75
Log_REN	5853	4.136	5.524	-8.006	9.617
REN/Sales	5853	0.9315	1.686	0	1.409
REN_D	5853	0.3873	0.4872	0	1
REN/TE	5853	58.97	1065	0	4
CC_EXP	5853	1.53	3.118	0.1944	1.332
N_Climate_EXP	5853	-0.000	0.9135	-0.6528	0.534
ESG_Risk	5853	8.209	20.89	0	6
Pillar_ENV	5853	57.29	22.06	42.13	75.03
Pillar_GOV	5853	61.7	19.91	47.13	77.54
Log_Emissions	5853	11.8	5.025	10.81	15.05
Leverage	5853	0.2844	0.1749	0.1564	0.3928
ROA	5853	0.051	0.07328	0.0151	0.08933
LogQ	5853	0.5441	0.5398	0.09915	0.8524
Cap_INT	5853	0.4835	0.4046	0.1573	0.7586
Cash	5853	0.1229	0.1278	0.0315	0.166
Assets	5853	9.32	1.665	8.151	10.35
Audit_CSRA	5853	0.3192	0.4662	0	1
SCI	5853	0.3996	0.4899	0	1
R&D	5853	0.02215	0.0389	0	0.0260
MB	5853	4.152	10.17	1.575	4.802

Note: The table reports descriptive statistics at the firm level based on all the observations used to estimate the main regression The sample period is from 2007 to 2022. Variable definitions are provided in Table 1.

Table 3. Correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) Log_REN	1.000																
(2) CC_EXP	0.172	1.000															
(3) N_Climate_EXP	0.068	0.382	1.000														
(4) ESG_Risk	0.142	-0.044	0.031	1.000													
(5) Pillar_ENV	0.271	-0.020	0.070	0.282	1.000												
(6) Pillar_GOV	0.130	0.049	0.029	0.109	0.279	1.000											
(7) Log_Emissions	0.259	0.098	0.013	0.251	0.445	0.233	1.000										
(8) Leverage	0.150	0.025	-0.017	-0.090	0.034	0.005	0.060	1.000									
(9) ROA	0.016	-0.103	-0.006	0.052	0.090	0.074	0.065	-0.100	1.000								
(10) LogQ	0.068	-0.124	-0.007	-0.012	0.021	-0.041	-0.051	0.045	0.488	1.000							
(11) Cap_INT	0.063	0.251	0.018	0.018	-0.006	0.079	0.210	0.174	-0.020	-0.100	1.000						
(12) Cash	-0.021	-0.107	-0.004	0.082	-0.034	-0.091	-0.114	-0.247	0.076	0.318	-0.247	1.000					
(13) Assets	0.158	-0.040	0.030	0.511	0.483	0.203	0.418	-0.094	0.013	-0.205	-0.133	-0.095	1.000				
(14) Audit_CSRA	0.250	-0.006	0.046	0.252	0.419	0.227	0.355	0.024	0.057	0.025	-0.024	-0.015	0.384	1.000			
(15) SCI	0.099	0.130	0.002	0.115	0.195	0.357	0.225	0.010	-0.025	-0.099	0.147	-0.069	0.215	0.184	1.000		
(16) R&D	0.018	-0.096	-0.022	-0.007	-0.010	-0.090	-0.079	-0.204	0.060	0.342	-0.220	0.545	-0.163	0.002	-0.087	1.000	
(17) MB	0.025	-0.038	0.019	-0.011	0.028	-0.018	-0.011	-0.000	0.151	0.290	-0.056	0.112	-0.036	0.055	-0.020	0.130	1.000

Note: Table 3 shows the correlation matrix. Refer to Table 1 for the definitions of the variables.

Table 4: Regression results for climate exposure and use of renewable energy.

Variable	OLS (1)	OLS (2)	Lagged OLS (3)	Lagged OLS (4)
	Log_REN		(t-2)	(t-3)
CC_EXP	0.1788***	0.1646***	0.2185***	0.2549***
	(0.0287)	(0.0261)	(0.0403)	(0.0476)
Pillar_ENV		0.0455***	0.0361***	0.0255***
		(0.0034)	(0.0044)	(0.0051)
Pillar_GOV		-0.0005	0.0008	0.0036
		(0.0032)	(0.0042)	(0.0048)
Log_Emissions		0.0572***	0.0720***	0.0709***
		(0.0145)	(0.0186)	(0.0209)
Leverage		1.6900***	3.2806***	3.7773***
		(0.4009)	(0.5539)	(0.6591)
ROA		0.2761	-1.3238	-2.6509
		(0.9690)	(1.3848)	(1.6704)
Log_Q		0.4703***	0.7394***	0.9854***
		(0.1466)	(0.2083)	(0.2494)
Cap_INT		1.4569***	1.6091***	1.6524***
		(0.2153)	(0.2869)	(0.3320)
Cash		0.9106	1.8959**	1.9158**
		(0.5857)	(0.8013)	(0.9230)
Assets		0.6365***	0.8105***	0.9061***
		(0.0567)	(0.0755)	(0.0873)
Audit_CSRA		0.7070***	0.4151**	0.3822*
		(0.1444)	(0.1871)	(0.2091)
SCI		0.1153	-0.0387	-0.2491
		(0.1352)	(0.1768)	(0.2000)
R&D		10.1480***	11.4347***	11.0714***
		(2.3329)	(3.1402)	(3.5847)
MB		-0.0090	-0.0054	-0.0053
		(0.0059)	(0.0078)	(0.0090)
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Observations	5,853	5,853	3,730	2,990
R^2	0.2880	0.3928	0.4227	0.4351
Adjusted R^2	0.2831	0.3873	0.4147	0.4255

Note: The table reports the results for climate exposure and use of renewable energy (log of total renewable energy consumption). ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Table 5: Regression results for number of newspaper article related to ESG and use of renewable energy.

Variable	OLS (1)	OLS (2)	Lagged OLS (3)	Lagged OLS (4)
	Log_REN		(t-2)	(t-3)
ESG_Risk	0.0540***	0.0111***	0.0113***	0.0145***
	(0.0032)	(0.0034)	(0.0043)	(0.0048)
Pillar_ENV		0.0467***	0.0375***	0.0271***
		(0.0034)	(0.0044)	(0.0051)
Pillar_GOV		-0.0011	0.0002	0.0032
		(0.0033)	(0.0043)	(0.0049)
Log_Emissions		0.0608***	0.0720***	0.0684***
		(0.0146)	(0.0186)	(0.0209)
Leverage		1.6804***	3.2048***	3.6261***
		(0.4023)	(0.5557)	(0.6604)
ROA		-0.1498	-1.7072	-2.9221*
		(0.9695)	(1.3874)	(1.6756)
Log_Q		0.4613***	0.7112***	0.9209***
		(0.1471)	(0.2095)	(0.2511)
Cap_INT		1.4251***	1.5962***	1.6113***
		(0.2168)	(0.2889)	(0.3346)
Cash		0.7923	1.5917*	1.4743
		(0.5929)	(0.8127)	(0.9358)
Assets		0.5309***	0.6790***	0.7327***
		(0.0623)	(0.0842)	(0.0977)
Audit_CSRA		0.7188***	0.4375**	0.4007*
		(0.1448)	(0.1877)	(0.2098)
SCI		0.1383	0.0047	-0.2022
		(0.1355)	(0.1773)	(0.2006)
R&D		8.6410***	10.0800***	9.5896***
		(2.3399)	(3.1480)	(3.5950)
MB		-0.0083	-0.0045	-0.0046
		(0.0059)	(0.0078)	(0.0091)
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Observations	5,853	5,853	3,730	2,990
R^2	0.2880	0.3928	0.4227	0.4351
Adjusted R^2	0.2831	0.3873	0.4147	0.4255

Note: The table reports the results for number of negative newspaper article related to ESG and use of renewable energy (log of total renewable energy consumption). ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Table 6: Regression results for climate exposure and use of renewable energy (using alterative measure).

Variable	REN/TC	REN/Sales	REN_D
CC_EXP	0.4434***	0.0847***	0.0095***
	(0.0625)	(0.0085)	(0.0024)
Pillar_ENV	0.0307***	0.0120***	0.0044***
	(0.0081)	(0.0011)	(0.0003)
Pillar_GOV	-0.0129*	-0.0003	-0.0001
	(0.0078)	(0.0011)	(0.0003)
Log_Emissions	0.0309	0.0131***	0.0052***
	(0.0348)	(0.0047)	(0.0013)
Leverage	0.2154	0.3858***	0.1499***
	(0.9597)	(0.1301)	(0.0364)
ROA	2.7489	-0.2561	-0.0547
	(2.3199)	(0.3145)	(0.0880)
Log_Q	-0.0935	0.0896*	0.0350***
	(0.3509)	(0.0476)	(0.0133)
Cap_INT	0.4652	1.0067***	0.0261
	(0.5154)	(0.0699)	(0.0195)
Cash	-0.5325	0.6032***	0.0699
	(1.4022)	(0.1901)	(0.0532)
Assets	0.0446	0.0827***	0.0200***
	(0.1357)	(0.0184)	(0.0051)
Audit_CSRA	-1.3969***	0.0894*	0.0690***
	(0.3457)	(0.0469)	(0.0131)
SCI	0.1282	0.0248	0.0040
	(0.3236)	(0.0439)	(0.0123)
R&D	5.8660	2.7778***	0.7368***
	(5.5850)	(0.7572)	(0.2118)
MB	-0.0027	-0.0035*	-0.0006
	(0.0140)	(0.0019)	(0.0005)
Year effects	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes
Observations	5,853	5,853	5,853
R^2	0.0686	0.3168	0.3601
Adjusted R^2	0.0601	0.3106	0.3542

Note: The table reports the results for climate exposure and use of renewable energy (using alterative measure). ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Table 7: Regression results for climate exposure (normalized by industry and year) and use of renewable energy.

Variable	Log_REN	REN/TC	REN/Sales	REN_D
N_Climate_EXP	0.2853***	0.2499*	0.1097***	0.0175***
	(0.0621)	(0.1491)	(0.0203)	(0.0056)
Controls	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Observations	5,853	5,853	5,853	5,853
R^2	0.3939	0.0609	0.3086	0.3593
Adjusted R^2	0.3884	0.0524	0.3022	0.3535

Note: The table reports the results for climate exposure (normalized by industry and year) and use of renewable energy (using alterative measure). ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Table 8: Regression results for the effect of use of renewable energy and firm's ESG and Environmental Pillar Score Performance.

Variable	ESG Score	ESG Score	Environmental Pillar Score	Environmental Pillar Score
Log_REN	1.0356***	0.3238***	1.6632***	0.7568***
	(0.0717)	(0.0568)	(0.0918)	(0.0844)
Leverage		-2.5079		-3.3585
		(2.2056)		(2.9688)
ROA		10.2964**		1.3515
		(4.1635)		(5.6496)
Log_Q		1.5872**		1.9841*
		(0.7076)		(1.0122)
Cap_INT		3.9754***		3.2532*
		(1.2932)		(1.7204)
Cash		-3.4521		0.8377
		(3.0223)		(4.4686)
Assets		4.4307***		6.6065***
		(0.2662)		(0.4193)
Audit_CSRA		7.2928***		8.6713***
		(0.6397)		(0.9241)
SCI		6.2494***		2.4252***
		(0.5756)		(0.8128)
R&D		26.1059**		37.6736*
		(12.6264)		(19.9519)
MB		-0.0030		0.0185
		(0.0226)		(0.0280)
Year effects	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes
Observations	5,853	5,853	5,853	5,853
R^2	0.1503	0.4700	0.1815	0.4416
Adjusted R^2	0.1444	0.4653	0.1759	0.4367

Note: The table reports the results for the effect of use of renewable energy and firm's ESG and Environmental Pillar Score Performance. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.