Climate Change Impacts and Renewable Energy Innovation: A Firm-Level Analysis

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Abstract

Amidst the escalating challenges posed by climate change, the transition to renewable energy emerges as a pivotal strategy for businesses and organisations to reduce environmental footprints and enhance sustainability. Against this backdrop, this thesis delves into the complex interplay between climate change impacts and firms' pursuit of renewable energy innovation, drawing on the Behavioural Theory of the Firm. Concentrating on the specific impact of climate change-induced natural disasters, this research investigates their direct influence on firms' pursuit of renewable energy innovation, while also considering the moderating effects of market dynamics. With climate change posing unprecedented risks and opportunities for businesses, understanding these dynamics becomes crucial for developing effective strategies and policies to foster sustainable practices.

Employing a quantitative methodology, this study scrutinises the behaviour of U.S. firms following climatological disasters from 2013 to 2018, using a Difference-in-Differences model complemented by meta-analysis. The findings reveal that climatological disasters significantly motivate firms to pursue renewable energy innovation. The study also identifies that the pursuit of renewable energy innovation by peer firms is identified as a significant influence, underscoring the influence of industry trends and competitive behaviour on corporate innovation pathways. This contrasts with other market dynamics; investor sentiment and media coverage were found not to have a significant effect on firms' renewable energy innovation post-disaster.

In a deeper exploration of the factors moderating the effect of climatological disasters on renewable energy innovation, the research unveils that firms falling below their performance aspirations are more likely to intensify their pursuit of renewable energy innovation post-disasters, viewing innovation as a solution to narrow the performance gap. Additionally, subsidiaries of foreign multinational enterprises demonstrate a less pronounced increase in renewable energy innovation compared to domestic firms, indicating that firm origin significantly affects their pursuit of innovation following climatic events. Further, natural disaster uncertainty emerges as a significant determinant, affecting the propensity for renewable energy innovation in a context marked by unpredictability. Lastly, a firm's history of natural disasters influences its approach to renewable energy innovation, suggesting that

past experiences could foster a foundation of resilience or engender a posture of strategic prudence.

The thesis contributes to the academic literature by offering new insights into the interplay between climate change impacts and renewable energy innovation, highlighting the complexity of firms' behaviour following environmental challenges. It deepens the Behavioural Theory of the Firm by integrating the threat rigidity model to explain how firms behave following climate change impacts. The significance of this study extends beyond its academic contributions, providing a roadmap for climate action that enables policy-makers, business leaders, and stakeholders to effectively tackle the ongoing climate change crisis. The research offers guidance on how firms can leverage local insights and past disaster experiences to enhance their pursuit of RE innovation following climate change-induced natural disasters. It suggests that both domestic firms and multinational enterprises need targeted strategies that align with their operational contexts and previous experiences. The policy implications advocate targeted support that aligns with the distinct needs of domestic firms and multinational enterprises, thereby facilitating a more tailored and effective pursuit of RE innovation post-climatological disaster. Policies should promote the integration of natural disaster risk assessments into strategic planning, support collaborative innovation efforts, and enforce transparency in reporting RE innovation. These policy recommendations are designed to directly contribute to Sustainable Development Goals 7 (affordable and clean energy) and 13 (climate action), by enhancing energy security, promoting sustainable energy use, and fostering innovation to combat climate change impacts. This highlights the study's pivotal role in contributing to sustainable development and achieving climate action goals.

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Publications associated with this thesis

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- Rastegar, H., Eweje, G., & Sajjad, A. (2024). Sustainability-driven market impacts of climate change and firms' renewable energy innovation: a conceptual analysis. *Corporate Governance: The International Journal of Business in Society.* Q1 Scimago, 2023 CiteScore 11.1, 2022 Impact Factor 5.60 https://doi.org/10.1108/CG-07-2023-0298

Articles Under Review

- Rastegar, H., Sajjad, A., Eweje, G., & Kobayashi, K. (2024). Sustainability in the Wake of Crisis: Transforming Climate Change-Induced Disasters into Drivers of Renewable Energy Innovation in Business. *Journal of Economic Behavior and Organization* [Under Review]
- Rastegar, H., Eweje, G., & Sajjad, A. (2024). From Crisis to Opportunity: The Role of Natural Disasters in Shaping Firms' Green Innovation. *Renewable and Sustainable Energy Reviews* [Under Review]
- Rastegar, H., Sajjad, A., Eweje, G., & Kobayashi, K. (2024). Renewable Energy Innovation in the Wake of Climate Disasters: Navigating Peer Dynamics and Firm Characteristics. *Global Environmental Change* [Under Review]
- Rastegar, H., Sajjad, A., Eweje, G., & Kobayashi, K. (2024). Uncertainty's Role in Renewable Energy Innovation Against Climate Disasters. *Global Environmental Change* [Under Review]

Conference Presentations and Proceeding

- Rastegar, H., Sajjad, A., Eweje, R. G., & Kobayashi, K. (2024, August). Sustainability amidst crisis: Harnessing climate disasters as drivers of renewable energy innovation. In Academy of Management Proceedings (Vol. 2024, No. 1, p. 21038). Valhalla, NY 10595: Academy of Management.

- Rastegar, H., Eweje, G., & Sajjad, A. (2023, March). *Market-driven impacts of climate change and firms' renewable energy innovation: a conceptual review* [Paper presentation]. Academy of International Business (AIB) Conference, Las Vegas, USA.
- Rastegar, H., Lui, D., & Chung, H. (2022, July). *Does Exposure to Climate Change Make Firms' Innovation Greener? A Behavioral Perspective* [Paper presentation]. Academy of International Business (AIB) Conference, Miami, USA.

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Abbreviation Glossary

AAII	American Association of Individual Investors
BTOF	Behavioural Theory of the Firm
CDP	Carbon Disclosure Project
CEI	Climate Extremes Index
CER	Corporate Environmental Responsibility
COP	Conference of the Parties
CRI	Climate Risk Index
CPU index	Climate Policy Uncertainty index
CRED	Centre for Research on the Epidemiology of Disasters
CSR	Corporate Social Responsibility
DiD	Difference-in-Differences
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EM-DAT	Emergency Events-Database
ESG	Environmental, Social, and Governance
ETS	Emissions Trading Scheme
EU	European Union
FDI	Foreign Direct Investment
GHG	Greenhouse Gas
GIC	Global Industry Classification
HA	Historical Aspiration
IEA	International Energy Agency
IPC	International Patent Classification
IPCC	Intergovernmental Panel on Climate Change
ISS	Institutional Shareholder Services
ITSA	Interrupted Time Series Analysis
LOF	Liability of Foreignness
MNE	Multinational Enterprise
MS	Matched-Sample

MUHEC	Massey University Human Ethics Committee
NPV	Net Present Value
R&D	Research and Development
RD&D	Research, Development, and Demonstration
RE	Renewable Energy
RESET	Regression Equation Specification Error Test
ROA	Return on Assets
RQ	Research Question
RRI	RepRisk Index
SA	Social Aspiration
SDG	Sustainable Development Goal
TRI	Toxics Release Inventories
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USPTO	United States Patent and Trademark Office
U.S.	United States
VIF	Variance Inflation Factor
WIPO	World Intellectual Property Organisation
WRDS	Wharton Research Data Services

1. Chapter 1 Introduction

1.1. Introduction

This research delves into the nexus between climate change impacts and firms' pursuit of renewable energy (RE) innovation, framed through the lens of the behavioural theory of the firm (BTOF). It seeks to unravel how climate change impacts steer a firm's pursuit of RE innovation. Focusing on nature-driven impacts of climate change (Zhou & Wen, 2020), particularly climatological disasters, this study examines their role in the pursuit of RE innovation by firms. Additionally, by integrating the effects of market dynamics, it highlights the composite influence these factors exert on a firm's pursuit of RE innovations. Through this multifaceted exploration, the research aims to illuminate the complex interplay of climate change impacts and firms' pursuit of RE innovation. In terms of market-driven impacts, this investigation focuses on three specific market constructs and their impacts on firms' pursuit of RE innovation following climatological disasters. These constructs include peers' pursuit of RE innovation, investor sentiment, and media coverage. The purpose of this study is to model firms' behaviour following different climate change impacts and determine whether these impacts influence the pursuit of RE innovation.

This chapter introduces the research topic, its background, and its significance in relation to existing knowledge and practice. Section 1.2 provides the background and overview of the study. Following this, section 1.3 delves into the study's justification, highlighting the necessity and motivation behind the research. The research objectives, core questions, and hypotheses are then presented in sections 1.4 and 1.5. Section 1.6 outlines the research design. Subsequently, section 1.7 highlights the significance of the study and the key contributions to academia and practice. Finally, section 1.8 outlines the structure of the thesis and the content of each chapter.

1.2. Background of the Study

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, n.d.). Climate change is a significant global challenge and has had far-reaching impacts on various aspects of human life. Businesses have been particularly affected by climate change-induced natural disasters, leading to damages, losses, and the costly process of recovery and restoration. However, this is only part of the story. Countries around the world are developing strategies to lower carbon emissions (He et al., 2021). Further, numerous authoritative organisations at national, international, and supranational levels have implemented regulations aimed at mitigating or even preventing the effects of climate change. Meeting the objectives of these policies necessitates a significant shift in energy consumption and generation (Hakimi & Inglesi-Lotz, 2020). One notable example is the European Union (EU), which has introduced the world's largest CO_2 emission pricing regulation, known as the Emissions Trading Scheme (ETS), to reduce carbon emissions (Nippa et al., 2021b). Additionally, the United Nations (UN) spearheaded the Paris Agreement in 2015, a global collaborative effort to address climate change (Li & Zhou, 2017). These climate actions target businesses as primary agents for change, often subjecting them to criticism for their contributions to climate change and their profit-driven motives (Porter & Kramer, 2011).

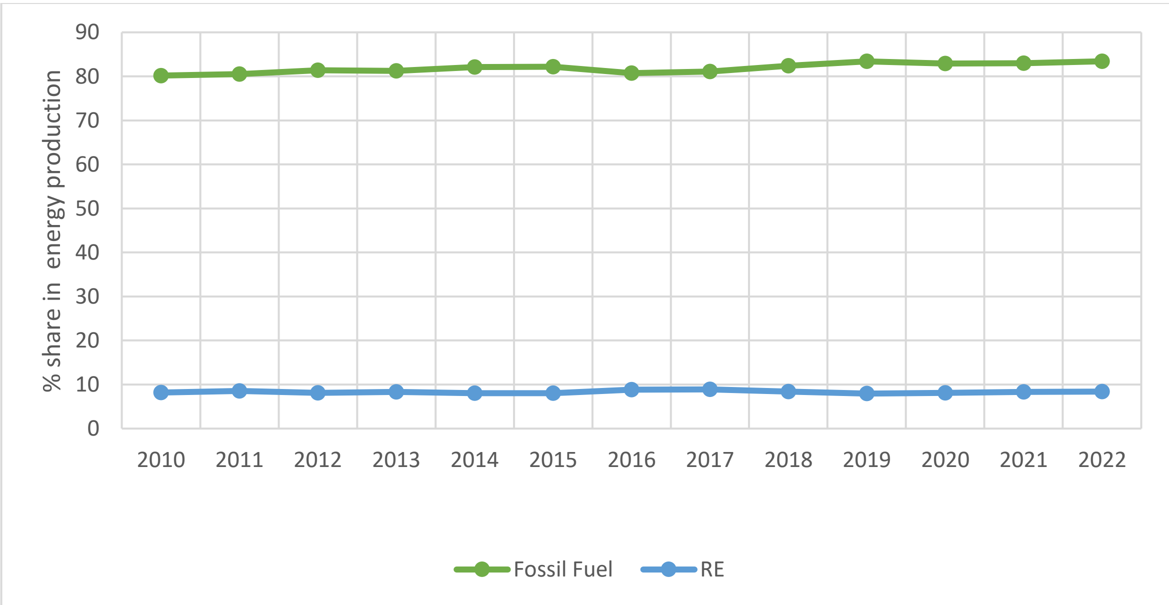
Alongside these regulations, the growing public awareness and market preferences have intensified the pressure on businesses. All these pressures have increasingly influenced business strategies and shaped firms' decision-making processes. These pressures are categorised into three main groups: nature-driven impacts, policy-driven impacts, and market-driven impacts (Flammer et al., 2021; Kouloukoui et al., 2019; Sakhel, 2017; Zhou & Wen, 2020). Nature-driven impacts relate to the physical effects of climate change (Flammer et al., 2021; Mithani, 2020), while policy-driven impacts pertain to climate policies implemented by various entities (Flammer et al., 2021; Sakhel, 2017; Zhou & Wen, 2020). On the other hand, market-driven impacts arise from the reactions of different market participants (Sakhel, 2017; Zhou & Wen, 2020), and this study focuses on three key market participants: peers, investors, and media.

Despite the considerable body of knowledge available about climate change impacts, there is insufficient understanding to develop a comprehensive framework for firms to respond effectively (Ferraro et al., 2015). Research on climate change and its consequences for human life has garnered significant attention thus far, utilising estimations to demonstrate potential future scenarios shaped by climate change. However, these estimations are plagued by the inherent uncertainty surrounding climate change impacts (Intergovernmental Panel on Climate Change [IPCC], 2014). In this context, the firms’ behaviour following climate change impacts becomes crucial for their survival. Firms allocate varying levels of resources towards achieving sustainability (Sadovnikova & Pujari, 2017) and adopt different strategies, ranging from non-compliance to proactive initiatives (Albertini, 2014). The escalating impacts of climate change and the significance of firms' behaviour following these impacts have motivated the researcher to model firms' behaviour following climate change impacts. To fulfil this objective and examine firms' vulnerability to climate change impacts and the effectiveness of their behaviour, this study focuses on firms' pursuit of RE innovation. RE technology has emerged as a response to the growing importance of climate change and the depletion of fossil fuel reserves (Lin & Zhu, 2019).

Transitioning to clean energy production and consumption, known as RE, is recognised as a viable solution to address the escalating impacts of climate change (Zhang et al., 2022). RE is defined as 'energy obtained from naturally repetitive and persistent flows of energy occurring in the local environment' (Twidell & Weir, 2015, p. 3). The RE industry encompasses various clean energy sources, including wind, biomass, geothermal, ocean, hydropower, and solar energy (Xu & Lin, 2018). These sources offer sustainable alternatives to traditional fossil fuels and contribute to reducing greenhouse gas (GHG) emissions, promoting environmental sustainability, and mitigating climate change.

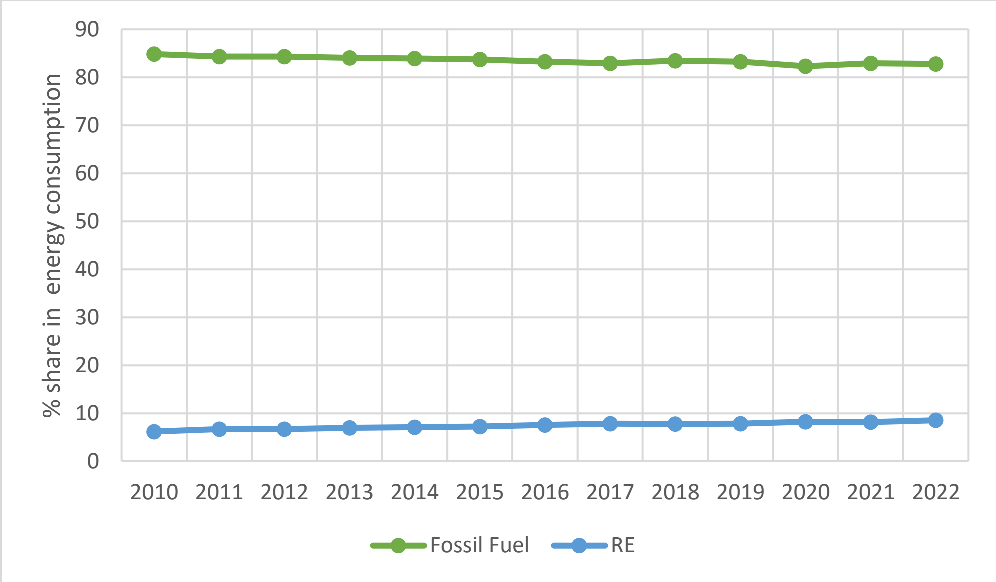
The literature on RE emphasises its role in promoting economic development (Lin & Zhu, 2019). Its significance is evident as it takes top priority on policy agendas worldwide (Steffen, 2020). Accelerating the deployment of RE is considered one of the effective solutions to achieve the goals of the Paris Agreement 2015 (Steffen, 2020). However, major carbon-intensive companies such as Exxon Mobil, Shell, and Glencore have conducted forecasts on the future global energy market. Their findings indicate that the industrialisation of developing countries will lead to a significant increase in global energy demand, which cannot be solely met by RE sources. This underscores the continued presence of fossil fuels in the energy market (Green & Newman, 2017). Moreover, based on data from the U.S. Energy Information Administration (EIA) Monthly Energy Review (December 2023), from 2010 to 2022, fossil fuels comprised an average of roughly 81.89% of the U.S. energy production, whereas RE contributed about 8.32% as shown in Figure 1. In the same timeframe, RE accounted for an average of 7.45% of the U.S. energy consumption, while fossil fuels dominated at 83.55%, as depicted in Figure 2. These charts indicate that both the production and consumption of RE are significantly trailing behind fossil fuels. The low level of RE production suggests a lack of motivation among energy sector firms to deploy innovative technologies, while the limited consumption of RE indicates that firms are unsure about the effectiveness of these technologies in replacing fossil fuels. This slow transition underscores a pressing need for RE innovation (Zhang et al., 2022). RE innovation, as defined by Bayer et al. (2013, p. 289), is 'the process of inventing and improving new energy technologies for commercial use'. This definition is crucial to the context of this study as it encapsulates the creation of new technologies that could accelerate the adoption of RE by firms and help bridge the gap between renewable and conventional energy sources.

Figure 1 Comparison of RE and Fossil Fuels in U.S. Energy Production



Source: Data derived from the Energy Information Administration [EIA] (2023, December, Table 1.1)

Figure 2 Comparison of RE and Fossil Fuels in U.S. Energy Consumption



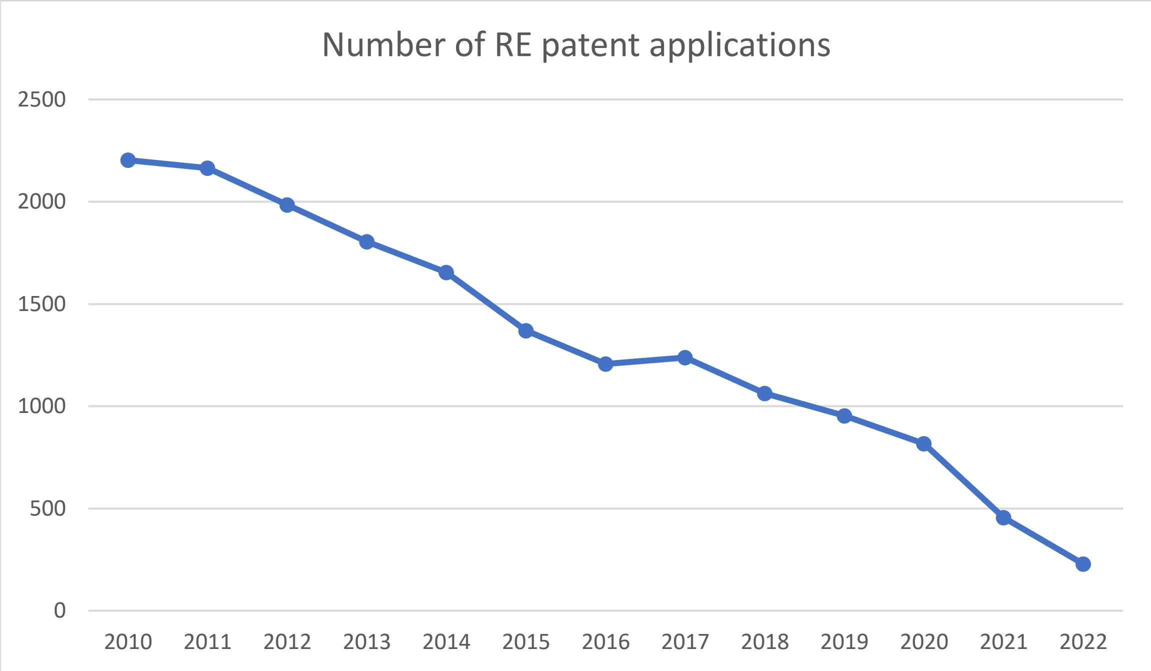
Source: Data derived from the Energy Information Administration [EIA] (2023, December, Table 1.1)

In recent years, green innovation has garnered increasing academic interest, particularly within the context of RE innovation (Costantini et al., 2017). Green innovation is characterised by the integration of environmental considerations into the value chain, enhancing product quality and reducing negative environmental impacts (Huang & Li, 2017). This proactive approach addresses various environmental challenges such as energy saving, pollution prevention, waste recycling, and eco-design (Chang, 2011). Unlike general innovation, green innovation specifically aims to reduce harmful effects on the environment (Leyva-de la Hiz et al., 2019). Much research has focused on identifying the drivers of green innovation (Brunnermeier & Cohen, 2003; Cai & Zhou, 2014; Costantini et al., 2017; Huang & Li, 2017; Li et al., 2018) and understanding its impact on business performance (Christmann, 2000; Huang & Li, 2017).

The trend of RE patent applications in the U.S., as illustrated in Figure 3, reflects a notable decline over the past decade. This decline is particularly concerning given the urgent need for innovative solutions to address the challenges posed by climate change. The data indicates a steady decrease in RE patent applications from 2010 to 2022, signalling a potential stagnation or lack of investment in RE innovation. This declining trend in RE patent applications underscores the pressing need for research and initiatives aimed at revitalising innovation in

RE technology. As the global community faces mounting environmental challenges, including the imperative to transition towards sustainable energy sources, it becomes increasingly crucial to understand the factors contributing to this decline and to identify strategies for fostering greater RE innovation.

Figure 3 Number of RE Patent Applications in the U.S.



Source: Data derived from the United States Patent and Trademark Office (USPTO)

While the impacts of climate change on the RE market in the U.S. are acknowledged (Sinha et al., 2024), there remains a significant gap in research exploring this interplay. This study seeks to address this need by investigating how climate change impacts shape the firm-level pursuit of RE innovation in the U.S. By delving into this underexplored area, the researcher aims to uncover how firms adjust their pursuit of RE innovation following the challenges and uncertainties brought about by climate change, thereby contributing to the development of more effective strategies for promoting RE innovation. Integral to the investigation are two crucial UN Sustainable Development Goals (SDGs): affordable and clean energy (SDG 7) and climate action (SDG 13) (Hille et al., 2020). These goals underscore the importance of this study in contributing to the global agenda for sustainable development and climate action.

1.3. Justification of the Study

Energy is a fundamental necessity for economic activities and human well-being (Huang et al., 2018). However, energy generation represents the primary source of anthropogenic CO_2 emissions (Steffen, 2020). For many decades, countries have relied heavily on fossil energy, including coal and oil, to drive their economic development (Bointner, 2014; Xu & Lin, 2018). The oil crises in the 1970s drew attention to the escalating concentration of CO_2 in the atmosphere resulting from the combustion of fossil fuels, leading to environmental pollution associated with their consumption (Bointner, 2014).

This formidable challenge, along with concerns about the limited availability of fossil fuels, has prompted the search for alternative, non-polluting energy sources known as RE, as a pathway toward sustainable development (Krueger et al., 2020; Xu & Lin, 2018). Furthermore, to achieve the goals outlined in the Paris Agreement 2015, investors are being urged to redirect their investments towards sustainable projects, shifting away from fossil fuels and carbon-intensive sectors towards a low-carbon transition (Monasterolo, 2020). RE technology is widely regarded as an effective approach to enhancing carbon emission efficiency, contributing significantly to energy conservation and emission reduction efforts (Lin & Zhu, 2019).

The significance of RE innovation in promoting sustainability and establishing a low-carbon economy in the fight against climate change has garnered attention from scholars (Roper & Tapinos, 2016). It also offers the potential for pioneering firms to gain a competitive advantage as first movers in the market (Perruchas et al., 2020; Roper & Tapinos, 2016; Zhou & Wen, 2020). To achieve net-zero greenhouse gas emissions and transition towards 100% RE systems worldwide, it is imperative to significantly increase investments in RE technology (Işık, 2024). While investments in RE are increasing, they are not accelerating at the necessary rate to tackle climate change (IRENA and CPI, 2023). Furthermore, private investments were primarily driven by corporations, which historically accounted for an average of 65%. However, in recent years, this share dropped to 41% annually (IRENA and CPI, 2023). Despite the recognition of RE technology as a potential solution to the challenge of climate change, its widespread pursuit by firms remains limited. The decline in firms' investments in RE technology, coupled with the escalating significance of RE innovation, underscores a concerning trend suggesting potential demotivation among firms. The declining trend in RE patent applications, as evidenced by the data presented in the previous section, aligns with the concerning decrease in firms' investments in RE technology (IRENA and CPI, 2023). This decline in RE patent applications suggests a lack of RE innovation, which is crucial for advancing sustainable energy solutions and addressing climate change challenges. As such, this trend further emphasises the need for research to investigate the underlying factors contributing to the decline in firms' pursuit of RE innovation.

This study is set against the backdrop of an escalating frequency and severity of climate change-induced natural disasters, which present a growing threat not only to environmental sustainability but also to the operational viability of businesses and corporations worldwide (Piperopoulos et al., 2023; Zhao et al., 2022). For instance, investors may perceive these disasters as a threat to the long-term stability and profitability of firms, affecting their valuations and investment decisions (Ai & Gao, 2023). Therefore, addressing the impacts associated with climate change-induced natural disasters is critical for enhancing the operational resilience and long-term viability of firms.

There is a growing body of evidence suggesting that nature-driven impacts of climate change have substantial macroeconomic implications. However, there is a lack of research focusing on how climate change specifically affects individual firms (Cevik & Miryugin, 2023). The increasing vulnerability of the corporate sector to these environmental challenges underscores the pressing need for a paradigm shift towards sustainable energy practices. Despite a consensus on the urgency of transitioning to RE sources, the move away from fossil fuel dependency remains sluggish, with traditional energy sources continuing to dominate global energy production and consumption (Energy Information Administration [EIA], 2023; Green & Newman, 2017). This slow transition underscores the critical need for innovative solutions within the realm of RE technology (Zhang et al., 2022). By investigating the influence of climate change impacts on firms' pursuit of RE innovation, this study addresses a pivotal gap in the existing literature on climate change impacts and firms' innovation.

While the necessity for firms to adapt and innovate following climate change-induced natural disasters is widely acknowledged, there remains a significant gap in understanding the specific ways in which these events catalyse or hinder the pursuit of RE innovation. The literature presents a complex picture marked by varied impacts and responses across different contexts and industries. This gap arises from divergent findings in the literature. For instance, Ren et al. (2022) showed that increased climate risks such as natural disasters can lead to higher corporate carbon emissions in China, suggesting that under certain regulatory and geographical conditions, firms may struggle to transition to low-carbon technologies. Conversely, Ma et al. (2023) found that in OECD countries, climate risks can act as catalysts for shifting from traditional to green innovation, indicating that in economies with robust economic structures and political support for green technology, firms are more likely to pursue innovative sustainable practices following environmental threats. Further, Li et al. (2023) illustrated that in Bangladesh, a developing country vulnerable to natural disasters, these events positively affect long-term sustainable development by fostering greater reliance on RE technology. This contrasts with Huang et al. (2018), who reported that firms in countries with severe climate risks adjust their financial strategies by holding more cash and opting for longer-term debt to mitigate the financial impacts of climate risks, rather than directly innovating in RE technologies.

This study seeks to bridge the gap in the literature by examining the direct influence of climatological disasters on firms' pursuit of RE innovation. Instead of solely relying on climate risk as an indirect measure for climate change-induced natural disasters, this research analyses firms' behaviour following actual climatological events. By doing so, it aims to provide objective findings regarding the impact of these disasters on firms' innovation behaviour. Specifically, this study leverages the BTOF to understand how firms' performance relative to their aspirations influences their pursuit of RE innovation following environmental challenges.

The adoption of the BTOF allows for a nuanced examination of firms' pursuit of RE innovation following environmental adversities. By considering firms' aspirations and performance, the BTOF provides insights into how firms behave following external pressures, such as climatological disasters. Moreover, the BTOF emphasises the importance of understanding firms as dynamic entities with bounded rationality. By acknowledging the bounded rationality of firms facing environmental uncertainties, this study can capture the complexities and nuances of firms' behaviour following climatological disasters. Through the lens of the BTOF, this research can uncover the underlying mechanisms driving firms' pursuit of RE innovation following environmental challenges, shedding light on the processes through which firms navigate and adapt to these disruptions.

Further, this study embarks on filling a critical gap in the current understanding of market-driven impacts of climate change on RE innovation, particularly in the context of climate change-induced natural disasters. Despite the acknowledgment of stakeholder pressures as key drivers for green practices within organisations (Albertini, 2014; Bansal & Roth, 2000), the literature reveals a complex and sometimes contradictory landscape regarding the efficacy of these pressures in promoting green innovation (Kouloukoui et al., 2019; Ren et al., 2022; Sakhel, 2017). The prevailing scepticism around the influence of market risks and stakeholder pressures in driving substantial environmental practices, juxtaposed with the increasing emphasis on climate risk disclosure as a strategy for managing stakeholder expectations (Kouloukoui et al., 2018), underscores the necessity for a deeper investigation. This study seeks to explore the interplay between market dynamics—peers' pursuit of RE innovation, investor sentiment, and media coverage—and their effects on firms' pursuit of RE innovation following climate change-induced natural disasters, a domain where existing research is notably sparse (Sinha et al., 2024). By delving into these dimensions, the study aims to provide valuable insights into the dynamic and often intricate relationship between market pressures and firms' pursuit of RE innovation following environmental challenges. In addition to market-driven impacts, this research initially included an examination of the effects of policy-driven impacts of climate change on the pursuit of RE innovation. However, given that the findings on this aspect showed an insignificant influence, it has been excluded from this thesis.

In conclusion, the justification for this study is rooted in the pressing need to address the complex impacts posed by climate change through the lens of firms' pursuit of RE innovation. By providing empirical evidence and insights into how climate change impacts affect firms' pursuit of RE innovation, this research offers a foundational framework for policy-makers, business leaders, and stakeholders to foster an environment conducive to sustainable development and climate resilience. Furthermore, the study aligns with the objectives of the UN SDGs, particularly SDG 7 and SDG 13, emphasising its relevance to the global agenda for sustainable development (Hille et al., 2020).

1.4. Research Objectives and Questions

Climate change is a pressing issue worldwide, making RE technology crucial. RE is set to be the main source of power in the future due to increasing energy needs and its positive impact on the environment (Chien et al., 2021). However, the adoption of RE innovation has not kept up with its growing importance, indicating a disconnect between its potential and its current use. This highlights a key gap in existing research regarding the influence of climate change impacts on RE innovation, particularly in the context of climate change-induced natural disasters. Given this research gap, the primary objective of this study is to contribute to our understanding of how climate change impacts influence a firm's pursuit of RE innovation. Specifically, the study aims to investigate the following core question:

'How do climate change impacts affect a firm's pursuit of RE innovation?'

By addressing this question, the study seeks to uncover the relationship between climate change impacts and the pursuit of RE innovation by firms, providing valuable insights into the factors that shape firms' behaviour following climate change impacts. To effectively address the core question, this study is structured around two sub-questions. The first assesses nature-driven impacts, specifically through the lens of climate change-induced natural disasters, as a representation of the broader category of nature-driven impacts on RE innovation. The second inquiry delves into the moderating role of market-driven impacts on the relationship between climate change-induced natural disasters and firms' pursuit of RE innovation. These sub-questions are as follows:

1- How do nature-driven impacts, exemplified by climate change-induced natural disasters, affect a firm's pursuit of RE innovation?

This sub-question focuses on understanding how natural events and phenomena associated with climate change, such as extreme weather events, influence a firm's pursuit of RE innovation.

2- How do market-driven impacts of climate change act as a moderating factor in the relationship between nature-driven impacts and a firm's pursuit of RE innovation?

This sub-question assesses the moderating role of market dynamics, including peers' pursuit of RE innovation, investor sentiment, and media coverage, on the initial relationship between nature-driven impacts and the pursuit of RE innovation by firms. It evaluates how market conditions influence the extent to which climate change-induced natural disasters affect a firm's pursuit of RE innovations.

By exploring these sub-questions, this study seeks to offer an in-depth analysis of how climate change impacts affect a firm's pursuit of RE innovation.

1.5. Research Hypotheses

In light of the aforementioned research objectives, this study aims to formulate and test hypotheses that clarify the intricate relationship between climate change impacts and a firm's pursuit of RE innovation. The researcher proposes several hypotheses to explore how these impacts influence a firm's pursuit of RE innovation. These hypotheses will provide the foundation for the empirical analysis, facilitating the derivation of meaningful conclusions about the factors influencing firms' behaviour following climate change impacts.

Regarding research question (RQ) 1 and to investigate the role of nature-driven impacts on a firm's pursuit of RE innovation, the following five hypotheses were developed:

Hypothesis 1a: *Following climate change-induced natural disasters, firms experience a positive change in the pursuit of RE innovation compared to the pre-disaster period.*

Hypothesis 1b: *Following climate change-induced natural disasters, firms with performance below the aspiration level will demonstrate a stronger positive change in the pursuit of RE innovation.*

Hypothesis 1c: *Following climate change-induced natural disasters, foreign multinational enterprise (MNE)'s subsidiaries will demonstrate a less significant positive change in the pursuit of RE innovation compared to domestic firms.*

Hypothesis 1d: *The effect of climate change-induced natural disasters on the pursuit of RE innovation, compared to the pre-disaster period, is moderated by natural disaster uncertainty.*

Hypothesis 1e: *The effect of climate change-induced natural disasters on the pursuit of RE innovation, compared to the pre-disaster period, is moderated by the firm's history of natural disasters.*

In examining the moderating role of market-driven impacts on a firm’s pursuit of RE innovation in the context of climate change-induced natural disasters, this study delves into the influences of three key market actors (peers, investors, and media), addressing RQ2 with three distinct hypotheses:

The first group is peers. The impact of peers’ pursuit of RE innovation on a firm's own pursuit of RE innovation is explored through the development of the following hypothesis:

Hypothesis 2a: *Increased RE innovation pursued by peers will result in a less significant positive change in the pursuit of RE innovation for firms affected by climate change-induced natural disasters.*

Second, the study of investors’ effect on a firm’s pursuit of RE innovation is focused on the role of investor sentiment by developing the following hypothesis:

Hypothesis 2b: *Higher investor sentiment will lead to a less significant positive change in the pursuit of RE innovation for firms affected by climate change-induced natural disasters.*

Lastly, media coverage and its effect on a firm’s pursuit of RE innovation are studied using the following hypothesis:

Hypothesis 2c: *Greater media coverage of a firm's contribution to climate change will result in a less significant positive change in the pursuit of RE innovation for firms affected by climate change-induced natural disasters.*

1.6. Research Design

To address the research questions and hypotheses, this study adopted a positivist approach. The positivist approach asserts that objective knowledge can be derived from factual data and figures (Helmi Alharahsheh & Oius, 2020). It focuses on establishing causal relationships to explain and predict future patterns (Neuman, 2014). In alignment with this approach, the study aims to investigate how climate change impacts related to the pursuit of RE innovation by firms, thereby aiding policy-makers in understanding and modelling firms' pursuit of RE innovation. Quantitative methodology is commonly employed to uncover truth, formulate explanatory theories, and make predictions (Getz & Page, 2016). Hence, this study employed a quantitative methodology to test the proposed hypotheses. This approach facilitates the systematic collection and analysis of numerical data, enabling the examination of relationships and patterns between variables associated with climate change impacts and the pursuit of RE innovation by firms.

To address the research questions and their corresponding hypotheses, this study builds upon the theoretical foundation of the BTOF (Cyert & March, 1963; Hoskisson et al., 2017). The BTOF has been widely utilised to explore firms' behaviour, including innovation, particularly in uncertain contexts. It provides a framework for understanding and modelling a firm's behaviour, including the pursuit of RE innovation (Chen, 2008; Gaba & Bhattacharya, 2012; Greve, 2003). The BTOF emphasises the performance-aspiration gap, which serves as a crucial motivational factor influencing a firm's inclination to take risks and pursue innovation (Chen & Miller, 2007; Cyert & March, 1963). This theory is particularly relevant as it explains how firms' behaviour following climate change-induced natural disasters can be shaped by the discrepancy between their actual performance and their aspiration levels. Firms falling below their aspiration levels tend to take riskier actions, such as pursuing RE innovation, to improve performance, while those above their aspiration levels often avoid high-risk strategies (Gaba & Bhattacharya, 2012; Hoskisson et al., 2017). Thus, the BTOF provides a robust theoretical foundation for understanding why firms adopt different approaches to RE innovation based on their performance-aspiration gap. By incorporating the threat rigidity model (Staw et al., 1981), this study builds on the BTOF to explain why firms may also exhibit conservative behaviour when confronted with significant external threats, such as climate change-induced natural disasters. This integrated theoretical framework provides a background for the firm's behaviour following environmental uncertainty and offers insights into their pursuit of RE innovation.

For testing the hypotheses, this study employed the Difference-in-Differences (DiD) model and meta-analysis. In essence, this research aims to compare the pursuit of RE innovation by firms before and after climate change-induced natural disasters. DiD is a well-established approach for studying quasi-natural experiments and assessing the impacts of exogenous shocks, such as extreme climate events, economic crises, political upheavals, or policy implementations (Belasen & Polachek, 2009; Fu et al., 2021; Yang et al., 2022). The fundamental assumption behind DiD analysis is that, in the absence of the intervention, the behaviour of both the group exposed to the intervention (treatment group) and the group not exposed to the intervention (control group) would have exhibited comparable trends over time (Stuart et al., 2014). Thus, the DiD model is particularly suited for this analysis, as it enables the researcher to evaluate the outcomes associated with the treatment group in comparison to the control group. To synthesise the results from the DiD models into coherent insights, the researcher employed a meta-analysis technique (Callaway & Sant'Anna, 2021; Deeks et al., 2019). This method offers a structured way to evaluate the cumulative effect of climate change impacts on firms' pursuit of RE innovation, providing a holistic understanding of the phenomenon.

Therefore, by integrating the DiD model to compare outcomes between the treatment and control groups, alongside utilising meta-analysis to aggregate these findings, this research methodology offers a comprehensive framework for assessing the influence of climate change impacts on the pursuit of RE innovation. Through this combined approach, the study seeks to furnish empirical evidence and deepen our understanding of how climate change impacts affect firms' pursuit of RE innovation.

1.7. Research Contributions to Knowledge, Practice, and Policy

This study makes several important contributions to the existing literature. First, it adds new insights to the discussion on green innovation, particularly focusing on RE innovation following climate change impacts. It addresses a previously overlooked area by exploring how climate change-induced natural disasters influence the pursuit of RE innovations. While RE innovation is widely acknowledged as a pivotal solution to the significant challenges brought forth by climate change (Roper & Tapinos, 2016), existing research has predominantly focused on operational strategies for reducing emissions (Zhou & Wen, 2020), with a notable lack of emphasis on how firms proactively pursue RE innovations as part of their environmental practices. Moreover, unlike most studies that look at climate risks from a national perspective, as highlighted by Huang et al. (2018), this work offers a fresh look from the viewpoint of individual firms. It moves beyond the common practice of examining the effects of a single type of natural disaster by analysing a wide variety of climatological disasters that occurred in the United States (U.S.) between 2013 and 2018. The U.S. provides a compelling context for this study due to several key factors. Primarily, despite the U.S. being among the top countries for patent grants (WIPO, 2023), there has been a decreasing trend in RE innovation patent applications over the last decade according to USPTO data, underscoring a shift that warrants further exploration. Additionally, the fluctuating political climate (Leyva-de la Hiz et al., 2019), high incidence of natural disasters, and significant carbon emissions (Friedlingstein et al., 2020) offer a dynamic backdrop for analysing the impacts on RE innovation. Furthermore, the accessibility of extensive data through North America Compustat supports comprehensive research in this setting. The period from 2013 to 2018 was selected for the empirical analysis due to its significance in reflecting recent climatic challenges and the comprehensive nature of the available data. The methodology involves a detailed examination of a four-year period surrounding each disaster—two years before and two years after—allowing for a thorough assessment of RE innovation before and after each event. The selection of these specific years is strategically important, not just for data availability, but also to include a critical evaluation period around the adoption of the Paris Agreement in 2015. This ensures the analysis covers a varied timeline that is crucial for understanding the impact of significant policy changes on corporate pursuit of RE innovation towards climate change-induced natural disasters. Through a detailed DiD analysis covering 19 different climatological disasters, this study stands out by offering a deeper and more rigorous examination than what is typically found in the field (Ren et al., 2022). This approach makes the research a significant addition to the existing literature on RE and climate change impacts.

Second, this study leverages and expands upon the BTOF and the threat rigidity model to offer a nuanced understanding of firms' behaviour following climate change impacts. Specifically, by integrating the BTOF and the threat rigidity model, the research provides a novel framework for analysing how firms' performance-aspiration gaps and their perceptions of external threats influence their pursuit of RE innovation. This research not only extends the application of the BTOF but also incorporates the threat rigidity model to examine the varied behaviours of firms following climate change-induced natural disasters. This study delves into how a variety of factors, both internal and external, influence these behaviours. Specifically, the study looks at the firm's global reach, distinguishing between MNEs and domestic firms, the degree of environmental uncertainty they face, and their previous experiences with natural disasters. This multifaceted approach offers a more comprehensive understanding of firms' behaviour following climate change impacts, highlighting how the nature of a firm and its past interactions with natural disasters shape its behaviour.

Third, this study makes a significant contribution by introducing a novel moderator, namely the ‘firm's history of natural disasters’. The purpose of this moderator is to investigate how a firm's previous encounters with natural disasters influence its pursuit of RE innovation. What sets this moderator apart is its unique measurement approach, which combines multiple variables to capture a firm's history of natural disasters. Specifically, these variables include firm age (George, 2005; Gimenez-Fernandez et al., 2020; Wagner, 2011) as well as the magnitude and frequency of natural disasters (Oetzel & Oh, 2014, 2021; Tilcsik & Marquis, 2013). The question of whether being a new firm brings about advantages or disadvantages has been a subject of interest among scholars. While some researchers, such as Gimenez-Fernandez et al. (2020), argued for the liability of newness, others have found evidence supporting the asset of newness (Wagner, 2011). Given the mixed findings concerning the relationship between firm history and innovative practices, the researcher decided to incorporate this moderator by combining firm age with country-level indicators of the magnitude and frequency of natural disasters. In other words, this study enriches the literature by integrating information about the magnitude and frequency of natural disasters that occurred during a firm's existence with its age, thus shedding light on the effect of a firm’s history in the context of climate change.

Fourth, this study provides practical insights for managers and firms navigating the challenges posed by climate change while also contributing to SDGs. By highlighting the importance of performance-aspiration gaps, global reach, and firm history in shaping the pursuit of RE innovation, managers can tailor their approaches to sustainability and resilience more effectively. Understanding how peers’ pursuit of RE innovation, investor sentiment, and media coverage influence a firm's pursuit of RE innovation following climate change-induced natural disasters empowers managers to benchmark their practices and refine their behaviour accordingly. Additionally, recognising the moderating role of natural disaster uncertainty enables firms to anticipate and respond proactively to emerging environmental risks. These insights contribute directly to SDG 7 by fostering a culture of sustainable innovation that promotes the adoption of clean energy technologies and SDG 13 by enhancing firms' resilience and adaptability to climate change impacts.

Lastly, this project offers a valuable contribution to the broader community by assisting policy-makers at various levels, ranging from local to international, in formulating effective climate actions. Given that MNEs exert significant influence on international markets and can greatly affect the actions of their domestic counterparts, policy-makers are keen to understand the behavioural patterns of MNEs and their potential reactions to environmental policies (Nippa et al., 2021a; Robertson, 2009). This research illuminates the role of market constructs in shaping the pursuit of RE innovation at the firm level, providing actionable insights for designing policies that encourage RE innovation. By aligning these policies with firms' strategic goals, policy-makers can foster an environment conducive to achieving SDG 7 and SDG 13, ultimately contributing to a more sustainable and resilient future.

1.8. Thesis Structure

The thesis is structured as follows, with each chapter serving a specific purpose in the overall research.

Chapter 1 serves as an introduction to the study, providing an overview of its key components, such as the justification for the research, objectives, research questions, and hypotheses. It also briefly discusses the research design and methodology adopted. Additionally, this chapter highlights the contributions of the study to both knowledge and practice.

Chapter 2 delves into a comprehensive review of the existing literature on RE innovation and climate change impacts. By identifying gaps in the literature, the research questions and hypotheses are formulated, leading to the development of the conceptual model.

Chapter 3 presents the research design and methodology employed in the study. It includes a detailed description of the sample, measures, and data analysis techniques used. Ethical considerations relevant to the research are also addressed within this chapter.

Chapter 4 focuses on presenting and discussing the results obtained from testing the hypotheses formulated in Chapter 1. This chapter provides a clear presentation of the empirical findings.

Chapter 5 offers a thorough discussion and interpretation of the results presented in Chapter 4. It also highlights the limitations of the study and suggests potential avenues for future research.

Chapter 6 serves as the conclusion of the study, summarising the main findings and their implications. It provides a final synthesis of the research, emphasising its significance and potential impact.

Overall, this structure ensures a logical flow of information, guiding the reader through the various components of the research and ultimately delivering a comprehensive understanding of the study's objectives, findings, and implications.

2. Chapter 2 Literature Review

2.1. Introduction

This chapter presents a review of the extant literature, covering key concepts and existing studies related to the main focus of the research. It is divided into two main parts, each addressing important aspects of the literature. The first part introduces two broad streams of literature: RE innovation and climate change impacts. Section 2.2 provides an overview of the key concepts of green innovation, with a particular emphasis on RE innovation. It explores the current understanding of RE innovation, its significance in addressing environmental concerns, and its potential benefits for firms. Section 2.3 provides a concise overview of climate change and the global dialogue surrounding it. Following this, section 2.4 delves into the effects of climate change. This section provides an understanding of the different dimensions of climate change impacts, highlighting their relevance to firms' behaviour.

The second part of this chapter, specifically section 2.5, presents the proposed model for this study. It addresses the research gaps identified in the core questions through an extensive literature review. This section is divided into two subsections, corresponding to the nature-driven impact and market-driven impact, and their effects on a firm's pursuit of RE innovation. Each subsection provides a comprehensive analysis of the literature, highlighting the relevant findings and theories related to the specific impact category.

Finally, section 2.6 serves as a summary of the chapter, providing a cohesive overview of the literature review conducted in this chapter. It summarises the main points discussed in each section and subsection, emphasising the research gaps addressed and the hypotheses derived from the literature. This summary sets the stage for the subsequent chapters, which will present the research design, methodology, results, and discussions.

2.2. Renewable Energy (RE) Innovation

Firms, societies, and nature are interconnected and rely on each other for mutual success. For a firm to thrive, it requires a healthy and supportive society that provides access to product markets, public goods, and favourable environments. Conversely, societies rely on successful firms to generate employment opportunities and create wealth for their citizens (Porter & Kramer, 2011). This interdependence has given rise to the concept of shared value, as introduced by Porter and Kramer (2006). Shared value refers to the adoption of policies and operating practices that not only enhance a company's competitiveness but also contribute to the economic and social well-being of the communities in which it operates (Porter & Kramer, 2011, p. 6).

While shareholder value maximisation has traditionally been the primary focus of firms, there is a growing recognition among some firms of the importance of shared value. This paradigm shift indicates that firms are aligning their financial objectives with social goals, acknowledging the need to create value that benefits both their shareholders and society as a whole. The shift is driven by a variety of factors: the environmental crisis threatening our ecosystem, economic inequalities exacerbated by the 2008 Great Recession, and intense calls from government officials, social activists, global investors, and corporate leaders who are pressuring firms to integrate financial performance with positive social impact (Battilana et al., 2022; Porter & Kramer, 2011).

Social goals encompass a wide range of areas and stakeholders, including environmental protection, employee well-being, poverty reduction, and more (Battilana et al., 2022). At its core, a social goal requires a company to refrain from intentionally harming its stakeholders (Battilana et al., 2022; Porter & Kramer, 2006). However, with different stakeholder groups having distinct expectations and objectives, companies adopting the shared value approach may struggle to strike a balance among these various demands (Battilana et al., 2022). Additionally, lack of trust in businesses—stemming from past corporate scandals, perceived corporate greed, and failures in corporate governance—compounds the challenge. This distrust leads stakeholders to often view companies' socially responsible actions through a lens of scepticism, associating these efforts with a sense of corporate guilt regarding societal challenges (Porter & Kramer, 2011).

As a solution, Porter and Kramer (2006) suggested that firms seek opportunities for creating shared value within their specific business and value chain, rather than engaging in generic social responsibility programmes that may not align with their core operations (Porter & Kramer, 2011). In this context, innovative practices, particularly green innovation, play a crucial role in enhancing both the financial and environmental performance of enterprises (Dai & Xue, 2022; Huang & Li, 2017; Tu & Wu, 2021). In the past, companies were often criticised for neglecting investments in environmental protection, considering them unnecessary and detrimental to their progress (Chen, 2008). However, scholars such as Porter and van der Linde (1995), Cai and Li (2018), and Tu and Wu (2021) argued in favour of environmental protection practices, highlighting that they can help companies utilise their resources more efficiently. They believed that the negative impacts of firms on the environment, such as pollution, indicate inefficiency in resource management. Therefore, pursuing innovative practices enables companies to redesign their processes, increase resource productivity, and improve their overall corporate image (Chen, 2008; Chen et al., 2006).

In particular, green innovation, which encompasses both product and process innovations with an environmental focus, has the potential to enhance a company's image and confer competitive advantages (Chen, 2008). This study specifically focuses on RE innovation, which involves the development and utilisation of non-polluting energy sources. While RE holds promise as a solution to climate change and GHG emissions, it also faces limitations (Shin et al., 2018). RE technologies require substantial upfront investments, posing financial challenges (Kim & Park, 2016; Lin & Zhu, 2019; Shin et al., 2018; Steffen, 2020; Xu & Lin, 2018). The energy sector's information costs and the high specificity of assets further hinder the development of RE (Kim & Park, 2016). The interplay between two opposing forces in the energy landscape influences RE innovation. In the short term, the prevalence of low-cost fossil fuel energy impedes progress in expensive RE technologies. However, in the long run, the urgent need to address climate change motivates firms to embrace clean energy generation (Lin & Zhu, 2019). Furthermore, according to the U.S. Energy Information Administration (EIA) Monthly Energy Review of December 2023, the United States continues to rely heavily on fossil fuels for energy production and consumption (Energy Information Administration [EIA], 2023). This slow pace of transitioning from non-renewable sources to RE is a pressing concern (Shin et al., 2018) that warrants further investigation.

Recognising the challenges and potential of RE innovation, it is crucial to explore the factors that encourage its pursuit and development. Shin et al. (2018) proposed that several driving factors contribute to RE innovation, including social and political pressures imposed by shareholders and regulators, as well as consumer attitudes. Shareholders exert social pressure on companies to be environmentally responsible, which helps shape their ethical image (Albertini, 2014; Flammer et al., 2021; Ibikunle & Steffen, 2017). Regulators, at the political level, play a role in promoting RE innovation, as seen in the example of the U.S. Environmental Protection Agency (EPA)'s 2013 emission rule that imposed limits on CO_2 emissions from new power plants (Shin et al., 2018). Consumer attitudes also play a crucial role, as they are influenced by their knowledge and beliefs regarding the environmental benefits of RE compared to conventional energy sources. Consumers who are aware of these benefits may be more willing to pay a premium for environmentally friendly products (Shin et al., 2018). Overall, these social, political, and consumer factors drive RE innovation.

In a similar vein, Xu and Lin (2018) conducted a study on the development of the RE industry in China, a country known for its high CO_2 emissions. They employed a non-linear model to examine the impact of six driving factors on RE development. These factors comprised economic growth, foreign energy dependence, fuel price, energy consumption structure, technological progress, and agricultural development. The findings of their study revealed an inverted U-shaped relationship between foreign energy dependence and agricultural progress with RE development. This suggests that as foreign energy dependence and agricultural progress increase up to a certain point, they have a positive impact on RE development, but beyond that threshold, their effect becomes negative. On the other hand, economic growth, energy consumption structure, and technological progress exhibited a positive U-shaped relationship with RE development. This implies that these factors initially have a limited impact on RE development, but as they reach a certain level, their influence becomes more pronounced. Based on these results, Xu and Lin (2018) emphasised the importance of considering these non-linear relationships when formulating policies to promote RE. Policy-makers should be aware of the thresholds and optimal levels of these driving factors in order to effectively stimulate RE development. By taking these findings into account, policy-makers can design more targeted and effective strategies to foster the growth of the RE industry in China and beyond.

Furthermore, Steffen (2020) analysed the cost of capital in RE innovation and found that it varies depending on the economic development of countries. Developing countries generally have higher average costs of capital compared to industrialised countries. Moreover, there are differences in the cost of capital among different RE technologies, with solar power generally having a lower cost compared to wind power (Steffen, 2020).

Additionally, Stucki (2019) conducted a study in Germany, Austria, and Switzerland to explore the moderating role of energy consumption on the relationship between environmental innovation and productivity. The findings revealed that the effect of environmental innovation on productivity can be influenced by different levels of energy costs. The study also highlighted the connection between a firm's willingness to invest in green innovation and its energy consumption. Specifically, companies with low and medium energy costs showed reluctance to pursue green innovation independently. In contrast, regulations played a significant role in encouraging green investment among companies with medium energy consumption, while companies with high energy costs considered regulations as an indication of resource inefficiencies. These findings shed light on the complex relationship between environmental innovation, energy consumption, and productivity, emphasising the importance of considering energy costs when implementing green initiatives (Stucki, 2019).

Previous studies have explored different facets of RE innovation within the climate change framework, yet a significant gap remains in comprehensively understanding how climate change impacts influence RE innovation. This study seeks to fill this gap by examining the effect of climate change impacts on firms' pursuit of RE innovation. In undertaking this analysis, the present research enriches the knowledge concerning how firms can adeptly manage climate change impacts and pursue RE innovation.

2.3. Climate Change and International Discussions

Climate change is defined by Fawzy et al. (2020) as 'the shift in climate patterns mainly caused by greenhouse gas emissions'. These emissions originate both from natural processes and human activities (Fawzy et al., 2020), with anthropogenic sources contributing between 47.9% and 66.6% to global GHG emissions (Yue & Gao, 2018). In response to this challenge, efforts to mitigate the impact of anthropogenic emissions have been initiated at various levels, aiming to address and curb the escalating threat of climate change effectively.

The international response to climate change was initially framed by the establishment of the UNFCCC in 1992, and its subsequent Kyoto Protocol (Howard-Grenville et al., 2014). The Kyoto Protocol, however, was critiqued for disproportionately focusing on the obligations of developed nations while overlooking the responsibilities of developing countries (Howard-Grenville et al., 2014; Kuyper, Schroeder, & Linnér, 2018). In an attempt to address this imbalance, the Copenhagen Accord was reached in 2009, which aimed to achieve a more equitable distribution of responsibilities by involving both developed and developing countries. Under the Copenhagen Accord, countries agreed to make efforts to reduce their emissions by 2020 (Howard-Grenville et al., 2014). Additionally, in 2015, the international community forged the Paris Agreement, a landmark treaty that sets forth commitments for countries to significantly cut emissions beyond 2020, representing a unified stride towards mitigating climate change impacts (Howard-Grenville et al., 2014).

At the heart of ongoing global discussions on climate change is the Conference of the Parties (COP), the annual summit that serves as the pivotal forum for negotiating and advancing comprehensive strategies to address climate change (Bernardo et al., 2021). The most recent conference, COP 28, took place in Dubai in December 2023, marking a critical juncture in international climate negotiations. The discussions at COP 28 underscored a stark reality: the current nationally determined contributions for CO_2 emission reduction are falling short of the trajectories needed to limit global warming in line with the objectives of the Paris Agreement 2015 (Jiang et al., 2024).

A focal challenge of COP 28 was the imperative to ramp up RE production as a strategy to phase out fossil fuels. The parties are committed to altering their energy portfolios by significantly boosting the production of renewable sources to fulfil the ambitions of the Paris Agreement 2015. The world leaders at COP 28 agreed to a dramatic expansion in RE, setting a goal to triple the world’s capacity for RE generation. This ambitious target reflects a global commitment to transitioning towards sustainable energy solutions and marks a significant step forward in the collective journey towards mitigating climate change (Jiang et al., 2024). This shift towards a renewable and low-carbon future emphasises the strategic importance of increasing the pursuit of RE innovation.

2.4. Climate Change Impacts

Climate change is a multifaceted challenge that encompasses a wide range of impacts. These impacts, often referred to as climate risks, pose a threat to companies as they can be caused by climate-related events (Flammer et al., 2021). The research on climate change and its impacts has garnered significant attention from scholars due to its increasing influence on human lives. For instance, the unprecedented occurrence of extremely hot weather during summer is disrupting our daily routines, highlighting the extensive reach of climate change into our everyday lives.

Different classifications have been proposed to categorise climate change impacts and risks. Tsalis and Nikolaou (2017) classified climate risks into two broad groups: direct and indirect risks. Direct risks are associated with the physical impacts of climate change, including extreme weather events and gradual changes such as rising temperatures and sea levels. For example, a firm may face damage to its physical assets due to a flood caused by climate change. Indirect risks, on the other hand, encompass reputational, regulatory, and litigation risks. Reputational risks arise from shifts in market participants' attitudes, such as consumers' preference for low-carbon products and investors' focus on environmentally responsible firms. Regulatory risks involve potential changes in climate change regulations, while litigation risks result from a firm's failure to achieve climate change projects, with the severity depending on the stringency of relevant regulations (Tsalis & Nikolaou, 2017).

In another study, Krueger et al. (2020) proposed a categorisation of climate risks into three groups: physical, regulatory, and technological climate risks. Physical risks refer to the direct impacts of climate change on physical assets, infrastructure, and ecosystems. Regulatory risks pertain to the changing legal and policy landscape surrounding climate change, including new regulations and carbon pricing mechanisms. Technological risks involve the emergence of new technologies and innovations that may disrupt existing industries and business models in the context of climate change (Krueger et al., 2020).

Zhou and Wen (2020) proposed a similar categorisation for climate change impacts, specifically focusing on carbon constraints. Carbon constraints refer to conditions related to carbon emissions that can influence firms' business strategies, operational decisions, and profitability. These constraints can be viewed from two perspectives: input and output. The input dimension relates to the requirement of carbon-based inputs for a firm's operations, while the output dimension pertains to the release of carbon-containing outputs (Busch & Hoffmann, 2007; Zhou & Wen, 2020).

Within the output dimension, which specifically addresses human-made climate change issues, Zhou and Wen (2020) conducted a systematic literature review of 116 journal articles on carbon constraints and business strategies to reduce CO_2 emissions. They categorised the output dimension of carbon constraints into three main categories: nature-driven, policy-driven, and market-driven. These categories capture the different ways in which climate change impacts and associated constraints manifest and influence firms' actions and decisions (Flammer et al., 2021; Kouloukoui et al., 2019; Sakhel, 2017; Zhou & Wen, 2020).

To explore how climate change impacts affect RE innovation at the firm level, this study adopted the classification framework proposed by Zhou and Wen (2020), with a specific focus on the output dimension of carbon constraints, addressing nature-driven and market-driven impacts. Although initially considering the policy-driven impacts of climate change on RE innovation, these aspects were excluded from the thesis due to their negligible influence on the findings. By utilising this framework, the study aims to unravel the relationship between climate change impacts and the pursuit of RE innovation at the firm level (Zhou & Wen, 2020). The importance of studying these impacts at the firm level is underscored by the significant vulnerability of firms to climate change impacts, with a substantial number of large U.S. firms having assets at high risk of extreme climate events (Ai & Gao, 2023). Investors require detailed insights into how firms are affected by climate change to accurately assess their valuations (Ai & Gao, 2023).

Despite the growing awareness of these impacts, there remains a notable gap in firm-level research (Cevik & Miryugin, 2023). Additionally, the urgent need for a transition to 100% RE systems to achieve net-zero emissions highlights the critical role of firm-level pursuit of RE innovation in this global effort (Işık, 2024). However, recent investment trends show a shift, with corporate investments in RE technologies not keeping pace with the necessary advancements required to meet global climate goals (IRENA and CPI, 2023). This shift underscores the critical need for a deeper understanding of firm-level investment in RE. Given the significant vulnerability of firms to climate disasters, the need for robust RE solutions, and the observed decrease in firm investments in RE technologies, this study aims to bridge the existing knowledge by exploring how climate change impacts influence the pursuit of RE innovation at the firm level.

Nature-driven impact, or physical risk, is directly linked to the direct consequences of climate change. This type of impact encompasses the environmental damages caused by natural disasters resulting from gradual or extreme changes in climatic conditions (Ren et al., 2022). Climate, being a complex and non-linear system, often leads to unpredictable impacts (Flammer et al., 2021; Howard-Grenville et al., 2014; Mithani, 2020). Climate events and changes can have both direct and indirect negative effects on a firm's profitability. These impacts serve as a catalyst for technological advancements aimed at reducing carbon emissions and mitigating the adverse effects of climate change (Ren et al., 2022). Moreover, the increased frequency of extreme climate events serves as a clear warning to firms, urging them to prioritise environmental performance improvements and take measures to reduce their carbon footprint (Ren et al., 2022).

Research on firm responses to such nature-driven impacts has highlighted varying effects on innovation and risk-taking behaviour. While some studies suggest that climate change-induced natural disasters prompt firms to conserve resources and rely on existing capabilities due to the perceived rigidity caused by environmental threats (Hoskisson et al., 2017; Staw et al., 1981), others show that these events can act as a catalyst for firms to enhance environmental performance and adapt more innovative practices (Ren et al., 2022). This divergence underscores the complexity of firms’ behaviour in the face of environmental risks. Scholars like Huang et al. (2018) and Marshall et al. (2021) have further explored how financial decisions and green investments vary across industries and disaster contexts. By applying the BTOF, this study seeks to examine how climate change-induced natural disasters influence the pursuit of RE innovation by firms, with a focus on firms' behaviour when their performance falls short of aspirations.

Market-driven impacts encompass changes in consumer attitudes and financial markets driven by an increased awareness of the urgency and importance of climate change (Sakhel, 2017; Zhou & Wen, 2020). Market-driven impacts are characterised by shifts in consumer behaviour and investor preferences, leading to changes in the demand for products and services. Consumers are increasingly favouring environmentally friendly options, and in parallel, investors are actively divesting from carbon-intensive firms and redirecting their funds towards green investments (Sakhel, 2017). This movement has the potential to negatively affect firms with high environmental impacts. As consumer preferences evolve, there may be a decline in demand for products and services offered by environmentally unfriendly firms, resulting in reduced market share. Additionally, these firms may experience a decrease in the value of their shares as investors demonstrate a growing preference for environmentally responsible businesses (Sakhel, 2017). The change in consumer attitudes towards climate change carries significant implications across various sectors, with global initiatives such as the Paris Agreement 2015 playing a pivotal role in driving this shift. Signed by over 195 countries committed to reducing carbon emissions and limiting global warming to below 2°C above preindustrial levels, the Paris Agreement 2015 has influenced market participants, particularly investors, to adjust their expectations accordingly (Bolton & Kacperczyk, 2020; Flammer et al., 2021).

While climate change is a non-market force, its impacts reverberate throughout markets and have led to the emergence of green products and services (Pinkse & Kolk, 2012). One notable example is the ongoing transition in the energy sector, where there is a growing consensus globally that green energy resources should replace fossil fuels to mitigate the climate change impacts (Nippa et al., 2021b). This shift in mindset is transforming behaviour in capital markets, redirecting investments from polluting industries towards environmentally friendly technologies and firms.

As this shift continues to reshape markets, research has identified a range of market-driven forces influencing firms' environmental behaviours. Stakeholder pressures, such as evolving consumer preferences and investor demands for sustainable investments, are playing an increasingly significant role in shaping market dynamics (Albertini, 2014; Sakhel, 2017). However, while consumer behaviour and divestment from carbon-intensive firms drive change, some studies argue that market pressures alone may not be as influential as regulatory forces in promoting green innovation (Kouloukoui et al., 2018; Ren et al., 2022). The role of stakeholders, particularly in high-polluting industries, remains a contested area, as firms may sometimes prioritise managing external perceptions over implementing genuine environmental improvements (Sprengel & Busch, 2011). However, the importance of transparency and climate risk disclosures continues to grow, aligning firms with the evolving expectations of markets (Kouloukoui et al., 2019). Accordingly, this study examines how market-driven factors—such as peer innovation, investor sentiment, and media coverage—affect the pursuit of RE innovation following climate change-induced natural disasters, providing deeper insights into the firms’ responses to these pressures.

2.5. A Model for RE Innovation Following Climate Change Impacts

As the research on climate risks continues to expand, the incorporation of climate risk into firms' decision-making processes poses significant challenges (Krueger et al., 2020). The complexity of the climate system and our limitations in accurately projecting future climate scenarios contribute to the uncertainties involved in making decisions in the context of climate change (Howard-Grenville et al., 2014). These uncertainties create additional complexity and difficulties in effectively navigating the climate change impacts on business operations and behaviour.

There is no one-size-fits-all approach for businesses when it comes to addressing the costs and risks associated with climate change along their value chains (Porter & Reinhardt, 2007). Each business must carefully evaluate its exposure to climate change and assess the level of uncertainty it faces in order to determine the most appropriate response. In other words, the appropriate behaviour should be chosen based on the specific uncertainties imposed by climate change (Kolk & Pinkse, 2005; Porter & Reinhardt, 2007).

The study conducted by Huang et al. (2018) delved into the influence of climate risk—a factor evaluated at the country level—on corporate performance. Their research revealed that companies in countries facing heightened climate risks often endure diminished economic performance and increased earnings volatility, underscoring the detrimental effects of extreme weather events on business operations. However, it is noteworthy that their analysis was based on the Global Climate Risk Index (CRI), which may not accurately reflect the diverse experiences of firms within the same country due to its broad national focus. To overcome this limitation and provide a more detailed perspective, this study shifts the focus to a firm-level examination of climate change impacts. This approach allows for a more granular analysis, differentiating between nature-driven and market-driven impacts of climate change. This distinction is crucial for understanding the multifaceted nature of climate change and its varied implications on businesses at different regional scales.

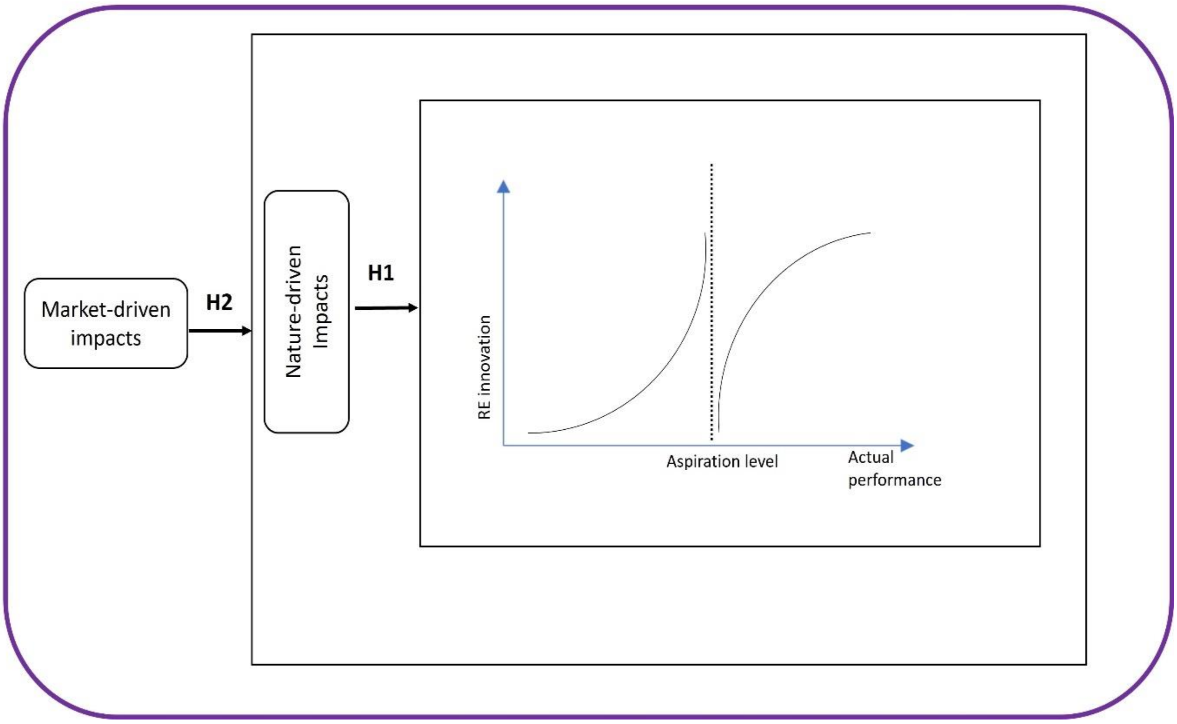
Kouloukoui et al. (2019) conducted a study focusing on the behaviour of the world's largest GHG emitting companies in response to climate risk and how they manage their exposure to such risks. By analysing the Carbon Disclosure Project (CDP) questionnaire, the researchers discovered that regulation emerges as the most influential factor in stimulating companies to adopt strategies that combat climate change, particularly among the largest global polluting companies. This suggests that the influence of physical and market risks alone may be insufficient to prompt companies to undertake climate change-related practices (Kouloukoui et al., 2019). However, this finding contradicts the argument made by Sakhel (2017), who found that physical risks significantly affect European firms to the extent that they perceive physical risks as more significant than market risks (Kouloukoui et al., 2019).

Given the contradictory findings in the existing literature, there is still limited understanding regarding how climate change impacts influence firms' pursuit of RE innovation. This study aims to bridge this gap by differentiating climate change impacts based on the classification proposed by Zhou and Wen (2020). It seeks to explore not only the direct influence of climate change-induced natural disasters on firms' pursuit of RE innovation but also to address the moderating role of market-driven impacts within this dynamic. To address this gap, this study draws on the BTOF and the threat rigidity model, which provide nuanced frameworks for understanding how firms respond to external pressures such as climate change-induced natural disasters. Unlike traditional economic theories, such as agency theory, which view firms as purely rational and profit-maximising entities, BTOF suggests that firms operate as goal-oriented organisations composed of individuals and groups pursuing collective objectives (Chen & Miller, 2007; Cyert & March, 1963). This theory has been instrumental in explaining firms' behaviour under uncertainty, particularly in the context of innovation (Greve, 2003; Gaba & Bhattacharya, 2012). A pivotal concept in the BTOF is the aspiration level. Aspiration levels refer to the benchmarks firms set for performance based on past achievements and/or those of their industry peers (Chen & Miller, 2007; Cyert & March, 1963; Hoskisson et al., 2017). This concept is vital for understanding how firms assess their performance relative to these benchmarks, influencing their behaviour. Specifically, the gap between a firm's actual performance and its aspiration level acts as a crucial motivator for strategic decision-making. It determines whether a firm will pursue risk-taking behaviours or opt for a more conservative approach following environmental pressures and changes (Gaba & Bhattacharya, 2012; Hoskisson et al., 2017). Firms that experience a shortfall in performance relative to their aspirations are more likely to embrace risky decisions such as green innovations to address these external challenges and enhance their competitive position (Bettinazzi et al., 2020; Dong et al., 2021).

Additionally, according to the threat rigidity model, when firms perceive climate change-induced natural disasters as a significant threat, they may adopt more rigid, conservative strategies, prioritising survival over innovation (Staw et al., 1981). This response can lead to reduced risk-taking and a tendency to rely on established practices rather than pursuing RE innovation. By integrating the threat rigidity model, this research examines whether or not firms exhibit more conservative behaviour in their pursuit of RE innovation when faced with climate change impact as a perceived threat.

Incorporating the BTOF and the threat rigidity model, this study examines how nature-driven impacts, alongside the moderating effect of market forces and firms' aspiration levels, shape the pursuit of RE innovation. A conceptual model that visualises these nuanced interactions is showcased in Figure 4, serving as a roadmap for the analysis.

Figure 4 The Conceptual Model



Source: Developed by the author

2.5.1. Nature-driven Impact and RE Innovation

The characteristics of climate change-induced natural disasters align with the concept of threats, defined as environmental events that have an immediate adverse impact and prompt firms to exhibit a sense of inability to act or initiate novel actions (Staw et al., 1981). Research suggests that this perceived inability, also known as rigidity, can lead to a reduced willingness to pursue risky actions (Hoskisson et al., 2017) and may cause firms to rely on prior knowledge to conserve resources rather than pursue innovative actions (Staw et al., 1981). These findings are consistent with the study by Huang et al. (2018), which revealed that firms operating in environments with higher climate risk tend to hold more cash, pay lower dividends, and rely on long-term borrowing due to concerns about liquidity in the event of extreme climate disasters. The study also demonstrated that different industries within a single country absorb the effects of climate risk in varying ways (Huang et al., 2018).

However, contrasting findings have been reported by Ren et al. (2022), who argued that extreme climate events can prompt firms to increase their production following climate events, ensuring stable performance. Additionally, firms operating in heavily polluting industries that are subject to strict environmental regulations may reduce their carbon footprint following climate events (Ren et al., 2022). Another study by Marshall et al. (2021) investigated the inflow of funds into U.S. mutual funds with an environmental focus following the occurrence of natural disasters. Their findings indicated that inflows into green funds are significantly higher during the months when natural disasters take place, and the proportion of green funds relative to total inflows is higher during those specific months. This relationship is particularly pronounced for disasters associated with greater asset damage (Marshall et al., 2021).

Additionally, Li et al. (2023) and Ma et al. (2023) investigated the relationship between natural disasters and sustainable development, albeit with different focuses and datasets. Li et al. (2023) analysed data from Bangladesh over a 37-year period (1985-2021), discovering that natural disasters have both short-term and long-term positive effects on the sustainable development index. In a similar vein, Ma et al. (2023) explored the impact of natural disasters on regional sustainable development, specifically examining how these events catalyse the transition from traditional industrial innovation to green innovation. Using panel data from OECD countries from 1985 to 2018, they constructed a two-way fixed effects model and found that natural disasters indeed encourage a shift towards green innovation, thereby fostering sustainable development.

In addressing the divergent findings in existing literature, this research leans on the BTOF theory to present a nuanced argument. Central to this theory is the notion of the performance-aspiration gap, rooted in the seminal works of Cyert and March (1963) and further elucidated by scholars such as Shinkle (2012) and Gaba and Bhattacharya (2012). This concept posits that firms set an aspiration level acting as a benchmark for evaluating their performance and shaping their risk-taking behaviours. Firms measure their actual performance against this benchmark and adjust their risk propensity based on the degree of gap (Chen & Miller, 2007; Cyert & March, 1963; Gaba & Bhattacharya, 2012; Hoskisson et al., 2017). Those falling short of their aspirations are inclined to pursue riskier strategies to boost performance, while those exceeding their aspirations tend to be more risk-averse.

The BTOF provides a robust framework for understanding the antecedents of green innovation, particularly RE innovation. This theory emphasises how firms adjust their behaviour following external environmental pressures and opportunities (Yang & Chen, 2024). Following climate change-induced natural disasters, firms often find their aspiration levels threatened or not achieved due to increased operational and environmental challenges. While such disasters are perceived as existential threats, they also create unique opportunities for firms to adapt and innovate following these new challenges (Mithani et al., 2021). This discrepancy between current performance and aspiration levels compels firms to innovate, seeking sustainable solutions that not only address these gaps but also enhance their competitive standing and ensure survival. Such strategic adaptations are particularly evident in firms' investment behaviour, where those falling short of their aspirations are more likely to increase investments in sustainability innovations (Bettinazzi et al., 2020; Dong et al., 2021). Building on this theoretical framework, the study hypothesises that the occurrence of climate change-induced natural disasters triggers a shift in firms’ pursuit of RE innovation. It further proposes that firms whose performance is below their aspiration level will exhibit a more significant positive change in firms’ pursuit of RE innovation post-disaster. This hypothesis reflects the BTOF's emphasis on firms’ behaviour, particularly how performance relative to aspirations influences behaviour under environmental uncertainties and challenges. Through this lens, the study aims to unravel the complexities of how firms pursue RE innovation following the dynamic pressures of environmental changes.

Hypothesis 1a: *Following climate change-induced natural disasters, firms experience a positive change in the pursuit of RE innovation compared to the pre-disaster period.*

Hypothesis 1b: *Following climate change-induced natural disasters, firms with performance below the aspiration level will demonstrate a stronger positive change in the pursuit of RE innovation.*

2.5.1.1. Foreign MNEs' Subsidiaries versus Domestic Firms

By examining firm-level behaviour, this study highlights the significance of foreign MNEs' subsidiaries as a distinct category of firms operating across various countries, each with its unique vulnerabilities to climate change impacts. Engaging in business activities in foreign countries entails additional costs arising from unfamiliarity with the cultural, economic, and political characteristics of the host countries. These costs associated with operating in foreign markets are collectively known as the liability of foreignness (LOF). LOF stems from the spatial distance between the home and host countries, the unfamiliarity of the foreign firm, as well as specific restrictions imposed by both the host and home country environments (Zaheer, 1995; Zaheer & Mosakowski, 1997). Consequently, LOF can result in a competitive disadvantage for MNEs (Baik et al., 2013; Zaheer, 1995; Zaheer & Mosakowski, 1997).

However, MNEs possess certain characteristics such as multinationality, foreignness, institutional ambiguity, and knowledge transfer that can be leveraged as competitive advantages over domestic firms (Regnér & Edman, 2014). Thus, the foreignness of MNEs' subsidiaries in host countries can act as a double-edged sword. On the one hand, it may imply lower profitability for foreign MNEs' subsidiaries in comparison to local firms due to their unfamiliarity with the market (Mithani, 2017). On the other hand, it can provide advantages due to the social position of foreign MNEs' subsidiaries compared to domestic firms (Regnér & Edman, 2014).

Foreign MNEs' subsidiaries face more complex challenges in the context of climate change compared to domestic firms. They not only need to determine whether pursuing a green practice will provide them with a competitive advantage, but they also need to navigate the variations in environmental regulations across the countries in which they operate. In essence, MNEs must develop a competitive advantage that is simultaneously tailored to the specific requirements of each country and aligned with their own firm-specific goals (Kolk & Pinkse, 2008). Furthermore, MNEs are subject to heightened pressure from a broader range of stakeholders due to their international presence. To alleviate this pressure and enhance their reputation, MNEs may voluntarily pursue socially responsible investments. Such investments demonstrate their commitment to addressing environmental concerns and contribute positively to the firm's overall reputation (Najah et al., 2016).

While MNEs play a crucial role in climate change, there remains a gap in the literature when it comes to modelling their behaviour. Existing studies present two contrasting scenarios regarding MNEs' environmental performance. The first scenario portrays MNEs as significant contributors to emissions, as they tend to shift their operations to pollution havens or countries with less stringent regulations, a phenomenon referred to as the ‘pollution haven effect’ (Aragón-Correa et al., 2016; Levinson & Taylor, 2008; Li & Zhou, 2017; Nippa et al., 2021b; Porter & Reinhardt, 2007). However, it is important to note that relocating operations may not be a feasible strategy for all MNEs, especially for capital-intensive industries where environmental costs represent a relatively small portion of overall costs (Candau & Dienesch, 2017). Additionally, some MNEs may attempt to influence regulations in their favour through their political power (Child & Tsai, 2005; Nippa et al., 2021b). As a result, MNEs may appear to have better environmental disclosure and image compared to domestic firms, yet their actual environmental performance might be worse (Aragón-Correa et al., 2016).

In the second scenario, MNEs are viewed as proactive agents that embrace innovative green initiatives and actively contribute to mitigating climate change, driven by their pursuit of firm-specific advantages (Nippa et al., 2021b). They may even demonstrate superior carbon performance compared to domestic firms when faced with climate actions (Nippa et al., 2021b). However, there remains a dearth of comprehensive studies that provide a holistic model for understanding MNEs' behaviour following climate change impacts (Backman et al., 2017; Mithani, 2017; Nippa et al., 2021b). Furthermore, while the literature has explored the subsidy argument as a mechanism for foreign MNEs’ subsidiaries to leverage innovations sourced outside the host country for their generic innovative practices (Un, 2011, 2016), this argument may not apply universally to RE innovation, as the effects of climate change impacts can vary across different countries. Therefore, innovation spillovers from the parent company or other subsidiaries located outside the host country may not be as effective in the context of RE innovation.

Sofka et al. (2022) explored the behaviour of foreign MNEs' subsidiaries in Germany compared to domestic firms regarding innovation activities triggered by host-country research and development (R&D) subsidies. Utilising longitudinal data on 5,266 firms, the findings revealed that foreign MNEs' subsidiaries respond more to R&D subsidies than domestic companies, both in terms of increased R&D investment and enhanced innovation outcomes. Further, Amendolagine et al. (2023) examined the role of MNEs in advancing green innovation capabilities through foreign direct investments (FDIs) in RE technologies, comparing subsidiaries' innovation outputs against domestic companies. Focusing on a dataset of 1,055 green FDIs from 2003 to 2015, the findings revealed that foreign MNEs' subsidiaries outperform domestic firms in green patenting, particularly in middle-income countries and sectors with low tradability and tacit knowledge such as wind energy. The impact of green FDIs varies by the host country's innovative capacity and the investment's nature. Similarly, Wang et al. (2023) investigated the eco-innovation impacts of FDI by MNEs' subsidiaries in emerging economies, focusing on whether foreign MNEs' subsidiaries surpass domestic firms in eco-innovation. Utilising data from China, the study revealed that foreign MNEs' subsidiaries are more eco-innovative than domestic firms.

Additionally, De Marchi et al. (2022) examined the role of foreign MNEs' subsidiaries in driving green innovation compared to domestic firms. The research used data from 39,000 manufacturing firms across 14 European countries, exploring whether foreign MNEs' subsidiaries, with their diverse resources and intra-MNE knowledge flows, outperform domestic firms in introducing green innovations. The findings suggested that subsidiaries do indeed lead in green innovation, particularly when they engage in both intra-MNE and external cooperative efforts for innovation.

However, Zhou et al. (2023) argued that intra-MNE knowledge transfer does not necessarily ensure that subsidiaries will develop local innovation capabilities. Further, Almodóvar and Nguyen (2022) explored product innovation in domestic firms versus foreign MNEs' subsidiaries, highlighting the competitive dynamics and innovation strategies within local and international contexts. Utilising data from Spanish manufacturing firms from 2006 to 2016, they found that external knowledge sources significantly boost domestic firms' innovation output, allowing them to compete effectively with foreign subsidiaries. Despite foreign MNEs' subsidiaries potentially benefiting from global networks and parent company resources, domestic firms play a crucial role in economic growth and innovation within their home countries.

Given the mixed findings regarding the behaviour of foreign MNEs' subsidiaries versus domestic firms following climate change impacts, this study aims to differentiate between foreign MNEs' subsidiaries and domestic firms in analysing the relationship between nature-driven impacts and pursuit of RE innovation, contributing to a more comprehensive understanding of their respective behaviour.

Hypothesis 1c: *Following climate change-induced natural disasters, foreign MNEs' subsidiaries will demonstrate a less significant positive change in the pursuit of RE innovation compared to domestic firms.*

2.5.1.2. Natural Disaster Uncertainty

Research on climate change and its implications for human lives has garnered significant attention. These studies have utilised estimation techniques to illustrate how climate change could shape the future, yet these estimations are plagued by the inherent uncertainties associated with climate change (IPCC, 2014). Uncertainty, as defined by Miller (1993, p. 694), refers to the unpredictability of environmental or organisational variables that affect corporate performance. Often referred to as 'novel risk', uncertainty is characterised by its complex, ambiguous, and unfamiliar nature. Due to its qualitative essence, uncertainty is challenging, if not impossible, to quantify (Drobetz et al., 2018). To navigate this challenge, firms often attempt to translate uncertainty into more familiar risks and then take corresponding action, as the expected utility framework falls short in effectively measuring it (Hardy & Maguire, 2020). The IPCC (2014) has underscored that the true challenge in addressing climate change lies in making high-quality decisions amidst uncertainty.

The uncertainty associated with climate change impacts arises from the intricate nature of the climatic system (Kolk & Pinkse, 2008). Furthermore, the inability to effectively manage its impacts has intensified the severity of this uncertainty (Berger et al., 2017). The natural environment, characterised by its complexity, introduces significant levels of uncertainty into strategic decision-making processes, as the natural variability of nature stands as a primary source of such uncertainty (Dastagir, 2015). Given that the occurrence of natural disasters profoundly influences managers' perception of risk (Huang et al., 2022), this study addresses the inherent uncertainty embedded in climate change-induced disasters and their impact on RE innovation. The role of uncertainty in climate change impacts has largely been overlooked in the existing literature (Dunz et al., 2021; Fabrizi et al., 2018; Kesidou & Demirel, 2012; Kouloukoui et al., 2019; Marshall et al., 2021; Ren et al., 2022; Tsalis & Nikolaou, 2017; Zhou & Wen, 2020). Recognising this gap, the present study seeks to address this limitation by incorporating the inherent uncertainty associated with climate change-induced natural disasters.

Hypothesis 1d: *The effect of climate change-induced natural disasters on the pursuit of RE innovation, compared to the pre-disaster period, is moderated by natural disaster uncertainty.*

2.5.1.3. Firm’s History of Natural Disasters

One significant implication of novelty in this study is the introduction of a new moderator: the firm's history of natural disasters. Uncertainty is a critical aspect of climate change and, recognising its importance, Augustine et al. (2019) proposed a fresh perspective on envisioning the future. They made a distinction between the near future and the distant future, with the latter being associated with ambiguity and aligning with Knightian Uncertainty. The authors argued that certain future-related issues, such as grand challenges, extend beyond the near future and necessitate an understanding of processes in the distant future. Unlike the near future, the concept of the distant future assumes a discontinuity between the present and the future, providing researchers with a more comprehensive lens to observe various phenomena.

However, contradicting the Augustine et al. (2019) theory of the distant future and its discontinuity with the present, Raynard et al. (2020) based their study on temporal continuity. They demonstrated that what initially seemed like a revolutionary strategy was rooted in the past. Since the challenges associated with climate change are mostly anthropogenic (IPCC, 2014) and have their origins in the past and present, it is impossible to separate the causes and effects through temporal discontinuity. Future events, even those in the distant future, need to be analysed in conjunction with the past (Oetzel & Oh, 2021).

Predictions suggest that climate change-induced natural disasters are more likely to occur in the future, with greater frequency and severity (Piperopoulos et al., 2023; Truong et al., 2018). Consistent with the principle of temporal continuity, firms' risk attitudes are influenced by their past performance (Imas, 2016). Temporal continuity has also been a fundamental assumption underlying the BTOF, emphasising the significance of firms' past experiences rather than their future expectations (Lant & Shapira, 2008). Consequently, past experiences are expected to guide firms in strategising for the future.

Furthermore, it is important to consider that younger firms in the market, with lower levels of experience, may exhibit different behaviours compared to more established ones, primarily due to the liability of newness (George, 2005). The liability of newness can be understood as the time required to learn the most efficient ways of addressing internal and external challenges (Gimenez-Fernandez et al., 2020). In other words, age is recognised as a crucial factor in a firm's ability to effectively utilise its resources for innovation (George, 2005).

Conversely, older firms may demonstrate poorer environmental performance compared to their younger counterparts. This is attributed to the need for reinvestment in order to update existing facilities, which incurs significant costs. In contrast, younger firms possess greater flexibility to invest in modern technologies that align with environmental requirements (Wagner, 2011).

Building upon these contrasting findings, this study brings attention to the significance of firms' experience with climate change impacts in relation to the effectiveness of their RE innovation. It achieves this by integrating the concept of firm age with the occurrence of climate change-induced natural disasters throughout a firm's existence. However, the existing literature provides limited insights into how to measure a firm's history of natural disasters. Oetzel and Oh (2021) have explored organisational experience with natural disasters by utilising the number of natural disasters that occurred in a country during a firm's tenure in its specific location as a proxy for organisational experience. While this measure has been employed in extant research (Oetzel & Oh, 2014, 2021), it fails to capture the complete scope of organisational experience as it does not differentiate between disasters with varying severity. Additionally, given that this study specifically focuses on the nature-driven impacts of climate change, relying solely on the number of general natural disasters could lead to misleading conclusions.

Firm age signifies the presence of a company in a market and the accumulation of experiences gained during that period. The accumulation of experience in dealing with climate change-induced disasters relies on both the magnitude and frequency of these destructive events. The magnitude of a natural disaster indicates the extent of the economic damage it has caused (Tilcsik & Marquis, 2013). Meanwhile, the frequency of disasters is determined by the total number of natural disasters that have occurred in the location where a firm operates (Oetzel & Oh, 2014, 2021).

Hypothesis 1e: *The effect of climate change-induced natural disasters on the pursuit of RE innovation, compared to the pre-disaster period, is moderated by a firm's history of natural disasters.*

2.5.2. Market-driven Impacts and RE Innovation

Stakeholder pressures are recognised as one of the key drivers of green practices within organisations (Bansal & Roth, 2000). These stakeholders encompass a wide range of entities, including local communities, environmental activist groups, and even nature itself. The growing significance of climate change impacts has captured the attention of various stakeholders in the market, leading to increased pressures on firms, especially those with a higher environmental impact (Albertini, 2014). Such pressures originate from diverse stakeholder groups, including customers, employees, suppliers, and local public agencies (Eiadat et al., 2008). Firms, following these pressures, allocate varying amounts of resources to transition towards sustainability (Sadovnikova & Pujari, 2017). Consequently, firms adopt different strategies along a spectrum ranging from non-compliance to proactivity (Albertini, 2014). The varying levels of stakeholder pressure contribute to the pursuit and implementation of green practices within organisations.

Contrary to popular belief, some scholars question the significance of market-driven impacts in promoting green innovation. According to their viewpoint, firms are not as susceptible to market risks as they are to regulatory risks (Ren et al., 2022; Sakhel, 2017). In support of this, the study by Kouloukoui et al. (2018) revealed that highly polluting companies do not perceive climate risk any differently from other firms and have not implemented additional strategies to combat climate change (Kouloukoui et al., 2019).

Another perspective, as highlighted by Eiadat et al. (2008), revolves around the role of various environmental forces in driving green innovation. These forces include stakeholders' pressures, managerial environmental concerns, and government environmental policies. Eiadat et al. (2008) investigated the influence of stakeholder pressures from customers, employees, suppliers, and local public agencies on green innovation through a survey-based approach. Surprisingly, their findings showed no significant relationship between the environmental pressures perceived by stakeholders and the pursuit of green innovation.

Furthermore, Kouloukoui et al. (2018) argued that market risk currently lacks the strength to effectively drive environmental practices. To meet stakeholders' expectations regarding climate change, one strategy that has gained traction is climate risk disclosure (Kouloukoui et al., 2018). Similarly, Sprengel and Busch (2011) conducted a study to explore the influence of stakeholders' pressure on firms' behaviour following climate change impacts. Surprisingly, their findings revealed that the most crucial factor determining a firm's behaviour following climate change impacts is its level of pollution and emission intensity, rather than the pressures exerted by stakeholders (Sprengel & Busch, 2011). In light of stakeholders' demands to reduce GHG emissions, firms may not always pursue strategies aimed at actual emission reduction. Instead, they may opt for strategies focused on managing the pressure itself, such as engaging in political lobbying (Sprengel & Busch, 2011).

Given the divergent findings in the literature and the rising frequency and severity of climate change-induced natural disasters (Piperopoulos et al., 2023; Zhao et al., 2022), which inevitably affect the market performance of RE (Sinha et al., 2024), a notable gap emerges. This gap concerns the exploration of market-driven impacts of climate change amidst such disasters. To bridge this gap, this study focuses on unravelling the influence of market-driven factors, including peers’ pursuit of RE innovation, investor sentiment, and media coverage, on the pursuit of RE innovation following climate change-induced natural disasters. This investigation aims to illuminate the critical role these market-driven factors play in pursuing RE innovation, thereby contributing to a deeper understanding of their importance in the context of climate change.

2.5.2.1. Peers’ Pursuit of RE Innovation and RE Innovation by Focal Firm

In this section, the researcher emphasises the significance of peers as stakeholders in influencing a firm's pursuit of RE innovation. Huang et al. (2022) emphasised the role of peer competition in R&D as a significant channel for improving green innovation quality. Leading firms are driven to sustain their competitive advantage through high-quality green innovation. Conversely, emerging firms, constrained by R&D budgets, must transition from low to high-quality green innovation to remain viable in the long-term market competition (Huang et al., 2022). Dai et al. (2015) asserted that competition and competitive forces play a crucial role in driving green innovation. In other words, mimetic pressure is a key driver for green innovation (Xu et al., 2023). Firms typically keep a close eye on the actions of their competitors and react accordingly (Hua-Hung et al., 2015; Zhao et al., 2021). When a competitor pursues environmental practices, it creates pressure on the focal firm within the same industry to respond. This prompts the focal firm to evaluate its current environmental responsibilities and decide whether to implement additional practices (Hua-Hung et al., 2015; Zhao et al., 2021). According to institutional theory, firms tend to imitate peers when facing external pressures (Husted et al., 2016).

In order to maintain their competitive advantage and respond to peers' environmental practices, firms are likely to imitate market leaders (Hua-Hung et al., 2015). However, it is still unclear how this response is translated into meaningful improvements in green practices (Zhao et al., 2021). Weigelt and Shittu (2016) found that peers’ investment decisions can influence a firm's investment in clean energy sources such as waste-to-energy, wind, and solar power. In the absence of regulatory policies, firms closely monitor their peers' investment decisions. Similarly, Hua-Hung et al. (2015) conducted a questionnaire survey among managers of manufacturing and service firms in Taiwan, revealing that competitive pressure has a positive and significant effect on the pursuit of green innovation. Furthermore, Dai et al. (2015) proposed that firms pursue environmental practices in response to competitive behaviour within the market. They demonstrated how a firm develops a green supply chain as a response to peers' green innovation practices. In a competitive market, the competition among firms serves as a driver for green innovation, particularly when customers are inclined to switch firms based on their environmental performance (Dai et al., 2015; Yalabik & Fairchild, 2011).

However, from another perspective, Mbanyele et al. (2023) investigated how peers' short-term stock market performance influences firms' green innovation policies, particularly the transition to low-carbon technologies. Analysing U.S. companies from 1988–2015, they found that higher peer performance leads to a reduction in green innovation output and quality. Firms are seen to cut R&D expenses and manipulate short-term performance to meet analyst forecasts.

Reflecting on the mixed findings in the literature regarding the influence of peers' pursuit of RE innovation on firms, a research gap emerges, particularly when considering the context of firms affected by climate change-induced natural disasters. Previous research fails to clarify whether and how competition influences the widespread shift to low-carbon technologies such as RE innovation (Mbanyele et al., 2023). Additionally, the extent to which these findings can be extrapolated to situations where firms are navigating the aftermath of climate change-induced disasters is not clearly understood.

This gap is particularly pertinent given that the response to peers' pursuit of RE innovation in the context of climate change-induced natural disasters might involve unique strategic considerations, as suggested by Zhao et al. (2021) and Husted et al. (2016). The pressures and uncertainties arising from such disasters could alter the traditional competitive landscape, thus affecting how firms behave in response to their peers' pursuit of RE innovations. The current literature does not adequately address whether the competitive response in these situations leads to a significant positive change in the pursuit of RE innovation, especially when firms are grappling with the direct and indirect impacts of climate change-induced natural disasters. This research gap underscores the need for a focused investigation into how the competitive dynamics around RE innovation evolve in the context of environmental crises, which is crucial for understanding the broader implications of competitive pressures on sustainable innovation during times of increased environmental uncertainty.

Hypothesis 2a: *Increased RE innovation pursued by peers will result in a less significant positive change in the pursuit of RE innovation for firms affected by climate change-induced natural disasters.*

2.5.2.2. Investor Sentiment and RE Innovation

Among the various stakeholder groups, investors stand out as a particularly influential cohort. Recognising the significance of stakeholder theory, it becomes imperative to examine the behaviour of investors and their role in shaping management's decision-making processes (Cheong et al., 2017). Consequently, this study aims to investigate the impact of investor sentiment as a means to gain insight into the expectations held by investors in the market and how these expectations might influence firms' pursuit of RE innovation following climate change-induced natural disasters. By analysing investor sentiment, this study seeks to provide valuable insights into the dynamics between investors and the pursuit of RE innovation by firms.

Sentiment, as a concept, refers to an individual's psychological state, which can be either positive or negative (Sun et al., 2022). It plays a crucial role in shaping investment decisions (Reis & Pinho, 2021). Investor sentiment encompasses both market sentiment, which reflects the collective sentiment of investors, and individual sentiment, which pertains to the sentiments held by individual investors (He, 2022). It captures the expectations investors have regarding returns and their beliefs about market performance (Yang & Wu, 2011).

Investors tend to swiftly adjust their investment decisions based on news reports, which can have a short-term impact on market returns. However, in the long run, the effect of sentiment is counterbalanced by traditional fundamentals (Song et al., 2019). This stands in contrast to the efficient market hypothesis, which asserts that stock prices reflect all past and present information. Wang et al. (2021) argued that media news, particularly when related to macroeconomic conditions, corporate announcements, and technological innovations, can significantly influence investor sentiment. When investors pay attention to media news, sentiment can shape trading volume, stock prices, and stock returns (Song et al., 2019; Wang et al., 2021).

In support of this, Wang et al. (2021) provided evidence that environmental news has a significant impact on the stock returns of Chinese companies operating in green industries, with investor sentiment partially mediating this relationship. Another study conducted by He (2022) examined the effect of investor sentiment on the time-varying risk-return trade-off in the U.S. stock market. The findings revealed that individual sentiment, as opposed to market sentiment, has a significant and negative impact on the risk-return trade-off. Furthermore, individual sentiment is found to exert a stronger effect compared to market sentiment (He, 2022).

Investor sentiment plays a crucial role in distinguishing firms that actively embrace corporate social responsibility (CSR) practices from those who adopt them merely in response to investor pressure (Cheong et al., 2017). Naughton et al. (2019) conducted a study to explore the influence of investor sentiment on a firm's motivation to engage in CSR practices. Their findings indicated that firms are more likely to increase their commitment to CSR practices in response to positive investor sentiment. Essentially, investor sentiment acts as a driving force in stimulating CSR practices (Naughton et al., 2019).

Azevedo et al. (2021) further argued that both CSR and corporate environmental responsibility (CER) are significantly affected by investor sentiment in the short term. However, following periods characterised by low (high) investor sentiment, firms with higher CSR or CER tend to earn higher (lower) expected returns in the subsequent period (Azevedo et al., 2021). Moreover, Cheong et al. (2017), in a multi-country analysis involving a sample of 3000 firms, highlighted investor sentiment as a prominent driver for firms to implement CSR practices. Their research demonstrated that across different countries, negative investor sentiment and bearish sentiments in the preceding year can motivate firms to enhance their CSR efforts (Cheong et al., 2017). Additionally, Huang et al. (2023) examined the influence of investor sentiment on fossil fuel consumption (crude oil, coal, and natural gas) in the world's top ten environmentally conscious countries from 2015 to 2022. Key findings indicated that a 1% increase in the investor sentiment index decreases consumption by 0.26% for crude oil, 0.39% for coal, and 0.01% for natural gas.

Investor sentiment exerts its influence on innovative practices through three distinct mechanisms, as outlined by Dang and Xu (2018). The first mechanism operates through the financing channel. When market sentiment increases, investors become more optimistic about future cash flows, leading to a reduction in the cost of capital. As a result, even financially constrained firms can embark on positive net present value (NPV) projects, thanks to the availability of cheaper funding. The second mechanism is known as the NPV channel. With a lower cost of capital, previously negative NPV projects can be transformed into positive ones. This is a significant outcome as it enables firms to pursue innovative projects that were previously deemed unviable. The third mechanism, the sentiment spillover channel, highlights the way in which collective opinions and actions can influence individual opinions and actions. Dang and Xu (2018) argued that investor sentiment, through this mechanism, can shape managers' responses. In particular, optimistic managers are more inclined to pursue innovation when investors are also optimistic, aligning their actions with the prevailing sentiment in the market (Dang & Xu, 2018).

Dang and Xu (2018) conducted a comprehensive study using a panel sample of 6,139 publicly traded U.S. firms spanning the period from 1985 to 2010. Their objective was to examine the effect of stock market sentiment on a firm's pursuit of innovation. The results of their analysis revealed that, at the aggregate level, market sentiment has a positive effect on a firm's investment in R&D activities (Dang & Xu, 2018). Upon further investigation at the individual firm level, they discovered that this positive effect of market sentiment on R&D investment is particularly significant for financially constrained firms (Dang & Xu, 2018). This finding provides support for the financing channel hypothesis, suggesting that optimistic market sentiment can enable financially constrained firms to undertake R&D investments by reducing the cost of capital and making funding more accessible. However, their analysis did not provide substantial evidence in support of the NPV channel hypothesis, which suggests that a lower cost of capital can transform negative NPV projects into positive ones (Dang & Xu, 2018). In contrast, the findings highlighted the importance of sentiment spillover for managers, indicating that when managers are exposed to optimistic market sentiment, they are more likely to make investments in innovation (Dang & Xu, 2018). Additionally, the study revealed that the financial position of a firm plays a moderating role in the relationship between market sentiment and the pursuit of innovation. The impact of market sentiment on innovation was found to be contingent on a firm's financial standing (Dang & Xu, 2018).

Lin (2023) and Majid et al. (2023) explored the interplay between investor sentiment and corporate innovation. Lin’s (2023) study revealed a robust positive correlation, suggesting that heightened investor sentiment bolsters a company's innovation by alleviating financial constraints and boosting R&D investments. The research by Majid et al. (2023), focusing on the U.S. context, further elaborated on this relationship, emphasising its significance, particularly in firms with lower information asymmetry and cost of capital. They also observed that while financial constraints only minimally influence innovation, optimistic investor sentiment tends to yield more valuable and high-quality patents.

In another study, Sun et al. (2022) examined the influence of environmental regulation on green innovation, focusing on the role of investor and market sentiment. They found that stringent environmental policies can generate fear and result in negative investor sentiment towards green innovation. However, they also highlighted that environmental regulations, when accompanied by media publicity, can foster positive public sentiment towards green innovation (Sun et al., 2022). Applying a text-analysis technique at the country level, the researchers specifically explored the impact of environmental regulation on China's green innovation. Their findings demonstrated a mixed effect: environmental regulations had a positive influence on green innovation through public sentiment, but a negative effect through investor sentiment (Sun et al., 2022). Furthermore, Wang et al. (2023) examined the mediating roles of investor sentiment on the relationship between environmental uncertainty and corporate environmental, social, and governance (ESG) performance. They found that investor sentiment amplifies the negative impact of environmental uncertainty on ESG performance.

Incorporating the insights from the reviewed literature, this study aims to bridge a critical research gap by examining the effect of investor sentiment on the pursuit of RE innovation, specifically in firms affected by climate change-induced natural disasters. Studies such as those by Dang and Xu (2018), Lin (2023), Majid et al. (2023), and Wang et al. (2021) have highlighted the pivotal role of investor sentiment in shaping investment decisions and innovation practices. However, these studies primarily focused on general market conditions, leaving a lack of understanding of how investor sentiment interacts with RE innovation in the context of climate change. When external factors, such as disasters, affect a firm, the capital market swiftly responds, leading to shifts in investor attitudes. This reactivity results in stock price fluctuations of firms, as investors chase profits. These fluctuations can significantly influence a firm's value (Wang et al., 2023). Furthermore, as highlighted by Sun et al. (2022), investor sentiment is often influenced by external elements such as environmental regulations and media coverage, which become particularly crucial following climate-related disasters. This underscores the importance of understanding investor sentiment in the specific context of RE innovation during such climate events. Moreover, the findings of Cheong et al. (2017) and Naughton et al. (2019) indicated that investor sentiment can drive CSR practices, but its specific impact on RE innovation during times of crisis remains unexplored. Given these dynamics, there is a pressing need to delve deeper into how investor sentiment translates into action following climate change-induced natural disasters. This research gap is crucial for understanding whether the established patterns of investor influence on RE innovation hold true in these more volatile and uncertain contexts, thereby shaping a more nuanced understanding of the interplay between investor sentiment and the pursuit of RE innovation in disaster-affected scenarios. To investigate this, the researcher formulated the following hypothesis:

Hypothesis 2b: *Higher investor sentiment will lead to a less significant positive change in the pursuit of RE innovation for firms affected by climate change-induced natural disasters.*

2.5.2.3. Media Coverage and RE Innovation

The media, as a highly influential stakeholder (Zobeidi et al., 2022; Zyglidopoulos et al., 2012), plays a pivotal role in directing public attention towards climate change (Tavakolifar et al., 2021; Zhang et al., 2022). With diverse outlets including newspapers, television, radio, blogs, and internet channels (Aguilera et al., 2015), the media possesses the ability to enhance public awareness of environmental issues (Geng et al., 2023).

Media coverage plays a crucial role in reducing information asymmetry between stakeholders and firms (Graf-Vlachy et al., 2020). By providing market-related news and reports, the media contributes to the social awareness of stakeholders and holds significant influence over the decisions made by consumers, firms, and policy-makers (Chen et al., 2019). Geng et al. (2023) found that media visibility and media favourability can enhance the influence of public environmental attention on green innovation. In essence, mass media serves as a catalyst for generating or reinforcing social norms, which in turn guide behavioural patterns (Chen et al., 2019).

Analysing the context of media coverage across four categories—strategy, finance, governance, and crisis—Graf-Vlachy et al. (2020) argued that the media in different contexts serve different functions and consequently elicit varied responses. One way in which the media raises public awareness and captures attention is by highlighting a firm's misconduct or wrongdoing (Tavakolifar et al., 2021). Fu (2023) examined the impact of negative media coverage on corporate social irresponsibility and its influence on corporate social performance improvement. Their study suggested that such media scrutiny acts as constructive feedback, prompting firms to improve their performance. Conversely, positive media coverage can raise public awareness and enhance a firm's reputation (Aguilera et al., 2015). Muttaqee et al. (2023) explored community responses to microgrid projects, emphasising the role of media coverage in shaping perceptions and outcomes. They found that positive media representation of RE sources significantly influences community support for microgrid initiatives. These different forms of media coverage play a significant role in shaping public perception and influencing stakeholder behaviour.

Media coverage possesses the remarkable ability to bring about changes in the strategies of various stakeholders. When a news report exposes the polluting activities of a firm, it not only triggers a response from the firm itself but also influences the behaviour of other stakeholders such as market participants, government entities, suppliers, and others (Graf-Vlachy et al., 2020). This, in turn, exerts additional pressure on firms to strengthen their commitments towards addressing climate change issues (Tavakolifar et al., 2021). As a result, the media has a dual impact on firms: it directly prompts them to take action and, indirectly, enhances the awareness of other stakeholders (Zyglidopoulos et al., 2012).

The social environment in which a firm operates has a notable impact on fostering a stronger sense of environmental protection (Dukangqi & Weitao, 2022). Through the channel of stakeholders, this social environment exerts pressure on firms to elevate their environmental awareness and practices, ultimately driving them towards the pursuit and implementation of green technologies (Dukangqi & Weitao, 2022; Zhang et al., 2022). Tavakolifar et al. (2021) explored how media coverage can influence a firm's commitment to climate change, particularly in terms of shifting from proactive to reactive solutions. They also investigated whether this relationship varies across different industries with varying environmental impacts. The findings indicated that higher media attention increases a firm's commitment to climate change, but the likelihood of increasing commitment is lower for firms operating in industries with significant environmental impacts (Tavakolifar et al., 2021). To assess firms' commitments to climate change, Tavakolifar et al. (2021) utilised the CDP survey data, along with the corresponding letter grade assigned to each firm. However, considering the subjective nature of self-reported data in the CDP, future research could benefit from examining the issue using objective proxies, which could strengthen the validity of the findings.

Moreover, Chen et al. (2019) conducted a study investigating the impact of media coverage of climate change on the sales of hybrid vehicles in the U.S. market. What sets their study apart is their examination of general news coverage rather than focusing on news specifically related to hybrid vehicles. The findings revealed that mass media coverage of climate change impacts creates a social norm that promotes socially aware behaviour, leading to an increase in consumers' purchase of sustainable products. However, the significance of this effect is observed specifically for news articles acknowledging climate change impacts, while the results are not significant for neutral news or news denying climate change impacts (Chen et al., 2019). In another study, Fan et al. (2020) examined the impact of the media on firms' environmental disclosure practices. They asserted that the media acts as a complementary force to regulatory policies in monitoring firms' environmental behaviour, supporting findings from previous studies (Fan et al., 2020; Kong et al., 2020; Wang & Zhang, 2021).

Similarly, Zhang et al. (2022) argued that the media plays a supplementary role to formal institutions. To investigate the role of the media, Zhang et al. (2022) analysed a sample of Chinese listed companies from 2013 to 2017, focusing on different dimensions of media tone and medium. Their findings revealed a partial substitution relationship between formal institutions represented by green regulations and informal institutions represented by media coverage. Regardless of the tone and medium of the media report, their study demonstrated that media exposure encourages firms to enhance their environmental performance (Zhang et al., 2022). In addition, Zyglidopoulos et al. (2012) argued that firms are likely to pursue CSR practices that align with issues receiving high media attention. Building upon stakeholder theory, they confirmed that an increase in media attention can lead to an expansion of CSR activities by firms.

Kong et al. (2020) highlighted the situation in developing countries where governments often prioritise monitoring economic performance and pay less attention to other aspects of businesses, such as environmental performance. This lack of adequate environmental regulation underscores the crucial role that the media plays in urging businesses to address their environmental impacts. By analysing data from Chinese listed firms, Kong et al. (2020) identified a positive relationship between media attention and firms' environmental performance. Notably, this relationship is more pronounced for state-owned firms.

Furthermore, the influence of media attention on environmental performance is stronger when it comes from local media sources and has a negative tone (Kong et al., 2020). It is important to note that Kong et al. (2020) used textual analysis of annual reports as a measure of environmental performance, which may not capture the entirety of a firm's environmental performance accurately.

Campa (2018) also explored the impact of media coverage on a firm's environmental performance. His findings confirmed that media coverage, as well as the proximity to the headquarters of local newspapers, influence the level of a firm's emissions. Negative media attention can result in decreased demand for a firm's products, divestment from the firm, and increased pressure on politicians to impose stricter regulations (Campa, 2018). Moreover, Campa (2018) established that industry-related characteristics can moderate the effect of media coverage on firms' environmental performance. This suggests that the influence of media coverage may vary depending on the specific industry in which a firm operates.

Additionally, Hu et al. (2024) explored how media coverage affects corporate innovation in China, using data from Chinese listed firms between 1998 and 2013. They found that increased media coverage positively correlates with corporate innovation, measured by the number of invention patent applications. Similarly, Chen et al. (2022) examined the media's role as an informal institutional factor in enhancing green innovation in firms. Using data from Chinese listed industrial firms from 2015 to 2019, they demonstrated that media coverage significantly boosts green innovation in those firms.

On the other hand, scholars such as Wang and Zhang (2021) contended that media coverage primarily leads to symbolic behaviour rather than substantial improvements in environmental performance. Wang and Zhang (2021) investigated how media coverage of pollution events affects firms' pursuit of green acquisition and to what extent green acquisition serves as a symbolic decoupling strategy in response to media coverage. They argued that green acquisition serves as a strategic response by firms to regain legitimacy following media coverage of pollution incidents (Wang & Zhang, 2021). By analysing a sample of Chinese listed firms operating in polluting industries from 2012 to 2016, they revealed that negative media coverage stimulates firms to pursue green acquisition. However, the nature of this strategy is primarily symbolic rather than a substantial investment in green transformation (Wang & Zhang, 2021). Some managers employ symbolic strategies to mitigate the pressures arising from media attention. Instead of actively engaging in environmental practices, they may resort to strategies such as greenwashing to create an illusion of commitment (Aguilera et al., 2015). Hu et al. (2024) highlighted that while high media coverage can mitigate information asymmetry, oversee managerial short-termism, and alleviate financial constraints to enhance corporate innovation, it also introduces short-term market pressures that could hinder firms from undertaking long-term innovation projects. Moreover, a significant portion of existing research has primarily focused on the short-term impact of media coverage, specifically examining how it improves firms' environmental disclosure practices (Fan et al., 2020; Griffin et al., 2015), rather than considering the long-term performance. This emphasis on short-term effects raises questions about the effectiveness of media coverage in driving sustained environmental practices, such as green innovation, particularly in light of the ongoing trend of slow progress in RE production and consumption as mentioned in Chapter 1, despite the increasing media attention given to climate change issues.

The mixed findings in the existing literature served as a motivation for the researcher to investigate whether media coverage of climate change impacts has the potential to stimulate the pursuit of RE innovation following climate change-induced natural disasters. In other words, this study aims to shed light on the capacity of media to foster RE innovation.

Hypothesis 2c: *Greater media coverage of a firm's contribution to climate change will result in a less significant positive change in the pursuit of RE innovation for firms affected by climate change-induced natural disasters.*

2.6. Chapter Summary

Chapter 2 of the thesis presented an extensive literature review focusing on RE innovation and climate change impacts. The review was organised into two main parts: first, an exploration of RE innovation and the dimensions of climate change impacts, and second, the development of a proposed model to address the gaps identified in existing research.

The section on RE innovation delved into the essential need for RE as a response to climate change and environmental degradation, discussing the different drivers of RE innovation including societal, political, and consumer influences. The chapter also classified climate change impacts. The nature-driven impacts focus on how climate change-induced natural disasters affect firms' pursuit of RE innovation, discussing the concept of the performance-aspiration gap and its role in shaping firms' behaviour following environmental changes. Market-driven impacts were analysed in terms of several factors such as peers' pursuit of RE innovation, investor sentiment, and media coverage, highlighting the need for further research to understand these relationships, especially in the context of climate change-induced natural disasters.

The chapter concluded by summarising the main findings from the literature review, emphasising the identified research gaps and the hypotheses that have been developed. This sets the stage for the subsequent chapters of the thesis, which will delve into the research design, methodology, results, and discussions, building upon the comprehensive foundation laid out in this literature review.

3. Chapter 3 Methodology

3.1. Introduction

Chapter 2 has laid the groundwork by providing an extensive review of the existing literature on RE innovation and its intricate relationship with climate change impacts. This review has identified critical knowledge gaps within the current body of work, prompting the formulation of the central research question: 'How do climate change impacts affect a firm's pursuit of RE innovation?' To effectively address this question and contribute valuable insights to the field, the current chapter, Chapter 3, outlines an appropriate quantitative research methodology.

This chapter outlines the theoretical framework and methodology guiding this study, beginning with an in-depth discussion on the BTOF and the threat rigidity model. These frameworks are instrumental in explaining how firms' performance-aspiration gaps and their behaviour in response to external threats influence their pursuit of RE innovation following climate change impacts. Following this theoretical grounding, the chapter systematically analyses data across two distinct but interconnected streams: nature-driven impacts and market-driven impacts. Each of these streams represents a unique dimension of climate change impacts on the pursuit of RE innovation by firms. Nature-driven impacts encompass the effects of climate change-induced natural disasters. Market-driven impacts explore the dynamics of the market, examining factors such as peers' actions, investor sentiment, and media coverage in relation to climate change.

This study employed quantitative techniques, notably the DiD model and meta-analysis. By systematically collecting and analysing numerical data within these two impact streams, this study aims to unravel the intricate relationships between climate change impacts and the firms' pursuit of RE innovation following climate change-induced natural disasters. Additionally, Chapter 3 will address ethical considerations pertinent to this research, ensuring a comprehensive and robust approach to understanding the dynamics between climate change impacts and RE innovation.

3.2. Theoretical Framework

To address the central question and develop the research framework, this study relies on the BTOF proposed by Cyert and March (1963). The BTOF, which operates at the firm level, emphasises the significance of the performance-aspiration gap in shaping a firm's decisions. The theory explains how this gap serves as a motivational factor for firms, driving them to take risks to achieve their desired levels of performance (Chen & Miller, 2007; Cyert & March, 1963; Gaba & Bhattacharya, 2012; Hoskisson et al., 2017). To enhance the theoretical foundation, this study incorporated the threat rigidity model (Staw et al., 1981), combining it with the BTOF, to formulate appropriate behaviour following climate change impacts.

The BTOF proposed by Cyert and March (1963) provides a comprehensive framework for modelling a firm's behaviour, including its pursuit of RE innovation (Greve, 2003). This theory has been widely utilised by scholars to investigate firms' behaviour, particularly in uncertain situations, such as when pursuing innovative practices (Chen, 2008; Chen & Miller, 2007; Gaba & Bhattacharya, 2012; Greve, 2003). Hence, leveraging the BTOF in this paper can establish a robust behavioural foundation, supporting the rationale behind firms' behaviour following environmental uncertainty.

The BTOF, as an influential group-level theory, challenges the traditional assumption of firms as rational profit-maximisers. Instead, the BTOF views firms as goal-directed systems comprising individuals and groups with collective firm-level goals (Chen & Miller, 2007; Cyert & March, 1963). One of the key principles emphasised by this theory is the significance of the performance-aspiration gap in a firm's behaviour and how it motivates a firm to take risks in pursuit of its aspiration level (Chen & Miller, 2007; Cyert & March, 1963; Gaba & Bhattacharya, 2012). Firms often seek innovative solutions to address performance shortfalls, particularly during climate change-induced natural disasters that pose existential threats while simultaneously offering unique opportunities for innovation (Dong et al., 2021; Mithani et al., 2021). The BTOF highlights how such critical situations propel firms towards sustainable practices, aiming to close the gap between current performance and their aspiration levels, thereby adapting to new market realities. Research indicates that firms falling below their aspiration levels are more likely to enhance investments in sustainable innovations such as RE innovation following environmental pressures (Bettinazzi et al., 2020). In essence, the BTOF revolves around the concept of aspiration level, which represents the desired and targeted level of performance in specific firm outcomes (Cyert & March, 1963; Shinkle, 2012). The aspiration level serves as a reference point that either encourages or discourages firms from undertaking risky actions (Gaba & Bhattacharya, 2012). Firms evaluate their actual performance relative to their aspiration level, and based on the discrepancy between the two, they determine the appropriate level of risk to take (Chen & Miller, 2007; Cyert & March, 1963; Gaba & Bhattacharya, 2012; Hoskisson et al., 2017). Firms that fall below their aspiration level are motivated to improve their performance through the pursuit of risky practices, while firms that surpass their aspiration level exhibit less inclination towards risky actions (Chen & Miller, 2007).

Previous research has found that performance below the aspiration level encourages firms to invest in R&D and enhance their innovative capabilities (Chen, 2008; Chen & Miller, 2007; Gaba & Bhattacharya, 2012). Conversely, when performance exceeds the aspiration level, firms tend to reduce their R&D investments (Greve, 2003). Against this backdrop, the present study adopted a firm-level behavioural perspective to explore the determinants of firms' pursuit of RE innovation following climate change impacts. The researcher also argues that foreign MNEs' subsidiaries may show a less significant positive change in their pursuit of RE innovation post-disaster, due to different organisational goals influenced by their parent company's global strategy, which might not prioritise aggressive RE innovation as strongly as domestic firms do. This disparity in strategic priorities could result in a less robust pursuit of RE innovations, as their performance aspirations may not align closely with local or regional environmental impacts. Additionally, a firm's history of natural disasters can influence its current behaviour and aspiration levels. Past experiences with disasters might lead firms to integrate resilience and RE innovation into their strategic planning as a response to past disruptions. This historical context could lead to moderated behaviour when similar future disasters occur, as these firms may have developed adaptive capabilities or strategies that reduce the urgency to innovate further.

Having established a foundational understanding of the BTOF and how it influences firms' behaviour following performance disparities, this study incorporated the complementary threat rigidity model, as introduced by Staw et al. (1981). This model elucidates how firms, faced with varying external circumstances, may deviate from their performance-aspiration gap following climate change-induced natural disasters. Staw et al. (1981) conducted a seminal study exploring the phenomenon of organisational adaptation when faced with adversity. They proposed that in threatening situations, organisations often exhibit a predisposition towards rigidity. This propensity towards rigidity is attributed to two underlying factors. First, when an organisation perceives a threat, it tends to limit its information-processing capabilities. This may manifest as a narrowing of attention, a simplification of information codes, or a reduction in the utilisation of communication channels. Second, the onset of a threat can lead to a concentration of control within the organisation. Power and influence may become centralised, often within higher echelons of the organisational hierarchy. Consequently, it is postulated that a threat triggers alterations in both information and control processes within the organisational system, ultimately resulting in a reduction in the firm's behavioural flexibility (Staw et al., 1981).

Staw et al. (1981) conceptualised threat broadly, encompassing various impending negative consequences for the entity, which can arise from incremental changes or more radical environmental shifts. Threat, as defined by Staw et al. (1981), is often linked to adverse environmental conditions, including but not limited to resource scarcity, intensified competition, or a contraction in market size. The consequences of these perceived threats on organisations can be categorised into three primary domains. First, they can impede the information-processing capacity of the organisation. This is typically observed as an overload of communication channels, greater reliance on existing knowledge, and a simplification of communication complexity. Second, following these threats, organisations may centralise authority and adopt more formalised procedures, resulting in a constriction of control. Lastly, organisations may react to threats by intensifying efforts to economise resources within the system, often through cost-cutting measures and a drive for enhanced operational efficiency (Staw et al., 1981).

Through experiencing climate change-induced natural disasters, firms are exposed to external uncertainties. Drawing on the BTOF, the firm's behaviour following this external uncertainty generates an internal perception, reflected in its environmental performance. Firms gauge their actual performance against their aspiration level, using this comparison to determine their risk tolerance. Those falling short of their aspiration level are driven to take on riskier strategies, while those exceeding it tend to avoid high-risk actions. This assessment can also be influenced by the firm's threat perception, as introduced by the threat rigidity model. In a context marked by heightened natural disasters, uncertainty, and market-driven impacts, firms often perceive these factors as significant risks. This perception can trigger a defensive posture according to the threat rigidity model, where firms opt for more rigid, conservative strategies to manage instability. Consequently, this cautious approach may lead firms to curtail investments in new, uncertain areas such as RE innovation during periods of climate change-induced natural disasters. This conservative shift, primarily a protective behaviour to maintain operational stability and mitigate risks associated with unpredictable policies and market conditions, results in a less pronounced pursuit of RE innovation. Incorporating the threat rigidity model, this study recognises that when firms perceive a significant threat stemming from climate change events, their internal perception of threat is heightened. This intensified perception of threat may lead to more conservative behaviour as firms prioritise stability and risk aversion over innovative endeavours.

This integrated theoretical framework, which combines the BTOF and the threat rigidity model, forms the foundation for understanding how firms pursue RE innovation following climate change impacts. It takes into account the firm's performance-aspiration gap and its reactions to perceived threats, encompassing both internal and external factors, which ultimately shape a firm's behaviour following climate change impacts.

3.3. Research Philosophy

To commence the methodology section of this study, it is essential to address the researcher's paradigm, which serves as a fundamental consideration. The researcher's paradigm encompasses their perception of the research and the world at large (Boeren, 2018) and is selected based on the study's nature and contextual factors (Helmi Alharahsheh & Oius, 2020). Acting as an overarching framework, it has the potential to influence the researcher's approach and decisions throughout the research process (Boeren, 2018). This paradigm, regarded as the fundamental framework within research (Boeren, 2018), comprises four key components: ontology, epistemology, methodology, and methods (Helmi Alharahsheh & Oius, 2020; Scotland, 2012).

Ontology, as a component of the researcher's paradigm, revolves around the perception of reality and how it is understood (Neuman, 2014; Park et al., 2020; Scotland, 2012). It explores the nature of existence and delves into the fundamental essence and meaning of ‘being’ (Getz & Page, 2016). Within ontological approaches, the researcher in this study grapples with the objective nature of knowledge (Park et al., 2020) and maintains the belief in the existence of an objective reality that requires investigation and measurement.

Epistemology, on the other hand, pertains to the researcher's viewpoints and perspectives on the world (Helmi Alharahsheh & Oius, 2020). It concerns itself with how knowledge is acquired and transmitted (Scotland, 2012). In this thesis, the researcher chose a positivist approach, advocating that reality is objective and measurable, uninfluenced by subjective interpretations (Scotland, 2012). Positivism often seeks to establish causal relationships (Park et al., 2020) and is particularly suited for investigating the relationship between explanatory variables and outcomes (Park et al., 2020). This approach is particularly pertinent in examining the effects of climate change impacts on firms' pursuit of RE innovation, where phenomena are observed and quantified without personal bias. By employing the BTOF, the researcher formulated hypotheses to rigorously test the causal relationships between climate change impacts and the pursuit of RE innovation.

Positivism is inherently suited to this research, as it aims to establish causal links between variables, enabling the researcher to rely on statistical findings to generalise outcomes and predict behaviours across a broader dataset (Helmi Alharahsheh & Oius, 2020). The choice of a positivist over an interpretivist approach was deliberate. While positivism allows for a clear, objective analysis of empirical data, ensuring that the conclusions drawn are solely based on observable, quantifiable data, interpretivism focuses on understanding the deeper meanings and subjective experiences within contexts (Saunders, 2011). By opting for positivism, this study emphasises the measurable impacts of climate change on firms' pursuit of RE innovation, rather than exploring the subjective perceptions or nuanced interpretations that an interpretivist approach would prioritise. This methodological decision aligns with the study’s goals to provide definitive insights that can inform policy and corporate decisions.

Methodology represents the comprehensive plan of action that outlines the overall research strategy, guiding the researcher in selecting an appropriate method to address the research questions (Scotland, 2012). It encompasses both the design and implementation of the research. In this study, the chosen methodology is quantitative, involving the systematic application of statistical methods to test the formulated hypotheses (Helmi Alharahsheh & Oius, 2020). This quantitative approach is consistent with the positivist framework, which supports statistical analysis and the generalisation of findings to a broader context (Helmi Alharahsheh & Oius, 2020). The preference for a quantitative methodology over qualitative methods stemmed from the specific nature of the research questions, which aim to quantify the effect of climate change impacts on firms' pursuit of RE innovation. Employing quantitative methods allows for the rigorous application of statistical tools to establish causal relationships and to measure the influence of explanatory variables in a structured manner. This approach enhances the reliability of the findings by allowing for objective measurement and analysis of the data.

Methods, as the final component of the researcher's paradigm, guide data collection and analysis techniques. This study employed an explanatory approach, utilising longitudinal data to model how firms pursue RE innovation following climate change impacts. The research is fundamentally explanatory, aimed at identifying cause-and-effect relationships between climate change impacts and firms’ pursuit of RE innovation. This approach helped to clarify why firms pursue RE innovation following climate change-induced natural disasters and supported the creation of predictive models (Getz & Page, 2016). The primary methods used in this study were DiD and meta-analysis, which align with the explanatory purpose and adhere to the positivist worldview (Getz & Page, 2016). These methods are particularly effective for assessing changes in RE innovation before and after climatological disasters across multiple firms, thus providing robust evidence of causal effects. The adoption of a positivist approach significantly influences the choice of selected methods. DiD allows for a controlled comparison by analysing the difference in outcomes before and after an intervention, both for affected and unaffected groups, enhancing the reliability of the findings. With its emphasis on quantifying the causal effect of specific events such as climate change-induced natural disasters on RE innovation, DiD aligns well with positivism’s focus on objective measurement and empirical evidence. It allows the study to test hypotheses about cause-and-effect relationships while minimising the influence of external biases. Similarly, meta-analysis supports the positivist aim of generalising findings across different contexts by aggregating data from multiple studies to derive conclusions. Meta-analysis aggregates results from different DiD studies, offering a comprehensive view of the effects measured (Callaway & Sant’Anna, 2021). This statistical synthesis ensures that conclusions are drawn from a wide array of data, enhancing the validity and replicability of the findings. The positivist approach also shapes how results are interpreted by focusing on identifying patterns for firms' behaviours following climate change-induced natural disasters. This focus on objective measurement, quantifiable impacts, and causality guides the research design (Park et al., 2020).

The choice of DiD and meta-analysis reflects a deductive research approach, starting from theoretical frameworks—derived from the BTOF—to guide empirical investigation. In deductive research, the process begins with established theories that are tested through structured methodologies to confirm or refute hypotheses (Saunders, 2011). This contrasts with inductive research, which begins with data collection to explore phenomena and subsequently builds theories from the observed data (Saunders, 2011). By utilising these methods, the study not only tested predefined hypotheses but also synthesised findings across diverse contexts, which is essential for understanding the effect of climate change impacts on RE innovation.

3.4. Research Design

3.4.1. Data Collection

This study presents a model that explores the pursuit of RE innovation by firms following climate change impacts. To gather the necessary data for testing the hypotheses, relevant measures and data sources were extracted from the existing literature. A comprehensive description of the sample, measures, and databases employed in the study is provided in the subsequent subsections.

Three main limitations encountered during the data collection process must be acknowledged. First, firms tend to prioritise specific stakeholder groups over others in their practices, based on factors such as industry, firm lifecycle, external pressures from governmental and non-governmental organisations, and innovation priorities (Kolk & Pinkse, 2007). Due to the constraints of this study in collecting detailed information for each firm regarding stakeholder prioritisation, an assumption was made that all stakeholders are treated equally without any specific prioritisation by the firms (Huang et al., 2022).

Second, it is essential to recognise that environmental investments, such as RE innovation, require substantial time for R&D (Ren et al., 2022). Considering this time lag, the dependent variable in this study is lagged by one year to account for the developmental process of such investments. This approach aligns with established practices in the literature, particularly when examining the number of patent applications as the dependent variable (Costantini et al., 2017; Dang & Xu, 2018; Un, 2011, 2016). Additionally, the DiD methodology employed in this study covers a two-year period both before and after disaster events. This approach allows for the inclusion of the RE innovation in the second and third years following a disaster, providing a broader window to observe the progression of RE innovation.

Furthermore, it is essential to highlight that this research was distinctly oriented towards publicly traded firms within the U.S. This deliberate focus resulted in the exclusion of privately held firms that may have adopted distinct behaviour following climate change impacts (Mithani et al., 2021). These acknowledged limitations are addressed to ensure a comprehensive and accurate analysis within the study’s scope.

3.4.1.1. Sample Selection and Data Sources

This study relies on data from public firms operating in the U.S. to test the proposed model and hypotheses. The choice of the U.S. as the sample was motivated by several reasons, which are outlined as follows:

1- According to the World Intellectual Property Organisation (WIPO) database, the U.S. is among the top five countries in terms of the total number of patents granted to applicants from 2012 to 2020 (WIPO, 2023). However, data from the United States Patent and Trademark Office (USPTO) reveals a downward trend in RE innovation patent applications in the U.S., declining from 2023 applications in 2010 to 229 in 2022. This decrease occurred despite growing demand and attention to RE innovation, highlighting an area that warrants further investigation. Given these dynamics, examining the behaviour of firms operating in the U.S. can provide valuable insights for modelling the pursuit of RE innovation, particularly to understand factors influencing this unexpected trend.

2- The U.S.'s dynamic and evolving stance on climate change presents an interesting context for researchers. Its political stance on climate action has been inconsistent and subject to change (Sinha et al., 2024). The country's withdrawal from the Paris Agreement in 2017 during the presidency of Donald Trump, followed by its rejoining under President Joe Biden, reflects a high level of uncertainty in the institutional environment. This uncertainty can potentially affect firms' innovations and render them futile in the face of changing policies (Leyva-de la Hiz et al., 2019). The U.S. has experienced significant milestones in climate change policies, including joining, withdrawing, and rejoining the Paris Agreement, making it an ideal setting to study market-driven impacts.

3- Analysis of natural disaster data from the NASA EARTHDATA database reveals that the U.S. has had the highest number of natural disasters among 180 countries in the last six years of available data (2013-2018). This highlights the vulnerability of the U.S. to nature-driven impacts of climate change. Considering the study's aim to investigate nature-driven impacts, the U.S. provides a suitable sample for examination.

4- The U.S. ranks as the second-largest emitter of annual CO_2 globally, accounting for 14% of global emissions in 2019, following China (Friedlingstein et al., 2020). This underscores the significance of the U.S. in the field of climate change research.

5- Data accessibility played a role in selecting the sample. The researcher has access to North America Compustat, including financial data of firms operating in the U.S., through Massey University's subscription.

This study utilised annual data spanning from 2011 to 2019 to examine the effects of climate change-induced natural disasters that occurred between 2013 and 2018. Given the adoption of the DiD methodology, a two-year period before and after the disaster events was employed. For instance, in the case of a disaster occurring in 2013, the study designated 2011 and 2012 as the two-year pre-disaster period and 2013 and 2014 as the two-year post-disaster period. The sample size for each analysis in this study comprises all the firm-years for which data are accessible, ensuring that the sample selection is expansive yet specific to the availability of data. This approach allows for optimal use of available data, aligning with the study's goals. It should be noted that financial service firms are excluded from the sample as their business models and capital structures differ significantly from non-financial firms.

The researcher employed a diverse array of sources to collect the necessary data. These sources encompass the USPTO, the Centre for Research on the Epidemiology of Disasters (CRED), the Compustat-Capital IQ dataset for the North America region (fundamental annuals) accessed via Wharton Research Data Services (WRDS), the U.S. Census Bureau via Census.gov, Bloomberg, Institutional Shareholder Services (ISS), and RepRisk through WRDS.

3.4.1.2. Measures

3.4.1.2.1. Dependent Variable

The primary focus of this study centres on the dependent variable of the pursuit of RE innovation, operationalised using the number of RE patent applications, as supported by existing research (Brunnermeier & Cohen, 2003; Leyva-de la Hiz et al., 2019; Li et al., 2018; Perruchas et al., 2020). In the literature, innovation is commonly measured using two proxies: one is R&D expenditure, whether private or public, which is based on the input to innovation, and the other is an output measure for innovation in the form of the patent count (Johnstone et al., 2010; Wang et al., 2023). Patent count, as an output measure, serves as an indicator of a firm's innovative performance (Johnstone et al., 2010) and has the advantage of capturing the outcome of innovation, unlike R&D expenditure (Lindman & Söderholm, 2016). The accessibility of patent data and the International Patent Classification (IPC) developed by the WIPO further enable the categorisation of patents in different technological fields (Lindman & Söderholm, 2016). For the purpose of this study, the researcher adopted the output measure represented by the number of RE patent applications to gauge RE innovation. This choice was based on its wide recognition (Kittner et al., 2017; Lindman & Söderholm, 2016). Additionally, the researcher assumed that, on average, a fixed proportion of all innovations is patented (Lindman & Söderholm, 2016).

It is important to acknowledge the drawbacks of using patent count as a proxy for innovation, including the fact that not all innovations are patented, the inability to differentiate between high-value and low-applicability patents, variations in patenting procedures and regulations across countries, and differences in the tendency to apply for patent grants due to market structures and patent protection (Johnstone et al., 2010; Lindman & Söderholm, 2016). Despite these limitations, the patent count remains a widely accepted measure of innovation in the literature (Johnstone et al., 2010; Leyva-de la Hiz et al., 2019; Perruchas et al., 2020).

The challenge of measuring green innovation via environmental patents has historically arisen from the lack of specific patent classifications for identifying environmental innovations (Kunapatarawong & Martínez-Ros, 2016). However, this concern has been effectively addressed with the introduction of the IPC by the WIPO, as recognised by Johnstone et al. (2010), Nesta et al. (2014), and Noailly and Smeets (2015). The IPC is a hierarchical coding system that categorises patents into related subject areas (Johnstone et al., 2010). Although potential errors exist when using IPC to identify RE innovation, these errors are minimised, particularly in the context of RE innovation, due to the classification's well-defined criteria (Johnstone et al., 2010). This research utilised the RE innovation classification system developed by Johnstone et al. (2010) to ensure both consistency and precision in identifying relevant patents. Further details on this classification are available in Appendix 2. For the purposes of this study, focusing on publicly traded firms in the U.S., patent applications data was obtained from the USPTO, a common source in the literature for green innovation studies in the U.S. (Amore & Bennedsen, 2016; Bae & Kim, 2022; Smirnova et al., 2021).

Additionally, the researcher opted for patent applications rather than granted patents for three reasons: 1) the study's focus is on the 'intensity of inventive activity' rather than the potential quality of patents, which is better reflected in the number of patent applications; 2) the difference between patent applications and granted patents is minimal, according to patenting authorities' reports; and 3) there is an average lag of two to three years between patent application and patent approval, making patent applications a valuable source of information about the patent, its applicant, its topic, and the nature of the innovation (Hu et al., 2020; Johnstone et al., 2010; Liang & Fiorino, 2013).

In summary, the measurement of RE innovation in this study was explicitly quantified through the number of RE patent applications filed by firms. This measure directly reflects the innovation pursued by firms in new RE technologies. Each RE patent application was counted as an instance of RE innovation, providing a direct, quantifiable metric of RE innovation output. The focus on the number of patent applications, rather than granted patents, ensured that the data captured all efforts at innovation, regardless of their eventual success in the patent approval process (Hu et al., 2020). As previously mentioned in the Data Collection section, environmental investments, including RE innovation, necessitate considerable time dedicated to R&D efforts (Ren et al., 2022). To account for this time lag, the RE patent applications in this study have been intentionally lagged by one year to accommodate the developmental stages of these investments (Greer et al., 2023).

3.4.1.2.2. Independent Variables

3.4.1.2.2.1. Independent Variables for Nature-Driven Impacts Analysis

Nature-driven impacts are the physical manifestations of climate change, encompassing both acute physical impacts, such as damage from wildfires and droughts, and chronic physical impacts involving long-term shifts in climate patterns that lead to rising sea levels and temperatures (Gupta et al., 2023). In this study, the researcher specifically focused on acute physical impacts, representing immediate, disaster-driven consequences of climate change. These include highly visible natural disasters that are direct impacts of climate change (Winn et al., 2011). Given their direct and measurable effects on environmental conditions and the availability of robust data, the researcher chose to focus on climate change-induced natural disasters as a representation of nature-driven impacts of climate change.

To examine climate change-induced natural disasters, this study utilised the occurrences of climatological natural disasters that transpired in the U.S. between 2013 and 2018 as the independent variable. A climatological disaster is typically defined as a hazard caused by long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal climate variability (CRED, n.d.). The CRED maintains a comprehensive database known as the Emergency Events-Database (EM-DAT), which the researcher employed to gather data on these disasters. The CRED classifies natural disasters into five categories: biological (epidemics and insect infestations), climatological (droughts, extreme temperatures, and wildfires), geophysical (earthquakes, mass movements, and volcanoes), hydrological (floods and mass movements), and meteorological (storms) (Sodhi, 2016).

Given the specific focus of this study on the nature-driven impact of climate change, the analysis limited the natural disasters to climatological disasters as a representative measure of this impact. In line with the CRED, the criteria for including a disaster in the analysis were that it met at least one of the following conditions: (i) resulted in 10 or more fatalities, (ii) affected 100 or more individuals, (iii) led to the declaration of a State of Emergency, or (iv) prompted a call for international assistance (Boudreaux et al., 2022). This study applied the same criteria for including disasters in the analysis.

The analysis of climatological disasters, employed as the independent variable in this study, was facilitated using two key dummy variables in the DiD methodology: ‘Treat’ and ‘Period’. The ‘Treat’ dummy variable identifies whether a firm is located in a state affected by a climatological disaster; it is assigned a value of 1 for firms within the disaster state, and 0 for firms in other states. This binary classification enabled a comparative analysis between the affected and unaffected firms, highlighting the direct impact of the disasters on firms' pursuit of RE innovation. For operationalising the 'Treat' dummy variable, state-level data was used due to the unavailability of more detailed data on the exact locations of firms' operations within the disaster zones. This approach was essential as it distinguished between firms operating in states affected by disasters and those in unaffected regions. The 'Period' dummy variable distinguished the time before and after a climatological disaster. It was set to 0 for the pre-disaster period and 1 for the post-disaster period. This temporal differentiation allowed the study to measure changes in firms' behaviour attributable to the climatological disaster, providing insights into the immediate and lingering effects of climatological disasters on firms' pursuit of RE innovation.

3.4.1.2.2.2. Independent Variables for Market-Driven Impacts Analysis

Within this section, the study delves into the measures employed to scrutinise market-driven impacts. In the examination of market-driven impacts on firms' pursuit of RE innovation following climatological disasters, this study focused on three key market constructs: peers' pursuit of RE innovation, investor sentiment, and media coverage, as discussed in Chapter 2. These constructs offer valuable insights into market-driven influences and the varying perspectives of different stakeholders. The selection of these three market constructs was driven by two critical considerations: relevance to existing research and data availability. These constructs are well-established in the literature as significant influencers of firm innovation, particularly RE innovation (Bansal & Roth, 2000; Tariq et al., 2017). For instance, peers act as a powerful driver, pushing firms to pursue or improve eco-friendly practices to stay competitive (Dai et al., 2015; Hua-Hung et al., 2015; Zhao et al., 2021). Additionally, investors can heavily influence managerial decisions on green projects (Cheong et al., 2017). Similarly, the media plays a crucial role in raising public awareness about environmental issues, and indirectly pressuring firms towards sustainable practices (Tavakolifar et al., 2021; Zhang et al., 2022).

Focusing on these specific constructs allowed for a more in-depth analysis compared to a wider range of variables. This focused approach helped avoid diluting the results and ensured a clearer understanding of market constructs affecting firms' pursuit of RE innovation. Additionally, the chosen constructs offered accessible and measurable data crucial for the analysis. This data availability ensured the study's findings were grounded in robust, verifiable evidence, strengthening the research outcomes. For example, while customers were initially considered, the lack of accessible and relevant data for the specific firms in the sample made their inclusion impractical for this study. Therefore, prioritising constructs aligned with existing research and offering reliable data allowed for a focused and well-supported analysis of the market constructs influencing RE innovation.

Peers' pursuit of RE Innovation

In the examination of how peers influence the RE innovation of firms following a climate change-induced natural disaster, the focus shifts to a crucial market construct—peers' pursuit of RE innovation. This construct captures the extent to which firms' peers pursue RE innovation, a factor that can significantly affect a firm's innovation. To gauge peers' pursuit of RE innovation, the study employed a well-established metric—the number of RE patent applications, as outlined in section 3.4.1.2.1. This choice aligns with prior literature emphasising the significance of patenting activities in the context of RE innovation (Brunnermeier & Cohen, 2003; Leyva-de la Hiz et al., 2019; Li et al., 2018; Perruchas et al., 2020).

Determining industry peers was a crucial step in this analysis. To do so, the researcher utilised the Global Industry Classification (GIC) codes available in the Compustat database. These codes helped identify firms operating within the same industry as the focal firm. This selection of industry peers was pivotal in evaluating the relative position of the focal firm compared to its peers. With industry peers identified, the researcher calculated the total number of RE patent applications across all firms within each industry, excluding the focal firm, while considering a one-year lag. This measure captured the broader industry landscape, allowing for a comprehensive understanding of the competitive RE innovation environment.

By employing this construct and its associated measures, the study delved into the complex interplay between a firm's pursuit of RE innovation and the actions of its peers within the same industry. Understanding the dynamics of peers' pursuit of RE innovation provided valuable insights into the overall innovation landscape and the factors shaping firms' pursuit of RE innovation.

Investor Sentiment

Measuring investor sentiment presents a significant challenge as it is not directly observable (Huang et al., 2015). A range of measures has been employed to capture this complex concept, including surveys, such as that conducted by the American Association of Individual Investors (AAII) to gauge investor sentiment (Hudson & Green, 2015), and objective measures, such as the put-call trading ratio and volatility indices (Wang et al., 2006). Another objective measure is the single sentiment index introduced by Baker and Wurgler (2006). However, the sentiment index introduced by Baker and Wurgler (2006) is limited in that it does not account for firm-specific factors, relying primarily on macroeconomic indicators (Cheong et al., 2017; Dhasmana et al., 2023).

To capture firm-specific investor sentiment, a central focus of this study, the researcher adopted the put-call ratio obtained from the Bloomberg database (Dhasmana et al., 2023). The put-call ratio not only demonstrates strong predictability effects on stock returns (Jena et al., 2019) but also encapsulates the market's expectations based on investors' sentiments and emotions (Reis & Pinho, 2021).

The put-call ratio, derived from options, serves as an informative metric for gauging market sentiment (Dash & Maitra, 2018). It is calculated by dividing the total trading volume of puts by the total trading volume of calls (Simon & Wiggins Iii, 2001). In this study, the dataset consisted of daily closing observations averaged over each year and was obtained from the Bloomberg professional database (Simon & Wiggins Iii, 2001). The market generally interprets the put-call ratio as an indicator of fear, with higher values indicating bearish sentiment. This ratio typically reflects the idea that, during bearish periods, investors tend to acquire puts either to protect their portfolios or to engage in bearish trading strategies (Simon & Wiggins Iii, 2001). Conversely, a low put-call ratio suggests reduced demand for puts, indicating a more bullish sentiment among investors. It is widely accepted that the put-call ratio is predominantly influenced by demand factors rather than supply factors (Simon & Wiggins Iii, 2001). An increasing put-call ratio, characterised by a ratio exceeding 0.7 or even 1, indicates that equity traders favour puts over calls, signifying a growing bearish sentiment in the market. Conversely, a put-call ratio below 0.7 and approaching 0.5 is considered a bullish signal, reflecting a preference for calls over puts and suggesting a prevailing optimistic sentiment (Reis & Pinho, 2021).

Media Coverage

The level of media attention cannot be overstated in terms of shaping public discourse and agenda setting (Burke, 2022). To gather data on negative media coverage, the researcher relied on the RepRisk database, a pioneering source for information concerning ESG risks associated with corporate business conduct. The RepRisk Index (RRI) is widely utilised by financial intermediaries, insurance providers, and reputable institutions, including the UN, Dow Jones, CDP, Financial Times Stock Exchange, and the Norwegian Global Pension Fund (Berkan et al., 2021). RepRisk employs artificial intelligence to systematically aggregate critical or negative news items pertaining to ESG issues from a diverse array of sources, encompassing major print media, newsletters, news websites, blogs, social media, and more. This approach helps eliminate subjectivity in the research process as issues are categorised by RepRisk (Burke, 2022).

RepRisk specifically identifies news items that critique companies for ESG concerns, such as environmental degradation, human rights violations, and corrupt practices. Importantly, RepRisk does not pass judgement on the accuracy of these allegations; the data relies solely on media and external stakeholder reports. The search methodology adheres to a set of 28 predefined ESG issues, organised into five categories: environmental footprint, community relations, employee relations, corporate governance, and general issues. The data collection process involves two stages. Initially, automated algorithms scan over 80,000 publicly available sources to identify news items critiquing specific firms for ESG issues. Subsequently, trained analysts read and summarise the news items, linking them to the criticised firm, the reporting stakeholder, and the relevant ESG issue. If the same news story appears in multiple sources, the most influential source is prioritised. Each news story is entered only once into the database, unless it undergoes significant developments, reappears in a more influential source, or resurfaces after a span of six weeks (Kölbel et al., 2017; Li & Wu, 2020).

A distinct advantage of the RepRisk data source is that it derives its negative media attention indicators exclusively from adverse news events originating from external sources. This approach circumvents the common limitations of CSR indicators, which often combine strengths and weaknesses, primarily relying on internal sources and corporate accounting. This mitigates the risk of ethical or greenwashing bias and reinforces the reliability of RepRisk as a measure of responsible corporate conduct in practice (Becchetti et al., 2022). RepRisk data are accessible through WRDS (Becchetti et al., 2022).

In alignment with the research question in this study and to explore the influence of media coverage on the pursuit of RE innovation by firms following climate change-induced natural disasters, the researcher further narrowed down the RepRisk Index to its environmental footprint category, with a particular focus on the 'climate change, GHG, and pollution' issue predefined by RepRisk. This tailored approach allowed for a more targeted assessment of the specific ESG factors most pertinent to the research objectives.

3.4.1.2.3. Moderators

In this section, the study delves into the details of the four key constructs that moderate the relationships examined in this study. These constructs, comprising performance-aspiration gap, foreign MNEs' subsidiaries vs. domestic firms, natural disaster uncertainty, and firms' history of natural disasters, are pivotal to understanding the nuanced dynamics of climate change impacts on the pursuit of RE innovation. It begins with an in-depth explanation of each construct. These particular moderators were chosen because they each capture critical aspects of how firms react to external shocks and internal capabilities, providing a framework to assess the impacts of climate change on firms' pursuit of RE innovation. Their selection is grounded not only in their empirical relevance but also in their alignment with key theoretical constructs within the BTOF and the threat rigidity model. These theoretical frameworks suggest that firms' behaviour following environmental threats and pressures are complex and shaped by a variety of factors.

According to the BTOF, firms that find themselves below their aspiration levels may adopt more aggressive behaviour, such as pursuing RE innovation, to rectify their performance deficits. Essentially, firms assess their performance against aspirations, with significant discrepancies often leading to heightened risk-taking activities (Chen & Miller, 2007; Cyert & March, 1963). This dynamic highlights how the performance-aspiration gap crucially influences firms' behaviour in uncertain environmental conditions. Additionally, the BTOF suggests using peer performance as a benchmark for setting aspiration levels, thereby contextualising the social performance within the same market (Cyert & March, 1963; Hoskisson et al., 2017). Differences in strategic priorities and available resources between foreign MNEs' subsidiaries and domestic firms may also alter how these firms behave under environmental pressures. This analysis extends to how structural and contextual disparities affect the pursuit of RE innovations following climatological disasters.

Furthermore, the threat rigidity model offers insights into how uncertainty—specifically regarding the timing and severity of natural disasters—might sway firms towards either rigid or adaptive responses (Staw et al., 1981). The moderating role of natural disaster uncertainty explores whether this unpredictability prompts firms towards conservatism or innovative shifts aimed at risk mitigation. Lastly, the BTOF emphasises the significance of historical experiences in shaping contemporary firms' behaviour (Lant & Shapira, 2008). Firms with prior experiences of natural disasters might develop behaviours that either promote resilience or inhibit innovation, depending on their established routines. This historical perspective is vital as it examines how past experiences condition firms' behaviour following new and ongoing environmental threats. Together, these moderators created a robust framework that allowed for a detailed exploration of how firms pursue RE innovation following climatological disasters.

Performance-Aspiration Gap

In this study, the researcher aimed to investigate whether a firm's position in relation to its aspiration level, whether below or above, influences the impact of climate change on the pursuit of RE innovation. To measure this position, the researcher employed return on assets (ROA) as an indicator of a firm's actual performance and aspiration (Greve, 2003). ROA is a widely accepted proxy for firm performance in the literature (Greve, 2003; Xu et al., 2019). It is calculated by dividing a firm's net income by the average of its beginning and ending total assets for a specific fiscal year (Xu et al., 2019). The researcher sourced the data on ROA from WRDS, specifically from the Compustat-Capital IQ dataset for the North American region (fundamental annuals).

To measure aspiration levels, two constructs are often employed: Social Aspiration (SA) and Historical Aspiration (HA). SA is based on the performance of comparable firms within the focal firm's industry, while HA is derived from the focal firm's past performance. These constructs can be used individually or in combination to assess aspiration levels (Smulowitz et al., 2020). In this study, the researcher adopted a combined model, measuring SA using the prior year's industry average ROA and HA using the focal firm's prior year's ROA (Smulowitz et al., 2020).

The industry classification in this study was determined using GIC codes in Compustat, allowing the researcher to identify the industry peers of each firm. In BTOF studies, three models are commonly employed to measure aspiration levels: the weighted average model, the separate model, and the switching model (Bromiley & Harris, 2014; Han, 2022). Among these, the weighted average model is considered the least effective (Bromiley & Harris, 2014). This study opted for the switching model, which aligns with the research question and provides a more robust representation of aspiration levels. The switching model, originally proposed by Bromiley (1991), defines a single aspiration level that systematically transitions between social and historical referents. This model accounts for the fact that firms performing below or above industry benchmarks have distinct aspirations (Symeou et al., 2019). Firms performing below industry benchmarks aspire to exceed industry standards, while those performing above these benchmarks aim to surpass their previous performance, even if it remains above the industry average (Symeou et al., 2019).

In the switching model (Bromiley, 1991), the aspiration level is calculated as follows:

$$Aspiration_{i,t} = SA_{i,t-1} \qquad If\ P_{i,t-1} < SA_{i,t-1}$$

$$Aspiration_{i,t} = 1.05 * P_{i,t-1} \qquad If\ P_{i,t-1} > SA_{i,t-1} \qquad (3.1)$$

Where $Aspiration_{i,t}$ represents the aspiration level of firm i at time t, $P_{i,t-1}$ is the performance of firm i at time t-1, $SA_{i,t-1}$ is the social aspiration of firm i at time t-1 (the average performance of peer firms in the same industry). Finally, the researcher calculated the gap between a firm's performance and its aspiration level based on the model described above:

$$Gap = P_{i,t} - Aspiration_{i,t} \qquad (3.2)$$

This approach enabled the researcher to gauge the impact of the performance-aspiration gap on the relationship between climate change impacts and the pursuit of RE innovation in firms.

Foreign MNEs’ Subsidiaries vs Domestic Firms

In this study, a clear distinction was made between foreign MNEs’ subsidiaries and domestic firms during the formulation of the hypotheses. Foreign MNEs’ subsidiaries were defined as companies whose primary headquarters or base of operations are located outside the host country in which they conduct business. In contrast, domestic firms are deeply rooted in and primarily operate within the host country. This differentiation is a critical component of the hypotheses and aligns with widely accepted definitions within the field of international business (Fey et al., 2009). It enabled the researcher to explore the unique influences exhibited by these two categories of firms within the context of climate change impacts on the pursuit of RE innovation.

To identify foreign MNEs' subsidiaries, the study leveraged the WRDS, specifically drawing data from the Compustat-Capital IQ dataset for the North American region (fundamental annuals). A dummy variable was introduced to measure the distinction between foreign MNEs' subsidiaries and domestic firms. Firms with their headquarters located outside the host country (in this case, the U.S.) were assigned a value of 1, while those with headquarters within the host country were assigned a value of 0, in line with the criteria outlined by Fey et al. (2009).

Natural Disaster Uncertainty

In assessing the uncertainty posed by natural disasters, various indices are available as potential measures. Some notable options include the U.S. Climate Extremes Index (CEI), which has been introduced by the U.S. National Centres for Environmental Information, and the Actuaries Climate Index, as proposed by the American Academy of Actuaries. However, it is worth noting that these indices are not extensively utilised in the existing literature. Another option is the Climate Risk Index (CRI) compiled and published by Germanwatch, but it is limited by the unavailability of data for all the years within the research period.

A more focused and frequently used measure, known as 'real climate risk', revolves around a firm's exposure to extreme climate events, specifically natural disasters. This measure is calculated based on the number of climate-related disasters in the geographic regions where a firm's subsidiaries are situated (Huang et al., 2022). To enhance the precision of this index, discussions with experts from the U.S. Society of Actuaries led the researcher to incorporate the intensity of natural disasters by considering economic losses per capita, a methodology consistent with relevant reports (Wiese, 2020). The researcher calculated this measure by dividing the annual economic losses from climatological disasters in the states where firms operate by the population of those states in the preceding year.

The collection of data necessary for this measure involved several sources. For economic loss data, the researcher accessed the EM-DAT database, a comprehensive and trusted resource for disaster-related economic impact. Meanwhile, information regarding the population of states where these natural disasters occurred was obtained from the U.S. Census Bureau. This combination of data sources and indices enabled a more accurate understanding of natural disaster uncertainty and its potential influence on the pursuit of RE innovation within firms following climate change-induced natural disasters.

Firm’s History of Natural Disasters

In this study, the researcher introduced a unique moderator known as the ‘firm's history of natural disasters’ to explore the relationship between climate change-induced natural disasters and the pursuit of RE innovation. By using ‘firm's history of natural disasters’ as a moderator rather than a control variable, this study aimed to explore how variations in historical disaster experiences shape a firm's pursuit of RE innovation following new climatological challenges. This methodological choice facilitated an analysis of interaction effects, crucial for understanding the variability in firms' RE innovation following climatological disasters. This approach provided deeper insights than merely controlling for the firm's history of natural disasters, which could assume a uniform effect across all firms and potentially overlook the nuanced dynamics that vary by firm history. Additionally, understanding how the history of natural disasters moderates firms’ pursuit of RE innovation offers valuable insights for policy-makers and business leaders, enabling them to tailor strategies that consider a firm's unique experiences. This moderator stands out by combining not only the firm's age but also the frequency and magnitude of climatological disasters experienced during the firm's existence. This approach sets it apart from previous measures that merely tally the total number of natural disasters during a firm's tenure in a given location (Oetzel & Oh, 2021). Moreover, it differentiates between the exposure to small and major disasters, with a specific focus on climatological disasters, aligning with the study's emphasis on the influence of climate change impacts on the pursuit of RE innovation.

To approximate the firm's age, the researcher calculated the difference between the year under study and the year in which the firm was registered in the host country (Wiklund et al., 2010). This measure served as a proxy for the firm's operational history and provided insights into its industry experience. The relevant data was sourced from the Compustat-Capital IQ dataset for the North American region (fundamental annuals).

To gauge the magnitude of climatological disasters, the researcher considered the economic damages incurred as a result of these events (Tilcsik & Marquis, 2013). This metric offered a financial perspective on the impact of climatological disasters on the firm and could be obtained from the EM-DAT database. The researcher classified natural disasters into three categories based on the extent of economic damage. Small-scale disasters were defined as those causing damages below $1 billion. Major disasters encompassed the top 25% of billion-dollar disasters based on damages, which equates to a minimum threshold of $5 billion. Medium-scale disasters fell between these two categories, with damages exceeding $1 billion but below $5 billion (Tilcsik & Marquis, 2013). In this study, the focus was on major disasters. Simultaneously, the researcher measured the frequency of major climatological disasters by counting the total number of such events occurring in the state where the firm operates (Oetzel & Oh, 2014, 2021). This data was also drawn from EM-DAT.

By integrating these measures of firm age, economic damages, and the frequency of climatological disasters, the researcher constructed a comprehensive moderator that captured the firm's history of climate-related experiences. This moderator enabled an investigation into how a firm's exposure to and familiarity with nature-driven impacts shape the pursuit of RE innovation following climate change induced-natural disasters.

3.4.1.2.4. Control Variables

In this section, the control variables utilised in the study are introduced and explained. These control variables played a crucial role in ensuring that the observed relationships between climate change impacts and the pursuit of RE innovation were not distorted by other extraneous factors. Here, the discussion covers three specific control variables: firm size, firm's lifecycle, and firm age.

The first control variable, firm size, was determined by the natural logarithm of net sales, a measure frequently used in the literature (Leyva-de la Hiz et al., 2019; Mithani, 2017). Its inclusion as a control variable aimed to account for the potential impact of company size on the pursuit of RE innovation. The rationale was that larger firms may possess more resources and capabilities to pursue sustainable practices, potentially influencing their approach to RE innovation.

The second control variable under consideration is the firm's lifecycle. A firm's position within its lifecycle is an important factor influencing its behaviour following climate change impacts, as it affects stakeholder priorities (Kolk & Pinkse, 2007; Wang et al., 2023). To measure the firm's lifecycle, the researcher adopted a proxy initially developed by Dickinson (2011), which is based on the behaviour of operating, investing, and financing cash flows across different stages (Habib & Hasan, 2017). This approach is aligned with the classification used by Dickinson (2011), which distinguishes firms into five stages: introduction, growth, mature, decline, and shake-out.

- Introduction stage: OCF < 0, INVCF < 0, and FINCF > 0
- Growth stage: OCF > 0, INVCF < 0, and FINCF > 0
- Mature stage: OCF > 0, INVCF < 0, and FINCF < 0
- Decline stage: OCF < 0, INVCF > 0, and FINCF ≤ or ≥ 0

The remaining firm years are classified under the shake-out stage.

In this classification, OCF represents the operating cash flow, INVCF represents the investing cash flow, and FINCF represents the financing cash flow (Dickinson, 2011; Habib & Hasan, 2017). By including the firm's lifecycle as a control variable, the researcher could investigate how it potentially influences the pursuit of RE innovation and consider the effects of cash flows across these lifecycle stages, which are indicative of differences in profitability, growth, and risk (Habib & Hasan, 2017).

The final control variable under consideration is firm age, representing the length of time a firm has been operating in the industry. In this study, the researcher approximated the firm age by calculating the difference between the year under investigation and the year in which the firm was registered in the host country (Wiklund et al., 2010). This measure provided insights into the firm's operational history, industry experience, and familiarity with the business environment. The inclusion of firm age as a control variable allowed the researcher to examine how a firm's tenure in the industry may affect the pursuit of RE innovation, taking into account its historical context (Tilcsik & Marquis, 2013).

These control variables, firm size, firm's lifecycle, and firm age, were essential in refining the analysis, ensuring that the observed relationships between climate change impacts and the pursuit of RE innovation were examined within the context of other relevant factors that could influence the results. Data on these control variables was sourced from the Compustat-Capital IQ dataset, focusing on the North American region (fundamental annuals).

3.4.2. Data Analysis

3.4.2.1. Difference-in-Difference (DiD) Analysis

This study aimed to investigate the pursuit of RE innovation by firms following climate change impacts, including those driven by nature and market dynamics. To test the hypotheses, the researcher employed the DiD method. The DiD approach was instrumental in this analysis, offering a robust framework for assessing the effects of exogenous shocks, such as climatological disasters (Belasen & Polachek, 2009; Fu et al., 2021; Yang et al., 2022). This methodology underpinned the examination of the hypotheses, providing insights into the causal relationships explored in this study. The DiD approach was chosen for its ability to control for unobserved confounders that are constant over time, thus providing more reliable estimates of the causal effects of climatological disasters on firms' pursuit of RE innovation. Another potential method for this type of analysis is the Interrupted Time Series Analysis (ITSA), which also assesses the impact of interventions but can be applied without a control group. The ITSA is particularly useful for analysing long time series around an event (Cook et al., 2002; McDowall et al., 2021). However, given the structure of the data and the need to compare changes across groups—not just over time— the DiD method was deemed more suitable. The DiD method allows for a straightforward comparison between treatment and control groups before and after the intervention, making it ideal for this study where multiple firms and a clear demarcation of pre- and post-intervention periods are available. This methodological choice ensured a focused examination of how specific climatological disasters directly influence firm-level pursuit of RE innovation, as opposed to the broader, often more gradual trends analysed via the ITSA method.

Furthermore, the DiD method bears similarities to the matched-sample (MS) approach. Both methods involve comparing a treatment group, consisting of firms affected by a specific event, with a control group comprising unaffected firms, while controlling for various other variables. However, the MS method has its limitations. It restricts matching to a narrow set of firm characteristics, typically factors such as size. This restriction can introduce sample selection bias, artificially and arbitrarily constraining the sample size. In contrast, the DiD method offers a more comprehensive solution. It enables comparisons across all firm characteristics and utilises the entire population of firms within both the treatment and control groups. This broader approach significantly reduces the risk of coefficient bias that may arise due to non-random sample selection (Kacperczyk, 2009; Mithani, 2017).

The literature highlights the widespread use of DiD analysis to investigate the effects of climate change impacts. For instance, Belasen and Polachek (2009) utilised this technique to assess the economic impacts of a hurricane in Florida, while Mithani (2017) applied DiD analysis to demonstrate how MNEs resorted to philanthropy to mitigate losses in firm value following a natural disaster. Leiter et al. (2009) examined the effects of floods on firms' capital accumulation, employment growth, and productivity using DiD analysis. Qiu et al. (2021) employed DiD analysis to reveal that engaging in CSR practices during the COVID-19 pandemic increased stakeholder attention. Habibi and Feld (2020) used DiD analysis to estimate the impact of exposure to a major earthquake by comparing the preparedness of affected and unaffected households before and after the earthquake. Furthermore, DiD analysis has been widely employed to evaluate the effects of climate policies enacted at specific points in time (Pan et al., 2022; Stuart et al., 2014). For instance, Löfgren et al. (2014) used DiD analysis to evaluate the impact of the introduction of the EU ETS on firms' investment decisions in carbon-reduction technologies in Swedish industry. Xiongfeng et al. (2018) also examined the effect of an environmental policy in China on carbon emission efficiency using a DiD model.

The primary strength of the DiD design lies in the control group, which acts as the ‘counterfactual’ for the treatment group. In other words, the control group provides an estimate of what the treatment group's post-intervention outcomes would have been had they not received the intervention (Ryan et al., 2015; Stuart et al., 2014). By considering the historical trends of both groups, DiD analysis helps eliminate differences between them. Applying the DiD design requires the availability of longitudinal data for both the treatment and control groups, both before and after the intervention was introduced (Ryan et al., 2015).

In this study, the DiD model relied on the use of two distinct dummy variables: ‘Period’, which distinguishes observations before and after the event, and ‘Treat’, which differentiates the treatment group from the control group. The DiD model used in this study can be represented as:

$$y = \beta_0 + \beta_1 \times \text{Period} + \beta_2 \times \text{Treat} + \beta_3 \times \text{Period} \times \text{Treat} + \sum \beta_k \times controls + \varepsilon \qquad (3.3)$$

Where y represents the outcome variable (RE innovation), and β3 is the coefficient capturing the interaction effect of post-disaster implications for the treatment group. The coefficient 'β3' is significant only if the outcome variable for the treatment group relative to the control group is significantly different in the period after the event (t_2) relative to their difference prior to the event (t_1). That is,

$$\beta_3(est) = \left(y_{treatment_{t2}} - y_{treatment_{t1}}\right) - \left(y_{control_{t2}} - y_{control_{t1}}\right) \tag{3.4}$$

The goal was to assess whether the RE innovation pursued by firms exposed to climate change-induced natural disasters significantly differs from that of the control group following the event, compared to their difference before the event. DiD provides statistical estimates of these differences. If the RE innovation in the treatment and control groups follows the historical trend without significant change, the estimation model fails to predict a significant effect. If there is a change, but the change in the treatment group is similar to that of the control group, this also results in a lack of a significant effect. However, a prediction of a significant effect is confirmed if the change in RE innovation, relative to the historical trend, is greater in the treatment group than in the control group. When testing for moderating effects, the focus shifts to the interaction between the two dummies (Period and Treat) in the presence of the focal moderator variable. To account for the panel nature of the sample and the count value of the outcome, the researcher employed Poisson regression as the preferred estimator.

The analysis includes 19 individual climatological disasters, each with potentially varying impacts on the firms' pursuit of RE innovation. These disasters differ primarily in their geographical spread, which could lead to different levels of pursuit of RE innovation by firms. Each disaster occurred in distinct regions across the U.S., affecting firms differently depending on their location. Grouping all disasters occurring nationwide without accounting for these regional differences would have undermined the validity and precision of the findings. Analysing disasters separately ensured an accurate assessment of how specific events influence firms' pursuit of RE innovation within those particular areas. Aggregating all disasters into a single analysis could obscure the nuanced effects that different climatological disasters have on firms operating across various states. Furthermore, the use of meta-analysis in this study allowed for the aggregation of these individual effects, providing a comprehensive overview while still respecting the unique context of each disaster event. This methodological approach guaranteed detailed findings, offering insights that are relevant and actionable for firms and policy-makers.

Furthermore, this model acknowledged that a firm may experience multiple disasters in a single year. To accommodate this, the researcher employed a random effects model which handled the variations within firms over time as well as differences among firms, such as location and patenting experience. The random effects model is particularly well-suited for panel data, where the same firms are observed across multiple periods. It assumes that the individual firm effects are uncorrelated with the explanatory variables in the model, allowing for both within-firm and between-firm variation to be captured (Bell et al., 2019). This is important for the current study, as it allows the model to account for unobserved heterogeneity—factors unique to each firm that might influence their pursuit of RE innovation but are not directly measured in the dataset (Kacperczyk, 2009). For example, firm-specific characteristics such as management culture or historical investment in RE initiatives may affect how a firm responds to climate disasters, but these traits are often unobservable. Using random effects, the model efficiently manages cross-sectional heterogeneity (Bell et al., 2019), ensuring that both observed climatological disasters and these unobserved, firm-specific traits are considered. Additionally, this approach improves efficiency by allowing for the inclusion of time-invariant variables, such as firm location, which might otherwise be omitted in a fixed effects model. In doing so, the random effects model provides a balanced view that acknowledges the effect of observed climatological disasters and unobserved firm-specific traits that could influence a firm's pursuit of RE innovation.

3.4.2.2. Meta-analysis

In this research, which delves into the impacts of multiple climate change-induced natural disasters such as climatological disasters in conjunction with market dynamics on the pursuit of RE innovation, a vital step was the aggregation of DiD models' results to derive meaningful findings. To achieve this, the researcher opted for meta-analysis as the method for aggregating results from multiple DiD models, thereby establishing a robust framework to assess the impacts of climate change-induced natural disasters on the pursuit of RE innovation. An alternative to this method could have been to simply average all identified treatment effects (Callaway & Sant'Anna, 2021). However, such an approach would assume all study results are equally reliable, disregarding variations in their individual variances and data quality. In contrast, the meta-analysis used in this study applied weights based on the inverse of the variance (the square of the standard error) of the treatment effects (Callaway & Sant'Anna, 2021), enhancing the precision and reliability of the overall treatment effect estimate. This method allocates greater weight to studies with smaller variances, thereby accommodating variability in study quality and ensuring that the conclusions are drawn from the most reliable evidence available.

The meta-analysis process involves two key stages (Deeks et al., 2019). The first stage of meta-analysis involves calculating a summary intervention effect estimate for each study. These estimates represent the observed treatment effects in the different models, providing the foundation for comprehending the influence of climate change impacts on the pursuit of RE innovation (Deeks et al., 2001; Deeks et al., 2019). Moving to the second stage, these individual estimates are combined to generate an overall treatment effect (Deeks et al., 2019). This comprehensive treatment effect is calculated as a weighted average of the individual estimates, as suggested by Callaway and Sant'Anna (2021). This approach enabled a comprehensive assessment of how climate change impacts shape the pursuit of RE innovation by firms. The process of selecting weights for meta-analysis was deliberate and considered the amount of information available in each study. Typically, these weights are based on the inverse of the variance of the treatment effect, which is closely related to the sample size (Deeks et al., 2001; Deeks et al., 2019). Through the use of meta-analysis, this research strove to present results that were not only statistically significant but also robust.

Ultimately, the combination of the DiD model with meta-analysis provided a strong analytical framework for this study. Initially, the DiD model was applied across various datasets to capture the immediate impacts of climate change-induced natural disasters on the pursuit of RE innovation, yielding a set of effect estimates. These estimates were then used as inputs for the meta-analysis, which synthesised these individual results to generate a comprehensive overall effect. This process equipped the research with the necessary tools and methodologies to delve deeply into the intricate dynamics of RE innovation within the context of climate change impacts.

3.4.2.3. Model Specifications for Hypothesis Testing

In this study, hypotheses were tested through a series of econometric models, specifically crafted to explore the effects of climate change impacts on firms' pursuit of RE innovation.

Each hypothesis was evaluated using a DiD analysis conducted across 19 separate climatological disasters, with the results subsequently aggregated via meta-analysis. These models incorporated variables aligned with the theoretical constructs detailed in Chapter 2, ensuring each model was precisely tailored to examine various dynamics identified in the hypotheses. Table 1 below summarises the definitions and symbols for each variable used in the analysis.

Table 1 Variable Description

Variables	**Definition**	**Symbol**
RE Innovation	Number of RE patent applications	RE Innovation
Period	Dummy indicator takes value 1 for post-disaster period	Period
Treat	Dummy indicator takes value 1 for firms within the disaster state	Treat
Performance-aspiration gap	Categorical variable with two values: ‘Positive’ indicates performance above the aspiration level, and ‘Negative’ indicates performance below it.	Gap
Foreign MNEs’ subsidiaries vs domestic firms	Dummy indicator takes value 1 for firms with their headquarters located outside the U.S.	MNE
Natural disaster uncertainty	The annual economic losses from climatological disasters in the state where the firm operates divided by the population of that state in the preceding year.	Hazardrisk
Firm’s history of natural disasters	The extent of a firm's prior exposure to major climatological disasters	History
Peers’ pursuit of RE innovation	Number of RE patent applications by peers in the same industry	Peer
Investor sentiment	Put-call ratio	Investor
Media coverage	The extent of negative media attention captured through the RRI	Media
Size	Natural logarithm of net sales	Size
Lifecycle	Categorical indicator that classifies firms based on operating (OCF), investing (INVCF), and financing cash flows (FINCF). Categories: Introduction (OCF < 0, INVCF < 0, FINCF > 0), Growth (OCF > 0, INVCF < 0, FINCF > 0), Mature (OCF > 0, INVCF < 0, FINCF < 0), Decline (OCF < 0, INVCF > 0, FINCF ≤ or ≥ 0), and Shake-out (remaining firm years).	Lifecycle
Age	Difference between the year under investigation and the year in which the firm was registered in the host country	Age

Source: Developed by the author

The analysis commences with an examination of the first hypothesis (Hypothesis 1a), which investigates the impact of climatological disasters on firms' pursuit of RE innovation. To test Hypothesis 1a, the primary model utilised is as follows:

$$RE\ Innovation = \beta_0 + \beta_1 \times Period + \beta_2 \times Treat + \beta_3 \times Period \times Treat + \beta_4 \times Size + \beta_5 \times Lifecycle + \beta_6 \times Age + \varepsilon \quad (3.1)$$

Here, 'RE Innovation' represents the outcome variable, and β_3 is the coefficient capturing the interaction effect of post-disaster implications for the treatment group. Control variables include 'Size', 'Lifecycle', and 'Age'.

The second hypothesis (Hypothesis 1b) investigates the moderating role of the gap between actual performance and aspiration level on the relationship studied in Hypothesis 1a. The model developed to test this hypothesis is as follows:

$$RE\ Innovation = \beta_0 + \beta_1 \times Period + \beta_2 \times Treat + \beta_3 \times Period \times Treat + \beta_4 \times Period \times Treat \times Gap + \beta_5 \times Size + \beta_6 \times Lifecycle + \beta_7 \times Age + \varepsilon \quad (3.2)$$

Here, 'Gap' is a categorical variable with two values: 'positive' and 'negative'. Positive indicates that the actual performance is above the aspiration level, while negative indicates it is below. The coefficient β_4 captures the moderating effect of this actual performance, exploring how being above or below the aspiration level affects the relationship between nature-driven impacts and the pursuit of RE innovation. A negative gap is considered the baseline for this categorical variable.

The third hypothesis (Hypothesis 1c) examines the moderating role of foreign MNEs' subsidiaries versus domestic firms on the relationship between climate change-induced natural disasters and the pursuit of RE innovation. The model formulated to test this hypothesis is as follows:

$$RE\ Innovation = \beta_0 + \beta_1 \times Period + \beta_2 \times Treat + \beta_3 \times Period \times Treat + \beta_4 \times Period \times Treat \times MNE + \beta_5 \times Size + \beta_6 \times Lifecycle + \beta_7 \times Age + \varepsilon \quad (3.3)$$

In this model, 'MNE' is defined as a dummy variable, where 1 represents foreign MNEs' subsidiaries and 0 denotes domestic firms. The coefficient β_4 was designed to capture the moderating effect of MNEs' status on the relationship between climate change-induced natural disasters and the pursuit of RE innovation.

The fourth hypothesis (Hypothesis 1d) explores the moderating role of natural disaster uncertainty on the relationship between climate change-induced natural disasters and the pursuit of RE innovation. ‘HazardRisk’, the variable used in this analysis, quantifies the annual intensity of climatological natural disasters by considering annual economic losses per capita. The model for this hypothesis is structured as follows:

$$RE\ Innovation = \beta_0 + \beta_1 \times Period + \beta_2 \times Treat + \beta_3 \times Period \times Treat + \beta_4 \times Period \times Treat \times Hazardrisk + \beta_5 \times Size + \beta_6 \times Lifecycle + \beta_7 \times Age + \varepsilon \quad (3.4)$$

In this model, ‘HazardRisk’ serves as an indicator of the moderating role played by the ‘natural disaster uncertainty’. It quantifies the intensity of annual climatological disasters in the states where firms operate, highlighting the uncertainty these events create for businesses. The coefficient β_4 aims to measure the moderating effect of this disaster intensity on the relationship between climate change-induced natural disasters and the pursuit of RE innovation.

Building upon the fifth hypothesis (Hypothesis 1e), this section explores the moderating effect of a firm's history of natural disasters on the relationship between climate change-induced natural disasters and the pursuit of RE innovation. This aspect of the study hypothesised that a firm's previous experience with natural disasters significantly affects its pursuit of RE innovation following such events. The model, incorporating the firm's history of natural disaster, is as follows:

$$RE\ Innovation = \beta_0 + \beta_1 \times Period + \beta_2 \times Treat + \beta_3 \times Period \times Treat + \beta_4 \times Period \times Treat \times History + \beta_5 \times Size + \beta_6 \times Lifecycle + \beta_7 \times Age + \varepsilon \quad (3.5)$$

In this model, ‘History’ reflects the extent of a firm's prior exposure to and experience with natural disasters, operationalised as a continuous variable. The coefficient β_4 is aimed at capturing the effect of this historical experience on the pursuit of RE innovation in the context of climatological disasters.

In this study, the researcher explored the market-driven impacts of climate change on the pursuit of RE innovation, particularly in the context of climatological disasters. To do this, the researcher identified three key market constructs, which were discussed in previous chapters. These constructs form the basis of Group 2 hypotheses, each hypothesis representing the impact of one of these three market constructs on the pursuit of RE innovation following climatological disasters. The analysis considers two main aspects: the direct impact of climatological disasters (nature-driven impacts) and the indirect impact through these market constructs (market-driven impacts).

The first market construct examined in this research is peers’ pursuit of RE innovation, as delineated in Hypothesis 2a. This hypothesis delves into how a firm's competitive landscape, particularly the extent to which its peers pursue RE innovation, influences its own pursuit of RE innovation following climatological disasters. It suggests that a higher level of RE innovation among peers might temper the positive impact on a firm’s own pursuit of RE innovation following such disasters. The model used for this analysis is as follows:

$$RE\ Innovation = \beta_0 + \beta_1 \times Period + \beta_2 \times Treat + \beta_3 \times Period \times Treat + \beta_4 \times Period \times Treat \times Peer + \beta_5 \times Size + \beta_6 \times Lifecycle + \beta_7 \times Age + \varepsilon \quad (3.6)$$

In this model, ‘Peer’ is a crucial variable that quantifies the pursuit of RE innovation by peers, measured by the number of RE patent applications by peers, and is treated as a count variable. The coefficient β4 plays a key role, as it is intended to measure the impact of peers' pursuit of RE innovation on a firm's pursuit of RE innovation in the context of climatological disasters.

The second hypothesis in Group 2, labelled Hypothesis 2b, delves into the moderating role of investor sentiment. The researcher argues that higher investor sentiment (reflecting a more bearish or negative outlook in the stock market) will lead to a less pronounced positive change in RE innovation among firms affected by climatological disasters. The model used for this analysis is expressed as follows:

$$RE\ Innovation = \beta_0 + \beta_1 \times Period + \beta_2 \times Treat + \beta_3 \times Period \times Treat + \beta_4 \times Period \times Treat \times Investor + \beta_5 \times Size + \beta_6 \times Lifecycle + \beta_7 \times Age + \varepsilon \quad (3.7)$$

In this model, ‘Investor’ is a key variable that quantifies investor sentiment, with higher values indicating a more bearish (negative) sentiment in the stock market. This variable is treated as continuous. The coefficient β4 is particularly important as it aims to capture the effect of investor sentiment on the pursuit of RE innovation, especially in the context of climatological disasters. The essence of this analysis is to comprehend how market perceptions and attitudes, as mirrored in investor sentiment, affect the pursuit of RE innovations following climatological disasters.

The final market construct studied in this research is media coverage, as outlined in Hypothesis 2c. This hypothesis investigates the impact of media coverage on the pursuit of

RE innovation, particularly following climatological disasters. It posits that increased media attention to a firm's contribution to climate change may dampen the positive effect on the pursuit of RE innovation in firms affected by such disasters. The model for this analysis is formulated as:

$$RE\ Innovation = \beta_0 + \beta_1 \times Period + \beta_2 \times Treat + \beta_3 \times Period \times Treat + \beta_4 \times Period \times Treat \times Media + \beta_5 \times Size + \beta_6 \times Lifecycle + \beta_7 \times Age + \varepsilon \quad (3.8)$$

In this model, the variable ‘Media’ quantifies media coverage of firms' impact on climate change and is treated as a count variable. The coefficient $\beta4$ is critical, as it aims to measure the influence of media coverage on the pursuit of RE innovation in the context of climatological disasters.

This modelling approach lays the groundwork for understanding how various factors, from peer behaviour to investor sentiment and media coverage, influence firms' pursuit of RE innovation following climatological disasters. By structuring each hypothesis with a specific econometric model, this research not only tested direct impacts but also elucidated the moderating effects of external and internal variables on the pursuit of RE innovation. The subsequent analysis in Chapter 4 will further validate these models by presenting detailed results, thereby offering robust insights into the dynamics of climate change impacts on firms’ pursuit of RE innovation.

3.5. Research Quality - Validity and Reliability Criteria

Ensuring the robustness of the model introduced in this study is crucial to its applicability. Robustness is essential for validating causal inferences and ensuring the reliability of regression coefficient estimates (Lu & White, 2014). Robustness tests are conducted to assess the sensitivity of the main variables to the inclusion or exclusion of other variables and to identify any core variables that were initially overlooked (Lu & White, 2014). Given that the research relies heavily on the DiD analysis as its primary methodology, the researcher performed a series of tests to ensure both the validity and reliability of the models and their resulting findings. In the following sections, the researcher will elucidate the tests employed to assess the robustness of this research.

3.5.1. Parallel Trend Assumption

One crucial assumption essential for deriving unbiased DiD estimates is the 'parallel trend' assumption. This concept suggests that, in the absence of a specific event, the two groups under comparison would have exhibited a similar progression over time (Habibi & Feld, 2020). For instance, when analysing the impact of an event such as a disaster, the parallel trend assumption asserts that both the treatment group (exposed to the event) and the control group (not exposed) should experience parallel trends in their outcomes (Ryan et al., 2015).

To elaborate, even if the treatment and control groups initially have different outcome levels before the treatment begins, the core idea is that their trends in outcomes prior to the treatment should align. This implies that, in the absence of the treatment or event, both groups should see their outcomes change at a comparable rate. Consequently, any differences in the changes observed in outcomes between these groups can be attributed to the event itself, rather than to any pre-existing disparities in outcome trends (Ryan et al., 2015). To assess the assumption in this study, the researcher utilised a parallel trend plot (Fan & Zheng, 2020; Liu et al., 2023). This plot aids in evaluating whether the trends in outcomes for both groups exhibit the desired parallel behaviour before the intervention.

3.5.2. Model Specification Test

A crucial aspect of any statistical analysis is ensuring that the regression model accurately reflects the underlying data-generating process. The quality of the model's specification plays a fundamental role in determining the validity of the estimated relationships between variables. In this study, which investigates climate change impacts on the pursuit of RE innovation through a Poisson regression model, it is paramount to scrutinise the model's specification. To accomplish this, the researcher employed Ramsey's regression equation specification error test (RESET) to rigorously evaluate the specification of the Poisson regression model, which is commonly used for count data analysis. Ramsey's RESET test is a powerful diagnostic tool that assists in determining whether the regression model is correctly specified (Duc Dung et al., 2021; Fuinhas & Marques, 2012).

The RESET test's methodology involves regressing the dependent variable (in this case, the number of RE patent applications) on its predicted values and their powers, which include the squared, cubed, and fourth-order terms of the predicted values. Subsequently, the test examines whether the coefficients on these higher-order terms are jointly significantly different from zero. The underlying idea is to verify whether important explanatory variables, potentially correlated with the higher-order terms, have been inadvertently omitted from the model. In essence, if the higher-order terms are statistically significant, it may indicate that the original model might be inadequately specified, potentially missing critical factors that influence the dependent variable (Deb & Norton, 2018; Duc Dung et al., 2021; Shan & Troshani, 2014). The application of the Ramsey's RESET test in the analysis served as a robust mechanism to enhance the reliability and validity of the model by ensuring that it captures the true relationships between the explanatory variables and the number of RE patent applications, thus enhancing the integrity of the research findings.

3.5.3. Overdispersion Test

The researcher also assessed the robustness of the models by examining the suitability of Poisson regression, which is employed in the DiD analysis. The primary outcome variable in this study is the number of RE patent applications. Since patent counts are nonnegative and integer-valued, they fall within the domain of count data, making Poisson regression the natural choice for analysis (Cameron & Trivedi, 2013; Deb & Norton, 2018).

However, it is worth noting that count data may not always adhere to the strict assumptions of a standard Poisson distribution. The Poisson regression model relies on the assumption of equidispersion, where the conditional mean and variance of the count variable are equal. In cases where the variance exceeds the mean, we encounter a phenomenon called overdispersion. In other words, the actual data may exhibit a conditional variance of residuals that is larger than the conditional mean (predicted value) (Cameron & Trivedi, 2013). In the following chapter, the researcher will present and discuss the results of the overdispersion test, shedding light on the specific models where overdispersion is observed.

3.5.4. Panel Data Model

In determining the most appropriate panel data model for this study, the researcher faced a pivotal decision, weighing the choice between fixed effect and random effect models. In this decision-making process, the study relied on the widely accepted Hausman test, a valuable tool for model selection (Hussain et al., 2021; Zyglidopoulos et al., 2012). The

Hausman test plays a crucial role in distinguishing between fixed effect and random effect models, aiding in the determination of the model that best aligns with the data and the objectives of the research (Hussain et al., 2021; Zyglidopoulos et al., 2012). Within the Hausman test, the null hypothesis assumes the appropriateness of the random effect model. If the p-value exceeds 0.05, the null hypothesis is not rejected, signifying that the random effect model is more suitable than the fixed effect model (Almaqtari et al., 2019).

3.5.5. Multicollinearity

In the realm of regression analysis, one of the pivotal concerns is the presence of multicollinearity. This phenomenon occurs when explanatory variables within a model exhibit correlation among themselves, which can have adverse effects on the model's outcomes and its ability to disentangle the impact of each explanatory variable on the outcome variable (Bölük & Mert, 2014; Graves & Shan, 2014). In essence, it signifies that a specific variable has associations with other predictor variables (Hussain et al., 2021).

To address the issue of multicollinearity and ensure the robustness of the models, the researcher employed a statistical tool known as the Variance Inflation Factor (VIF). The VIF quantifies the degree of multicollinearity by examining how much the variance of the estimated regression coefficients is inflated due to the presence of correlated predictors. In simpler terms, it helps gauge the extent to which the explanatory variables interact and potentially compromise the model's reliability (Brogi & Lagasio, 2019). A high VIF value is indicative of stronger multicollinearity, which can jeopardise the model's effectiveness. Analysts often use a commonly accepted threshold, with a VIF above 10 being a key point of concern. This threshold is widely recognised in fields such as economics and finance (Gujarati, 2003; Shan & Troshani, 2014; Un, 2016). When the mean VIF value surpasses this threshold, it signals a multicollinearity issue that needs attention and resolution (Majeed & Ozturk, 2020). Addressing multicollinearity is pivotal for ensuring the integrity of the regression analysis. By identifying and mitigating this issue, the researcher can enhance the precision and trustworthiness of the regression coefficients, ultimately leading to more sound and reliable research outcomes.

3.6. Ethical Considerations

This study employed a combination of DiD and meta-analysis, utilising an examination of panel data collected from firms. The data required for this study primarily consists of secondary data sourced from databases subscribed to by Massey University. To ensure ethical considerations were addressed, the researcher applied for ethics approval from the Massey University Human Ethics Committee (MUHEC). The committee reviewed the project and assessed it as low risk, granting a low-risk notification valid for three years, as indicated in Appendix 1.

3.7. Chapter Summary

Chapter 3 of this thesis delved into the research methodology employed to investigate climate change impacts on a firm's pursuit of RE innovation. This chapter serves as the bedrock for understanding the framework, approach, data sources, research design, and research quality tests used to address the central research question: 'How do climate change impacts affect a firm's pursuit of RE innovation?'

In this chapter, the researcher laid the foundation for comprehending and analysing the intricate relationship between climate change impacts and the firms' pursuit of RE innovation. A quantitative research methodology was adopted in this study. The methodology encompassed the use of DiD models coupled with meta-analysis. The theoretical framework was built upon the BTOF as proposed by Cyert and March (1963), which underscores the significance of the performance-aspiration gap in shaping a firm's behaviour. To augment this framework, the researcher introduced the threat rigidity model by Staw et al. (1981), aiding in understanding how firms behave following threats and external uncertainties.

Regarding the research design, data collection encompassed various sources, including patent data from the USPTO for RE innovation, environmental and natural disaster data from the CRED, Compustat-Capital IQ data for financial information, and additional sources to account for market-driven factors. The researcher acknowledged certain limitations, such as the assumption of equal treatment of stakeholders by firms, potential delays in environmental investments, and a focus on publicly traded firms in the U.S.

This chapter introduced moderators as well. Four moderators were recognised, comprising the performance-aspiration gap, foreign MNEs' subsidiaries versus domestic firms, natural disaster uncertainty, and the firm's history of natural disasters. To assess the validity and reliability of the models introduced in this study, several tests were employed: the parallel trend assumption, which is a pivotal assumption in running DiD analysis, Ramsey's RESET test for checking model specification, the overdispersion test to ensure the suitability of Poisson regression for this study, the Hausman test to identify the best panel data model, and the VIF for assessing multicollinearity.

In summary, Chapter 3 provided the essential framework and methodological underpinning for exploring the relationship between climate change impacts and a firm's pursuit of RE innovation. This approach is aligned with a positivist research philosophy and utilised quantitative methods to yield valuable insights into the intricate interplay between climate change impacts and firms' behaviour. The data collection and measurement methods were carefully selected to ensure a comprehensive analysis of the research questions.

4. Chapter 4 Findings

4.1. Introduction

With the methodological foundation established in Chapter 3, this chapter unveils the empirical results of this study, marking the culmination of data collection, modelling, and analysis. At the heart of this chapter lies the central question: How do climate change impacts affect the pursuit of RE innovation by firms? In this empirical exploration, the researcher delves into a realm of quantifiable and data-driven insights, providing a window into how firms behave following the complex impacts of climate change. These findings offer a comprehensive understanding of the intricate relationship between climate change impacts and firms' pursuit of RE innovation, thereby contributing to the ongoing discourse on sustainability and innovation.

Within this chapter, section 4.2 presents descriptive statistics, offering a rich tapestry of information to set the stage for deeper analysis. In section 4.3, the researcher explores the results of the DiD and meta-analysis models, translating data into meaningful insights. Section 4.4 examines the validity and reliability of the findings, ensuring that the conclusions drawn are robust and defensible. Ultimately, section 4.5 synthesises the key findings of the chapter, shedding light on the critical takeaways from this empirical journey.

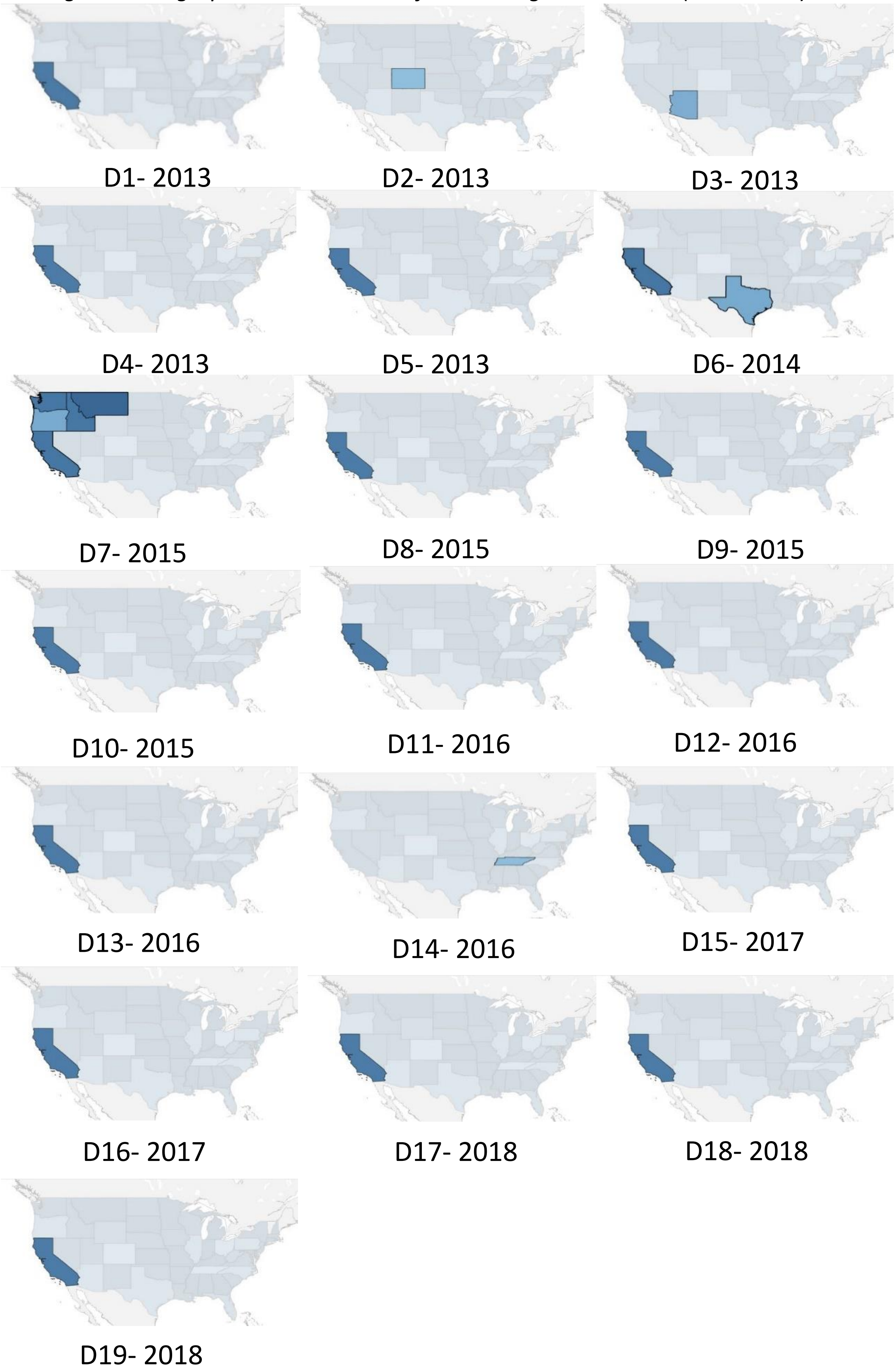
4.2. Descriptive Statistics

In this section, an aggregated overview of descriptive statistics for the variables studied is provided. Understanding the characteristics and distributions of the variables under examination is crucial for a comprehensive analysis. These variables encompass both the dependent and independent variables, which form the foundation for the investigation into the climate change impacts on the pursuit of RE innovation.

Commencing with a focus on the climatological disasters that occurred within the U.S. from 2013 to 2018, this study examined a total of 19 such events. Each disaster has been assigned a unique identifier for ease of analysis and reference, starting with D1 for the earliest event in the sequence and continuing sequentially through D19 for the most recent. These identifiers not only facilitate organised discussion but also correspond to the historical order of occurrence. Figure 5 maps the geographical distribution of these disasters across the U.S., showing their locations and the years in which they occurred. This map provides a clear reference to better understand the spatial and temporal context of each event labelled from D1 to D19. A prevalent trend emerges: the western region of the country, particularly California, witnessed the brunt of these disasters, with 14 out of the 19 studied disasters concentrated in this region. This geographical concentration underscores the significance of the western U.S. in the context of climatological disaster frequency and serves as a focal point for further analysis. Temporal patterns in disaster occurrences also come to the fore. Notably, the year 2013 stands out with the highest number of climatological disasters, registering a total of five events. Following closely, 2015 and 2016 each experienced four disasters, providing insight into the temporal clustering of these events during the study period.

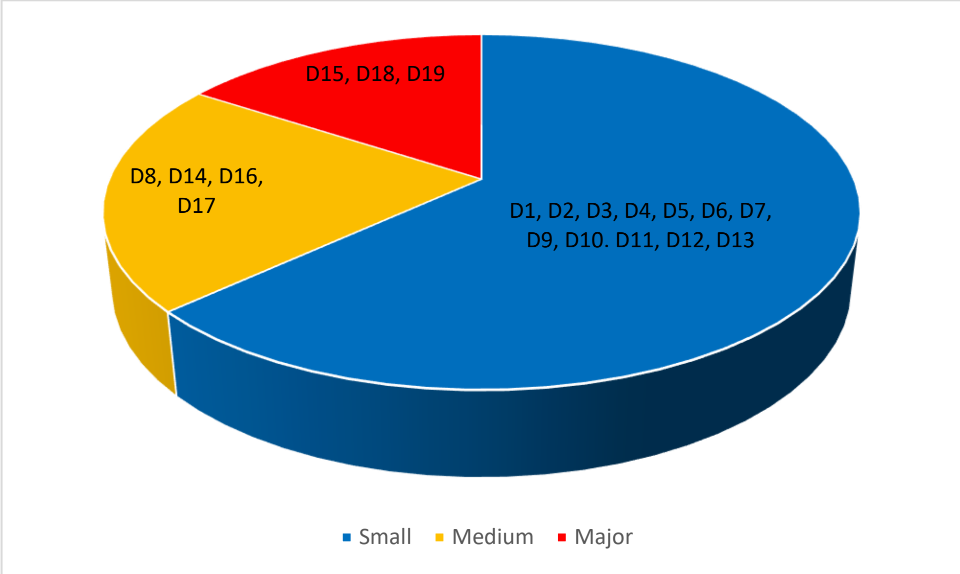
Figure 6 complements the descriptive statistics by categorising the intensity of these climatological disasters using the framework established by Tilcsik and Marquis (2013). The classification criteria encompass small, medium, and major disasters, each based on the extent of economic damage. This categorisation reveals that the majority, 12 out of the 19 disasters, are classified as small, signifying economic damages below $1 billion. Four disasters fall within the medium category, with economic damages exceeding $1 billion but remaining below $5 billion. The remaining three are categorised as major disasters, indicating their substantial economic impact. A significant trend emerges from this data; all three major disasters within this six-year period occurred in the last two years, 2017 and 2018, serving as a reminder of the alarming increase in climate change-induced natural disasters.

Figure 5 Geographical Distribution of Climatological Disasters (2013-2018)



Source: Developed by the author

Figure 6 Classification of Climatological Disasters by Intensity and Economic Impact



Source: Developed by the author

For clarity in presenting the model's results, certain variables are represented using abbreviations. The term 'Performance-Aspiration Gap' is abbreviated as 'Gap'. The comparison of 'Foreign MNEs' Subsidiaries vs Domestic Firms' is encapsulated as 'MNE'. 'Natural Disaster Uncertainty' is simplified to 'Hazardrisk', while 'Firm's History of Natural Disasters' is condensed to 'History'. Furthermore, 'Peers' Pursuit of RE Innovation' is abbreviated as 'Peer', 'Investor Sentiment' as 'Investor', and 'Media Coverage' as 'Media'.

Table 2 provides a summary of the descriptive statistics for both dependent and independent continuous variables, encompassing all the disasters considered in this study. These variables play a crucial role in deciphering the complexities of climate change impacts on the pursuit of RE innovation by firms. In particular, the dependent variable, 'RE innovation', represents a count value variable. This variable measures the level of RE innovation, which ranges from 0 to a maximum of 20. The mean value of 'RE innovation' falls within the range of 0.027 and 0.058 across all disasters under study. Notably, the mean values indicate that the 'RE innovation' variable tends to cluster nearer to the lower end of the scale (0), rather than approaching the maximum value of 20. This concentration towards the minimum suggests that, on average, the level of RE innovation remains limited, with relatively lower values, even in the presence of climatological disasters. This concentration towards the minimum may be attributed to the substantial upfront investments required for these innovations, making them less frequent and potentially more challenging to achieve.

Furthermore, the dummy variable ‘Period’, which differentiates periods before and after the occurrence of each disaster, maintains a mean of 0.5 across all disasters and all the hypotheses. This equilibrium signifies that, on average, the two periods are equally represented in the analysis, ensuring a balanced evaluation of both pre- and post-disaster dynamics.

Table 3 delves into the descriptive statistics of specific categorical variables that are crucial to the models. A key categorical variable across all hypotheses is ‘Lifecycle’, which functions as a control variable. This variable encapsulates the various stages of a firm's lifecycle, comprising ‘Introduction’, ‘Growth’, ‘Mature’, ‘Decline’, and ‘Shakeout’. In the analysis, ‘Mature’ is used as the baseline for reference, providing a benchmark for assessing the impact of different stages on the pursuit of RE innovation.

Additionally, for Hypothesis 1b, the researcher examined the moderating effect of ‘Gap’, another categorical variable in this study. Thus, in Table 3, the study presents two variables: ‘Lifecycle’ and ‘Gap’. ‘Gap’ signifies the divergence of a firm's actual performance from its aspiration levels and is categorised as ‘Negative’ or ‘Positive’. ‘Negative’ indicates performance below aspiration levels, while ‘Positive’ denotes the contrary. Analysing the ‘Gap’ is crucial for understanding how these disparities between expected and actual performance influence the dynamics between climate change-induced natural disasters and the pursuit of RE innovation. In this context, ‘Negative’ is the reference point.

Table 3 offers an in-depth overview of these categorical variables. It includes detailed information such as the frequency of each category, the corresponding percentage, and cumulative frequency. This approach provides valuable insights into the distribution of different lifecycle stages and performance-aspiration gaps within the dataset, enhancing our understanding of their influence on the pursuit of RE innovation.

Table 2 Descriptive Statistics of Variables

Variables	Statistics	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
RE Innovation	Mean	0.033	0.058	0.048	0.033	0.033	0.038	0.055	0.041	0.041	0.041	0.037	0.037	0.037	0.032	0.027	0.027	0.036	0.036	0.036
	Std. Dev.	0.218	0.279	0.255	0.218	0.218	0.358	0.51	0.239	0.239	0.239	0.255	0.255	0.255	0.242	0.226	0.226	0.407	0.407	0.407
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	5	5	5	5	5	15	20	5	5	5	8	8	8	8	8	8	20	20	20
Treat	Mean	0.263	0.12	0.066	0.263	0.263	0.331	0.225	0.224	0.224	0.224	0.21	0.21	0.21	0.025	0.205	0.205	0.206	0.206	0.206
	Std. Dev.	0.44	0.325	0.248	0.44	0.44	0.471	0.418	0.417	0.417	0.417	0.407	0.407	0.407	0.156	0.403	0.403	0.405	0.405	0.405
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Period	Mean	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Std. Dev.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Treat × Period	Mean	0.132	0.06	0.033	0.132	0.132	0.165	0.113	0.112	0.112	0.112	0.105	0.105	0.105	0.012	0.102	0.102	0.103	0.103	0.103
	Std. Dev.	0.338	0.238	0.178	0.338	0.338	0.372	0.317	0.315	0.315	0.315	0.306	0.306	0.306	0.111	0.303	0.303	0.304	0.304	0.304
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Size	Mean	19.318	19.275	19.312	19.318	19.318	19.699	19.714	19.704	19.704	19.704	19.677	19.677	19.677	19.697	19.732	19.732	19.787	19.787	19.787
	Std. Dev.	2.499	2.526	2.499	2.499	2.499	2.348	2.394	2.364	2.364	2.364	2.433	2.433	2.433	2.4	2.439	2.439	2.489	2.489	2.489
	Min	7.601	7.601	7.601	7.601	7.601	7.601	8.006	8.7	8.7	8.7	8.006	8.006	8.006	8.006	8.006	8.006	9.616	9.616	9.616
	Max	25.447	25.447	24.784	25.447	25.447	26.177	26.177	25.713	25.713	25.713	26.177	26.177	26.177	26.177	26.304	26.304	26.36	26.36	26.36
Age	Mean	13.768	13.817	13.6	13.768	13.768	14.956	15.458	15.592	15.592	15.592	15.268	15.268	15.268	15.335	15.672	15.672	16.275	16.275	16.275
	Std. Dev.	7.369	7.587	7.623	7.369	7.369	7.559	7.994	7.645	7.645	7.645	8.679	8.679	8.679	8.628	8.949	8.949	9.174	9.174	9.174
	Min	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
	Max	50	50	50	50	50	53	54	52	52	52	53	53	53	55	56	56	57	57	57
MNE	Mean	0.115	0.13	0.098	0.115	0.115	0.053	0.053	0.067	0.067	0.067	0.065	0.065	0.065	0.044	0.047	0.047	0.045	0.045	0.045
	Std. Dev.	0.319	0.336	0.297	0.319	0.319	0.225	0.224	0.25	0.25	0.25	0.246	0.246	0.246	0.205	0.212	0.212	0.208	0.208	0.208
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hazardrisk	Mean	4.819	4.81	5.224	4.819	4.819	5.148	4.479	4.898	4.898	4.898	18.949	18.949	18.949	19.594	45.8	45.8	46.847	46.847	46.847
	Std. Dev.	18.313	18.165	19.472	18.313	18.313	18.089	17.092	17.8	17.8	17.8	76.643	76.643	76.643	77.826	139.007	139.007	141.231	141.231	141.231
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	115.548	115.548	115.548	115.548	115.548	145.564	180.559	180.559	180.559	180.559	386.194	386.194	386.194	386.194	575.243	575.243	575.243	575.243	575.243
History	Mean	0.723	0.741	0.726	0.723	0.723	0.877	0.882	0.969	0.969	0.969	0.932	0.932	0.932	0.943	1.077	1.077	1.148	1.148	1.148
	Std. Dev.	0.798	0.803	0.793	0.798	0.798	0.902	0.945	0.96	0.96	0.96	1.063	1.063	1.063	1.069	1.265	1.265	1.404	1.404	1.404
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	2	2	2	2	2	3	3	3	3	3	4	4	4	4	5	5	5	5	5
Investor	Mean	0.045	0.07	0.082	0.045	0.045	0.194	0.222	0.118	0.118	0.118	0.331	0.331	0.331	0.279	0.274	0.274	0.329	0.329	0.329
	Std. Dev.	0.538	0.662	0.704	0.538	0.538	1.895	2.087	1.88	1.88	1.88	8.503	8.503	8.503	7.732	7.589	7.589	9.275	9.275	9.275

	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	15.93	15.93	15.93	15.93	15.93	100.859	100.859	100.859	100.859	100.859	559.39	559.39	559.39	559.39	559.39	559.39	559.39	559.39	559.39
Investor × Treat × Period	Mean	0.004	0.01	0.011	0.004	0.004	0.026	0.023	0.023	0.023	0.023	0.024	0.024	0.024	0.003	0.02	0.02	0.084	0.084	0.084
	Std. Dev.	0.077	0.231	0.164	0.077	0.077	0.464	0.396	0.429	0.429	0.429	0.383	0.383	0.383	0.091	0.354	0.354	5.169	5.169	5.169
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	2.75	10.343	5.119	2.75	2.75	20.778	20.778	20.778	20.778	20.778	17.103	17.103	17.103	5.596	17.103	17.103	379.65	379.65	379.65
Media	Mean	0.065	0.072	0.043	0.065	0.065	0.1	0.119	0.117	0.117	0.117	0.121	0.121	0.121	0.12	0.093	0.093	0.1	0.1	0.1
	Std. Dev.	0.56	0.588	0.397	0.56	0.56	0.647	0.741	0.755	0.755	0.755	0.813	0.813	0.813	0.783	0.716	0.716	0.782	0.782	0.782
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	11	11	10	11	11	14	16	16	16	16	17	17	17	17	17	17	23	23	23
Media × Treat × Period	Mean	0.004	0.004	0.003	0.004	0.004	0.019	0.01	0.005	0.005	0.005	0.006	0.006	0.006	0.001	0.004	0.004	0.004	0.004	0.004
	Std. Dev.	0.107	0.114	0.109	0.107	0.107	0.244	0.17	0.122	0.122	0.122	0.115	0.115	0.115	0.027	0.094	0.094	0.08	0.08	0.08
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	5	5	5	5	5	9	5	5	5	5	5	5	5	1	5	5	3	3	3
Peer	Mean	0.349	0.35	0.329	0.349	0.349	0.559	0.709	0.838	0.838	0.838	0.78	0.78	0.78	0.754	0.712	0.712	0.588	0.588	0.588
	Std. Dev.	1.156	1.16	1.093	1.156	1.156	1.799	1.951	2.127	2.127	2.127	2.289	2.289	2.289	2.257	2.233	2.233	2.008	2.008	2.008
	Min	0	0	0	0	0	0	0	0	0	0	8	8	8	0	0	0	0	0	0
	Max	14	14	14	14	14	17	17	17	17	17	22	22	22	22	22	22	22	22	22
Peer × Treat × Period	Mean	0.115	0.034	0.015	0.115	0.115	0.173	0.124	0.163	0.163	0.163	0.085	0.085	0.085	0.006	0.051	0.051	0.067	0.067	0.067
	Std. Dev.	0.648	0.365	0.18	0.648	0.648	0.989	0.882	1.035	1.035	1.035	0.75	0.75	0.75	0.119	0.561	0.561	0.566	0.566	0.566
	Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max	14	14	3	14	14	17	17	17	17	17	22	22	22	6	22	22	13	13	13
Observations		3056	2800	2376	3056	3056	5668	4512	3452	3452	3452	4520	4520	4520	5460	5688	5688	5472	5472	5472

Source: Author's analysis using STATA

Table 3 Descriptive Statistics of Categorical Variables

Variables	Categories	Statistics	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
Lifecycle	Mature	Freq.	1147	1037	905	905	905	2553	2036	1520	1520	1520	1961	1961	1961	2395	2555	2555	2461	2461	2461
		Percent	37.53	37.04	38.09	38.09	38.09	45.04	45.12	44.03	44.03	44.03	43.38	43.38	43.38	43.86	44.92	44.92	44.97	44.97	44.97
		Cum. Freq.	37.53	37.04	38.09	38.09	38.09	45.04	45.12	44.03	44.03	44.03	43.38	43.38	43.38	43.86	44.92	44.92	44.97	44.97	44.97
	Decline	Freq.	247	241	180	180	180	365	313	243	243	243	332	332	332	380	427	427	430	430	430
		Percent	8.08	8.61	7.58	7.58	7.58	6.44	6.94	7.04	7.04	7.04	7.35	7.35	7.35	6.96	7.51	7.51	7.86	7.86	7.86
		Cum. Freq.	45.62	45.64	45.66	45.66	45.66	51.48	52.06	51.07	51.07	51.07	50.73	50.73	50.73	50.82	52.43	52.43	52.83	52.83	52.83
	Growth	Freq.	843	764	650	650	650	1546	1188	902	902	902	1157	1157	1157	1428	1396	1396	1271	1271	1271
		Percent	27.59	27.29	27.36	27.36	27.36	27.28	26.33	26.13	26.13	26.13	25.6	25.6	25.6	26.15	24.54	24.54	23.23	23.23	23.23
		Cum. Freq.	73.2	72.93	73.02	73.02	73.02	78.76	78.39	77.2	77.2	77.2	76.33	76.33	76.33	76.98	76.97	76.97	76.06	76.06	76.06
	Introduction	Freq.	549	521	434	434	434	755	602	469	469	469	666	666	666	771	774	774	771	771	771
		Percent	17.96	18.61	18.27	18.27	18.27	13.32	13.34	13.59	13.59	13.59	14.73	14.73	14.73	14.12	18.61	18.61	14.09	14.09	14.09
		Cum. Freq.	91.16	91.54	91.29	91.29	91.29	92.08	91.73	90.79	90.79	90.79	91.06	91.06	91.06	91.1	90.58	90.58	90.15	90.15	90.15
	Shakeout	Freq.	270	237	207	207	207	449	373	318	318	318	404	404	404	486	536	536	539	539	539
		Percent	8.84	8.46	8.71	8.71	8.71	7.92	8.27	9.21	9.21	9.21	8.94	8.94	8.94	8.9	9.42	9.42	9.85	9.85	9.85
		Cum. Freq.	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	Total	Freq.	3056	2800	2376	2376	2376	5668	4512	3452	3452	3452	4520	4520	4520	5460	5688	5688	5472	5472	5472
		Percent	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Gap	Negative	Freq.	2458	2275	1882	1882	1882	4097	3274	2521	2521	2521	3240	3240	3240	3867	3926	3926	3815	3815	3815
		Percent	80.43	81.25	79.21	79.21	79.21	72.28	72.56	73.03	73.03	73.03	71.68	71.68	71.68	70.82	69.02	69.02	69.72	69.72	69.72
		Cum. Freq.	80.43	81.25	79.21	79.21	79.21	72.28	72.56	73.03	73.03	73.03	71.68	71.68	71.68	70.82	69.02	69.02	69.72	69.72	69.72
	Positive	Freq.	598	525	494	494	494	1571	1238	931	931	931	1280	1280	1280	1593	1762	1762	1657	1657	1657
		Percent	19.57	18.75	20.79	20.79	20.79	27.72	27.44	26.97	26.97	26.97	28.32	28.32	28.32	29.18	30.98	30.98	30.28	30.28	30.28
		Cum. Freq.	100	100	100	100	100	100	100	100	100	100	200	200	200	100	100	100	100	100	100
	Total	Freq.	3056	2800	2376	3056	3056	5668	4512	3452	3452	3452	4520	4520	4520	5460	5688	5688	5472	5472	5472
		Percent	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Source: Author's analysis using STATA

In conclusion, the descriptive statistics presented in this section provide a foundational understanding of the distribution and characteristics of the variables central to the investigation. These insights serve as a crucial backdrop for the subsequent analyses, where a deeper dive is undertaken into the intricate relationships between these variables and their impact on the pursuit of RE innovation in the context of climate change impacts.

4.3. Results

This section presents the analyses conducted to test the hypotheses developed in this research. As outlined in the preceding chapter, the DiD model was employed as the appropriate estimation technique, utilising treatment and control groups. This approach enabled the evaluation of whether the change in RE innovation in the treatment group deviates significantly from the historical trend observed in the control group. Given the broad scope of the analysis, encompassing all climatological disasters in the U.S. between 2013 and 2018, the researcher conducted a DiD analysis for each individual disaster to test each hypothesis. The results were then aggregated using meta-analysis to synthesise the overall findings for each hypothesis.

The investigation started by exploring the first hypothesis (Hypothesis 1a), which examines the impact of climatological disasters on firms' pursuit of RE innovation. Table 4 presents the predicted effects of climatological disasters on the pursuit of RE innovation for the two years post-disaster relative to the two years prior, across 19 climatological disasters. Each column in the table represents DiD analysis for a specific disaster, with the interaction term providing the DiD estimate. A positive coefficient indicates a positive change in the treatment group compared to the control group following the disaster. However, to test Hypothesis 1a, the researcher had to aggregate the predicted effects from the 19 disasters. This aggregation was accomplished through meta-analysis, as demonstrated in Table 5. The meta-analysis results reveal a significant positive effect of 0.74 at $p < 0.001$, indicating that firms exhibit a higher level of RE innovation following climatological disasters.

Figure 7 complements these findings by illustrating the forest plot of the meta-analysis, focusing particularly on the interaction between the two dummy variables, ‘Treat’ and ‘Period’, and their impact on the outcome variable, the main focus of Hypothesis 1a. The forest plot provides a visual representation of the test results for each disaster, with the overall summary effect estimate depicted by the diamond at the bottom, indicating a significant positive effect of 0.74. This aligns with the hypothesis that following nature-driven impacts in the form of climate change-induced natural disasters, firms experience a positive change in the pursuit of RE innovation compared to the pre-disaster period. Furthermore, the analysis of individual disasters in the plot reveals a consistent positive trend. The heterogeneity analysis indicates an I^2 of 0%, suggesting no significant heterogeneity among the studies. The p-value for the Q-test is 0.980, indicating that the observed variability is statistically insignificant. Despite the absence of heterogeneity, a random-effects model was employed throughout this study to test each of the hypotheses to provide more conservative estimates.

When conducting a meta-analysis, the choice between fixed-effect and random-effect meta-analysis hinges on the assumption regarding the nature of the estimated quantities in each study. In cases where it is reasonable to assume that every study is estimating the same quantity, a fixed-effect meta-analysis is typically employed. However, in this study, where the climatological disasters exhibit varying levels of intensity, as highlighted in the descriptive statistics section, the random-effect meta-analysis approach appeared to be more suitable. This approach acknowledges the assumption that different studies are estimating distinct yet interconnected intervention effects, as emphasised by Deeks et al. (2019). In simpler terms, while some level of divergence in results from the overall estimate is always anticipated due to random chance, the effectiveness of the treatment can also be influenced by unique trial characteristics, thereby increasing the variability of the results (Deeks et al., 2001; Deeks et al., 2019).

Table 4 Hypothesis 1a - DiD Results across 19 Disasters

Model	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
Innovation	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Treat	0.0689201*	1.744509***	1.330429**	0.0689201*	0.0689201*	0.9357776***	1.343159***	1.199639***	1.199639***	1.199639***	1.53939***	1.53939***	1.53939***	2.231108***	1.724163***	1.724163***	1.977603***	1.977603***	1.977603***
Period	1.075271***	1.383039***	1.283359***	1.075271***	1.075271***	-0.1	-0.7786217***	-0.8843408***	-0.8843408***	-0.8843408***	-0.15	-0.15	-0.15	-0.3006099*	-0.4	-0.4	-0.8182753***	-0.8182753***	-0.8182753***
Treat x Period	1.401859**	0.9561063**	0.818	1.401859**	1.401859**	0.6612763**	0.9167546***	0.8982944**	0.8982944**	0.8982944**	0.6706392**	0.6706392**	0.6706392**	0.8690164**	0.373	0.373	0.5771067*	0.5771067*	0.5771067*
Size	0.1408635**	0.1479044***	0.1686163***	0.1408635**	0.1408635**	0.230715***	0.2250904***	0.093	0.093	0.093	0.2677342***	0.2677342***	0.2677342***	0.2369741***	0.1895606***	0.1895606***	0.1774924***	0.1774924***	0.1774924***
Lifecycle																			
Decline	0.8951851**	1.025415***	1.250023***	0.8951851**	0.8951851**	0.303	0.075	0.355	0.355	0.355	0.507	0.507	0.507	1.24059***	0.938242**	0.938242**	0.6428684*	0.6428684*	0.6428684*
Growth	0.167	0.314	0.344	0.167	0.167	0.4128533**	0.4666059**	0.281	0.281	0.281	0.057	0.057	0.057	0.5492448**	0.074	0.074	-0.02	-0.02	-0.02
Introduction	0.433	0.497	0.7992776**	0.433	0.433	0.7275703**	0.8214523***	0.621102*	0.621102*	0.621102*	1.002586***	1.002586***	1.002586***	1.10782***	0.25	0.25	0.6124636*	0.6124636*	0.6124636*
Shakeout	0.495	0.7634197**	0.9467298**	0.495	0.495	0.6706079**	0.7375714**	0.8540013***	0.8540013***	0.8540013***	0.7154521***	0.7154521***	0.7154521***	1.195742***	0.4914413*	0.4914413*	0.249	0.249	0.249
Age	0.027	-0	0.017	0.027	0.027	-0.01	-0.01	0.012	0.012	0.012	0.013	0.013	0.013	-0.02	-0	-0	-0	-0	-0
Constant	-8.018394***	-7.880067***	-8.237094***	-8.018394***	-8.018394***	-8.749489***	-8.082607***	-5.776173***	-5.776173***	-5.776173***	-9.911083***	-9.911083***	-9.911083***	-8.625534***	-8.14419***	-8.14419***	-7.771628***	-7.771628***	-7.771628***
Wald χ^2	68.9***	221.63***	80.5***	68.9***	68.9***	59.12***	78.91***	57.34***	57.34***	57.34***	92.06***	92.06***	92.06***	60.09***	63.79***	63.79***	89.66***	89.66***	89.66***
N	3056	2800	2376	3056	3056	5668	4512	3452	3452	3452	4520	4520	4520	5460	5688	5688	5472	5472	5472

Note: *** p<.01, ** p<.05, * p<.1

Source: Author's analysis using STATA

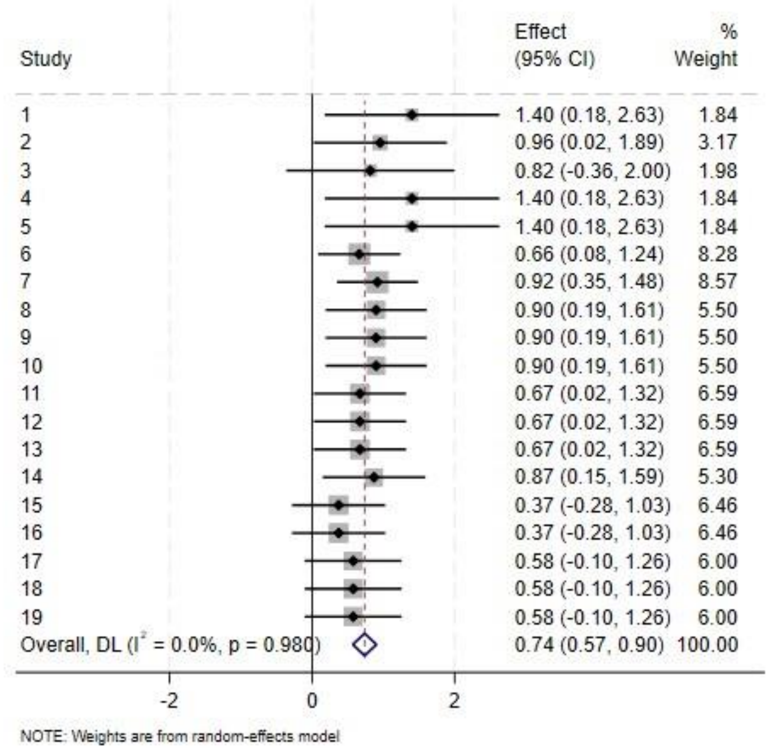
Table 5 Meta-analysis results

Meta-analysis	H1a		H1b		H1c		H1d		H1e		H2a		H2b		H2c	
Innovation	Coefficient	I^2	Coefficient	I^2	Coefficient	I^2	Coefficient	I^2	Coefficient	I^2	Coefficient	I^2	Coefficient	I^2	Coefficient	I^2
Treat	1.441***	45.7%	1.441***	43.9%	1.307***	57.2%	1.444***	35.9%	1.413***	69%	1.351***	42.2%	1.426***	48.1%	1.424***	49%
Period	-0.106	86.1%	-0.117	85.7%	-0.103	85.7%	-0.113	88%	-0.162	83.9%	-0.148	85.4%	-0.114	86.4%	-0.114	86.4%
Treat x Period	0.74***	0%	0.824***	0%	0.918***	37%	0.9***	10.5%	1.361***	37.1%	0.945***	0%	0.755***	0%	0.771***	0%
Gap			0.263***	17.3%												
Treat × Period × Gap			-0.273**	16.5%												
MNE					1.750***	13.2%										
Treat × Period × MNE					-0.569**	73.6%										
Hazardrisk							0.01***	92.2%								
Treat × Period × Hazardrisk							-0.007***	86.5%								
History									0.116*	74.6%						
Treat × Period × History									-0.349***	72.2%						
CPU																
Treat × Period × CPU																
Investor													0.001	0.0%		
Treat × Period × Investor													0.007	0.0%		
Media															-0.021	0.0%
Treat × Period × Media															0.086	0.0%
Peer											0.067***	0.0%				
Treat × Period × Peer											-0.076***	0.0%				
Shareholder																
Treat × Period × Shareholder																
Size	0.182***	0%	0.180***	0%	0.201***	4.6%	0.175***	18.4%	0.182***	6.8%	0.2***	13.9%	0.206***	15.5%	0.207***	15.7%
Lifecycle												0%				
Decline	0.658***	0%	0.696***	0%	0.770***	0%	0.639***	0%	0.679***	0%	0.667***	0%	0.642***	0%	0.662***	0%
Growth	0.214***	0%	0.236***	0%	0.225***	0%	0.201***	0%	0.226***	0%	0.196***	0%	0.19***	0%	0.2***	0%
Introduction	0.677***	0%	0.688***	0%	0.749***	0%	0.676***	0%	0.700***	0%	0.619***	0%	0.698***	0%	0.705***	0%
Shakeout	0.651***	0%	0.667***	0%	0.713***	0%	0.660***	0%	0.687***	0%	0.609***	0%	0.565***	0%	0.577***	0%
Age	0.005	0%	0.005	0%	0.004	0%	0.006	0%	0.006*	0%	0.005	0%	0.005	0%	0.005	0%
Constant	-8.010***	1.1%	-8.048***	2.2%	-8.648***	0%	-7.970***	11%	-8.108***	7.9%	-8.445***	13.6%	-8.528***	14%	-8.552***	8.9%

Note: *** p<.01, ** p<.05, * p<.1

Source: Author's analysis using STATA

Figure 7 Hypothesis 1a - Forest Plot of Meta Analysis



Source: Author's analysis using STATA

In summary, the results consistently support Hypothesis 1a, indicating that firms demonstrate a positive change in the pursuit of RE innovation following climatological disasters. The meta-analysis and forest plot offer a synthesis of findings, highlighting the overall impact across various disasters and reaffirming the positive trend observed in individual analyses.

The second hypothesis (Hypothesis 1b) explores the moderating effect of the gap between actual performance and aspiration levels on the dynamics outlined in Hypothesis 1a. Table 6 presents the predicted moderating effects across 19 disasters, with each column representing a DiD analysis for a specific disaster. For example, column D1, which details the DiD analysis for disaster D1, shows that the interaction term between the treatment and post-period effect, along with the positive gap, yielded a coefficient of -1.386169. This result is statistically significant ($p < 0.05$), indicating a substantial moderating effect of a positive gap on the relationship between climatological disasters and the pursuit of RE innovation. Specifically, while the base DiD estimate for firms with a negative gap captures the average change in the pursuit of RE innovation due to climatological disasters across time, the negative sign of the coefficient reveals a diminished effect by 1.386169 units for firms with a positive gap. Practically, this implies that firms whose performance exceeds their aspiration levels tend to show a markedly smaller increase, or possibly even a decrease, in the pursuit of RE innovation following climatological disasters, in contrast to their counterparts whose performance falls below aspiration level.

In the comprehensive meta-analysis aggregating effects from 19 disasters, a notable moderating influence was observed in the gap between actual performance and aspiration level on the relationship between climate change-induced natural disasters and the pursuit of RE innovation. The aggregated effect size of -0.273, as shown in Table 5 and statistically significant as indicated by the ** notation, points to a consistent yet modest pattern: firms with actual performance above the aspiration level exhibit a reduced impact of climatological disasters on the pursuit of RE innovation compared to those with performance below the aspiration level. This negative coefficient suggests that a positive gap between actual performance and aspiration level diminishes the effect size by 0.273 units on average.

The forest plot in Figure 8 represents this trend. It displays each study's effect size and confidence interval, providing a snapshot of individual contributions to the aggregated finding. The plot reveals a general clustering of effects around the aggregated mean, underscoring the consistency of the moderating role of the ‘performance-aspiration gap’ across different studies. A critical aspect of this meta-analysis is the low level of heterogeneity among the included studies, as evidenced by an I^2 statistic of 16.5%. This relatively low value suggests minimal variability in the effects observed across different studies, reinforcing the reliability of the aggregated findings. Furthermore, the p-value of 0.252 for this heterogeneity indicates that the observed variance is not statistically significant, implying that the differences in effect sizes across studies are likely to be due to chance rather than systematic differences.

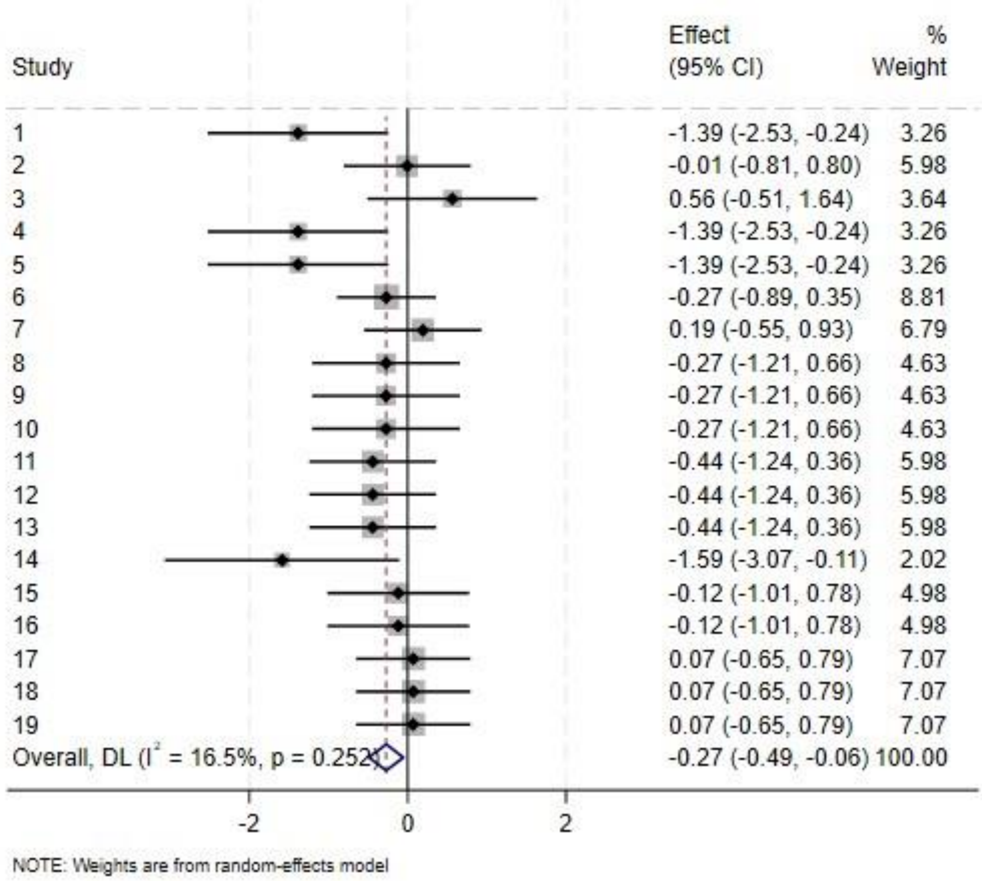
Table 6 Hypothesis 1b - DiD Results across 19 Disasters

Model	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
Innovation	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Treat	0.1784	1.760241***	1.327219**	0.1784	0.1784	0.8362124***	1.312085***	1.199704***	1.199704***	1.199704***	1.536416***	1.536416***	1.536416***	2.256413***	1.713267***	1.713267***	1.974924***	1.974924***	1.974924***
Period	1.041526***	1.336842***	1.281806***	1.041526***	1.041526***	-0.169	-0.7862193***	-0.8858275***	-0.8858275***	-0.8858275***	-0.1352	-0.1352	-0.1352	-0.3002941*	-0.4065	-0.4065	-0.8157611***	-0.8157611***	-0.8157611***
Gap: Positive	0.7972771**	0.3818	0.0215	0.7972771**	0.7972771**	0.6455419***	0.1473	0.0906	0.0906	0.0906	0.3917342*	0.3917342*	0.3917342*	0.3303101*	0.213	0.213	-0.1046	-0.1046	-0.1046
Treat × Period	1.637737***	0.95712**	0.6278	1.637737***	1.637737***	0.8315138**	0.8914051***	0.9664046**	0.9664046**	0.9664046**	0.8109386**	0.8109386**	0.8109386**	1.250037***	0.425	0.425	0.5643	0.5643	0.5643
Treat × Period × Gap	-1.386169**	-0.0066	0.5641	-1.386169**	-1.386169**	-0.2701	0.1906	-0.2743	-0.2743	-0.2743	-0.4426	-0.4426	-0.4426	-1.587244**	-0.1184	-0.1184	0.0693	0.0693	0.0693
Size	0.1408316**	0.1462919***	0.1623419***	0.1408316**	0.1408316**	0.2286678***	0.2271996***	0.0929	0.0929	0.0929	0.262979***	0.262979***	0.262979***	0.2308217***	0.1863762***	0.1863762***	0.1779923***	0.1779923***	0.1779923***
Lifecycle																			
Decline	0.8734063*	1.107011***	1.272132***	0.8734063*	0.8734063*	0.5640571*	0.1682	0.3606	0.3606	0.3606	0.5166	0.5166	0.5166	1.277359***	0.9474822**	0.9474822**	0.6427753*	0.6427753*	0.6427753*
Growth	0.1721	0.3494	0.3758	0.1721	0.1721	0.4778502**	0.4693337**	0.2854	0.2854	0.2854	0.102	0.102	0.102	0.5943466***	0.0923	0.0923	-0.0222	-0.0222	-0.0222
Introduction	0.425	0.5482322*	0.7936209**	0.425	0.425	0.7662472**	0.8873349***	0.6209506*	0.6209506*	0.6209506*	1.0061***	1.0061***	1.0061***	1.130914***	0.2666	0.2666	0.5972014*	0.5972014*	0.5972014*
Shakeout	0.4685	0.815273**	0.9691722**	0.4685	0.4685	0.7385116**	0.7795266***	0.8678889***	0.8678889***	0.8678889***	0.7387352***	0.7387352***	0.7387352***	1.246148***	0.5019601*	0.5019601*	0.242	0.242	0.242
Age	0.0253	-0.0021	0.0169	0.0253	0.0253	-0.0037	-0.0094	0.0118	0.0118	0.0118	0.0121	0.0121	0.0121	-0.0188	-0.0002	-0.0002	-0.0013	-0.0013	-0.0013
Constant	-8.191218***	-7.914983***	-8.127534***	-8.191218***	-8.191218***	-8.935789***	-8.181853***	-5.804125***	-5.804125***	-5.804125***	-9.9457***	-9.9457***	-9.9457***	-8.63034***	-8.16032***	-8.16032***	-7.746736***	-7.746736***	-7.746736***
Wald χ²	74.22***	224.18***	82.18***	74.22***	74.22***	68.19***	80.38***	57.76***	57.76***	57.76***	94.24***	94.24***	94.24***	64.72***	64.88***	64.88***	90.02***	90.02***	90.02***
N	3056	2800	2376	3056	3056	5668	4512	3452	3452	3452	4520	4520	4520	5460	5688	5688	5472	5472	5472

Note: *** p<.01, ** p<.05, * p<.1

Source: Author's analysis using STATA

Figure 8 Hypothesis 1b - Forest Plot of Meta Analysis



Source: Author's analysis using STATA

This synthesis of data suggests that while the overall direction of the impact of climatological disasters on the pursuit of RE innovation remains unaffected, the magnitude of this impact is significantly moderated by whether a firm's actual performance is above or below its aspiration level. This finding confirms Hypothesis 1b, indicating that firms with performance above their aspiration level (positive gap), as opposed to those below aspiration level (negative gap), are less influenced in their pursuit of RE innovation following nature-driven impacts of climate change.

The third hypothesis (Hypothesis 1c) investigates how foreign MNEs' subsidiaries compared to domestic firms moderate the relationship between climate change-induced natural disasters and the pursuit of RE innovation. Table 7 presents the anticipated moderating effects across the 19 disasters, with each column corresponding to a specific disaster's DiD analysis. For instance, column D1, which pertains to the DiD analysis for disaster D1, indicates that the interaction term involving treatment, post-period effect, and MNE status yielded a coefficient of -1.321854. This statistically significant result ($p < 0.05$) highlights a considerable moderating influence of MNEs on the relationship between climatological disasters and the pursuit of RE innovation.

Furthermore, the meta-analysis consolidates these findings, revealing a notable moderating impact with an aggregated effect size of -0.569 ($p < 0.05$), as detailed in Table 5. This outcome suggests that foreign MNEs' subsidiaries generally exhibit a substantially reduced level of RE innovation following climatological disasters compared to domestic firms. The forest plot in Figure 9 complements these findings. It displays each study's effect size along with its confidence interval, providing a comprehensive view of individual contributions to the aggregated result. The I^2 statistic of 73.6%, along with a highly significant p-value (less than 0), indicates notable variability in the MNE status's moderating effect across various disasters. This variation implies that the specific nature of each disaster, along with potential differences in the structure and operational strategies of MNEs in different regions, might significantly affect these firms' behaviour following climatological disasters, in contrast to domestic firms. Such findings suggest that the effect of being a foreign MNE's subsidiary, as opposed to a domestic firm, is not uniform across all disaster types and may depend on a range of external and internal factors unique to each disaster or firm.

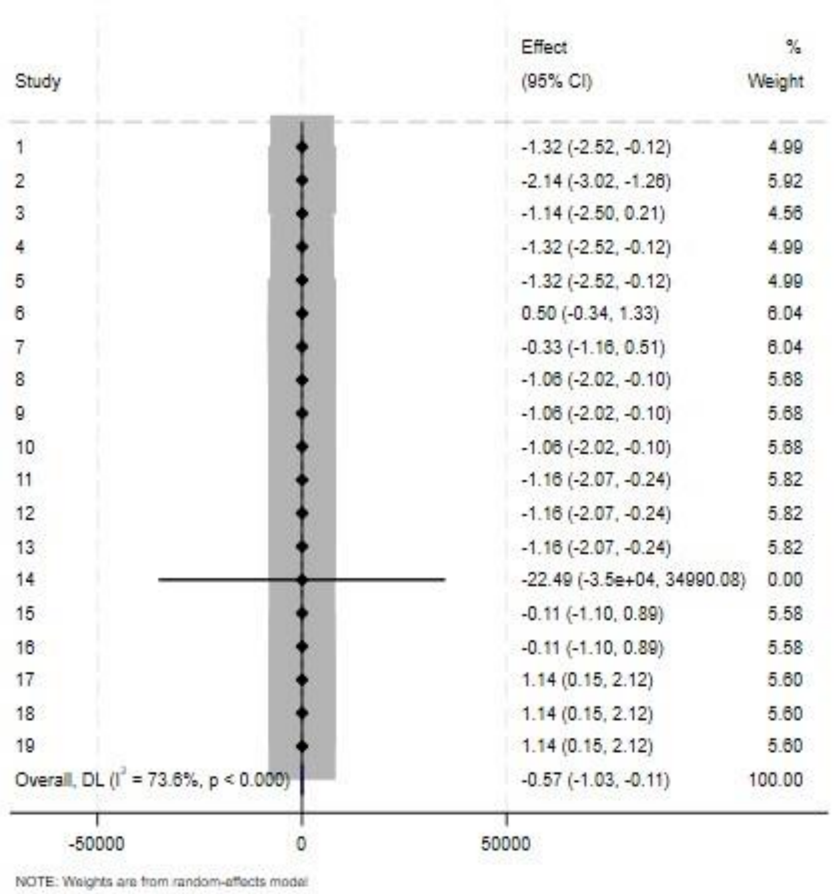
Table 7 Hypothesis 1c - DiD Results across 19 Disasters

Model	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
Innovation	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Treat	-0.3954	1.029322**	0.6333	-0.3954	-0.3954	0.9363892***	1.331359***	1.171153***	1.171153***	1.171153***	1.378348***	1.378348***	1.378348***	2.215821***	1.634001***	1.634001***	1.96238***	1.96238***	1.96238***
Period	1.053905***	1.376233***	1.263251***	1.053905***	1.053905***	-0.1067	-0.7630411***	-0.8610163***	-0.8610163***	-0.8610163***	-0.1306008***	-0.1306008***	-0.1306008***	-0.2746	-0.4066	-0.4066	-0.8181976***	-0.8181976***	-0.8181976***
MNE	2.163139***	1.237663***	1.628998***	2.163139***	2.163139***	1.552574***	1.741232***	2.2298***	2.2298***	2.2298***	1.560819***	1.560819***	1.560819***	1.967578***	1.144479**	1.144479**	1.240193**	1.240193**	1.240193**
Treat × Period	2.111115***	2.229486***	1.57603**	2.111115***	2.111115***	0.5489655*	0.9648321***	1.178974***	1.178974***	1.178974***	0.9291557***	0.9291557***	0.9291557***	1.166734***	0.3933	0.3933	0.3648	0.3648	0.3648
Treat × Period× MNE	-1.321854**	-2.139599***	-1.143744*	-1.321854**	-1.321854**	0.4961	-0.3277	-1.059575**	-1.059575**	-1.059575**	-1.155695**	-1.155695**	-1.155695**	-22.486	-0.1058	-0.1058	1.138208**	1.138208**	1.138208**
Size	0.164044**	0.1405644***	0.1866964***	0.164044**	0.164044**	0.2772066***	0.2520519***	0.1250803**	0.1250803**	0.1250803**	0.2866013***	0.2866013***	0.2866013***	0.2751133***	0.1928582***	0.1928582***	0.1937193***	0.1937193***	0.1937193***
Lifecycle																			
Decline	0.9859796**	1.180969***	1.293042***	0.9859796**	0.9859796**	0.4165	0.0879	0.4711	0.4711	0.4711	0.5338	0.5338	0.5338	1.268235***	1.001305***	1.001305***	0.8970069**	0.8970069**	0.8970069**
Growth	0.0737	0.3579	0.2826	0.0737	0.0737	0.4249723**	0.4811125**	0.294	0.294	0.294	0.1048	0.1048	0.1048	0.5543649**	0.0820935	0.0820935	0.017	0.017	0.017
Introduction	0.5038	0.6920512**	0.8149332**	0.5038	0.5038	0.7521342**	0.815577***	0.6610779**	0.6610779**	0.6610779**	1.100821***	1.100821***	1.100821***	1.196816***	0.325	0.325	0.723095**	0.723095**	0.723095**
Shakeout	0.6027	0.7561735**	0.9891683***	0.6027	0.6027	0.7038544**	0.7744055***	0.9999015***	0.9999015***	0.9999015***	0.7561607***	0.7561607***	0.7561607***	1.231738***	0.5214613*	0.5214613*	0.2862	0.2862	0.2862
Age	0.0225	0.0013	0.0172	0.0225	0.0225	-0.0078	-0.0128	0.0075	0.0075	0.0075	0.0135	0.0135	0.0135	-0.0217	0.0006	0.0006	-0.0008	-0.0008	-0.0008
Constant	-8.875548***	-7.969087***	-8.839017***	-8.875548***	-8.875548***	-9.854574***	-8.798528***	-6.816122***	-6.816122***	-6.816122***	-10.50413***	-10.50413***	-10.50413***	-9.607897***	-8.323371***	-8.323371***	-8.257596***	-8.257596***	-8.257596***
Wald χ^2	94.795	256.68	103.88***	94.795	94.795	74.35***	96.58***	104.25***	104.25***	104.25***	109.03***	109.03***	109.03***	96.58***	69.35***	69.35***	102.45***	102.45***	102.45***
N	3056	2800	2376	3056	3056	5668	4512	3452	3452	3452	4520	4520	4520	5460	5688	5688	5472	5472	5472

Note: *** p<.01, ** p<.05, * p<.1

Source: Author's analysis using STATA

Figure 9 Hypothesis 1c - Forest Plot of Meta Analysis



Source: Author's analysis using STATA

The fourth hypothesis (Hypothesis 1d) explores how natural disaster uncertainty moderates the relationship between climate change-induced natural disasters and the pursuit of RE innovation. The results of these individual DiD analyses are compiled in Table 8. For instance, the analysis for disaster D1 (column D1) shows that the interaction term involving treatment, post-period effect, and natural disaster uncertainty yielded a coefficient of -0.3243714, with a high level of statistical significance ($p < 0.001$). This significant effect suggests a moderating influence of disaster intensity on the relationship between climatological disasters and the pursuit of RE innovation.

Further expanding on these insights, the meta-analysis, as illustrated in Table 5, reveals an aggregated moderating effect size of -0.007 ($p < 0.001$). This outcome indicates that as the 'natural disaster uncertainty' increases, as measured by annual economic losses per capita, there tends to be a slightly reduced effect on the pursuit of RE innovation following a climatological disaster. The forest plot in Figure 10 presents these findings. It showcases the individual study effects and their confidence intervals, offering a holistic view of their contributions to the aggregated result. The I^2 statistic of 86.5%, along with a highly significant p-value (less than 0), suggests substantial variability in the effect of 'natural disaster uncertainty' on the pursuit of RE innovation post-disaster across different studies. This high degree of heterogeneity indicates that the specific characteristics of each climatological disaster play a crucial role in determining how it influences the pursuit of RE innovation following climate change-induced natural disasters. The results imply that the moderating effect of 'natural disaster uncertainty' on the pursuit of RE innovation post-disaster is not straightforward and may vary significantly depending on the context and scale of each disaster.

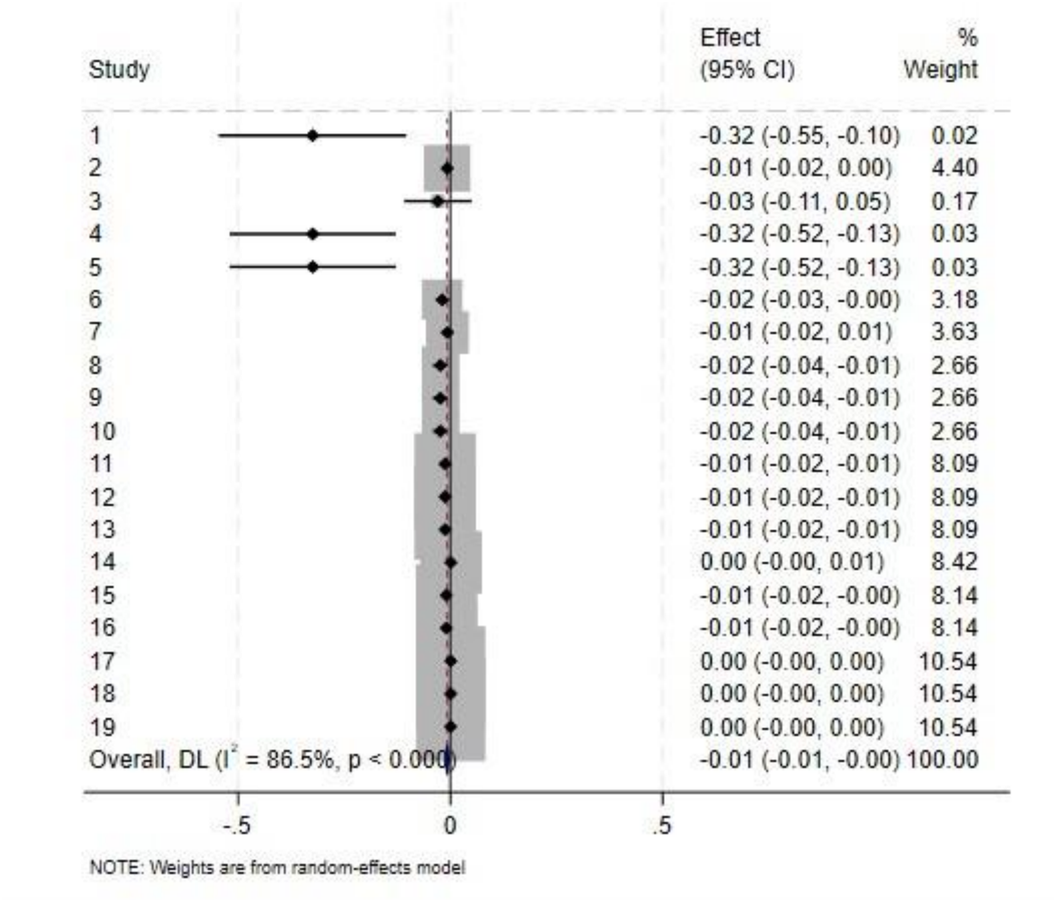
Table 8 Hypothesis 1d - DiD Results across 19 Disasters

Model	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
Innovation	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Treat	0.26	1.317062**	1.397043**	0.26	0.26	1.108732***	1.392663***	1.274035***	1.274035***	1.274035***	1.363496***	1.363496***	1.363496***	2.223918***	1.643194***	1.643194***	2.066943***	2.066943***	2.066943***
Period	1.218062***	1.420309***	1.360285***	1.218062***	1.218062***	0.077	-0.8379333***	-1.084947***	-1.084947***	-1.084947***	-0.31	-0.31	-0.31	-0.3272192*	-0.26	-0.26	-0.8256848***	-0.8256848***	-0.8256848***
Hazardrisk	0.0148855***	0.0106043*	0.0111225***	0.0148855***	0.0148855***	0.0104132**	0.0145395***	0.0178435***	0.0178435***	0.0178435***	0.0112917***	0.0112917***	0.0112917***	6E-04	0.0094804***	0.0094804***	-0	-0	-0
Treat × Period	1.838986***	1.313942**	0.864	1.838986***	1.838986***	0.5835568*	0.9084593***	1.222181***	1.222181***	1.222181***	1.098425***	1.098425***	1.098425***	0.8046139**	0.436	0.436	0.385	0.385	0.385
Treat × Period × Hazardrisk	-0.3243714***	-0.01	-0.03	-0.3243714***	-0.3243714***	-0.0189775**	-0.01	-0.0233303***	-0.0233303***	-0.0233303***	-0.0122119***	-0.0122119***	-0.0122119***	0.001	-0.0094662***	-0.0094662***	0.001	0.001	0.001
Size	0.1149621*	0.1488922***	0.1740689***	0.1149621*	0.1149621*	0.2413959***	0.2229129***	0.082	0.082	0.082	0.2637701***	0.2637701***	0.2637701***	0.2346078***	0.1831609***	0.1831609***	0.177642***	0.177642***	0.177642***
Lifecycle																			
Decline	0.7298701*	1.008338***	1.226113***	0.7298701*	0.7298701*	0.45	-0.1	0.311	0.311	0.311	0.542	0.542	0.542	1.197085***	0.9132221**	0.9132221**	0.6498794*	0.6498794*	0.6498794*
Growth	0.075	0.302	0.339	0.075	0.075	0.3713454*	0.4753414**	0.213	0.213	0.213	0.104	0.104	0.104	0.548727**	0.113	0.113	-0.01	-0.01	-0.01
Introduction	0.39	0.5473718*	0.9046146**	0.39	0.39	0.7699021**	0.8506104***	0.5939198*	0.5939198*	0.5939198*	1.016418***	1.016418***	1.016418***	1.090625***	0.202	0.202	0.6463285**	0.6463285**	0.6463285**
Shakeout	0.535	0.782129**	1.017118***	0.535	0.535	0.6973645**	0.7242931**	0.8600184***	0.8600184***	0.8600184***	0.7232834***	0.7232834***	0.7232834***	1.191053***	0.4775063*	0.4775063*	0.255	0.255	0.255
Age	0.026	4E-04	0.017	0.026	0.026	-0	-0.01	0.009	0.009	0.009	0.012	0.012	0.012	-0.02	-0	-0	6E-04	6E-04	6E-04
Constant	-7.740858***	-7.958242***	-8.536916***	-7.740858***	-7.740858***	-9.160815***	-8.129265***	-5.644031***	-5.644031***	-5.644031***	-9.847156***	-9.847156***	-9.847156***	-8.583894***	-8.144128***	-8.144128***	-7.805863***	-7.805863***	-7.805863***
Wald χ^2	91.72***	226.19***	87.98***	91.72***	91.72***	67.5***	95.59***	83.36***	83.36***	83.36***	110***	110***	110***	61.16***	76.21***	76.21***	91.64***	91.64***	91.64***
N	3056	2800	2376	3056	3056	5668	4512	3452	3452	3452	4520	4520	4520	5460	5688	5688	5472	5472	5472

Note: *** p<.01, ** p<.05, * p<.1

Source: Author's analysis using STATA

Figure 10 Hypothesis 1d - Forest Plot of Meta Analysis



Source: Author's analysis using STATA

The fifth hypothesis (Hypothesis 1e) delves into how a firm's history of natural disasters moderates the relationship between climate change-induced natural disasters and the firms' pursuit of RE innovation. This part of the study posits that a firm's past experiences with natural disasters profoundly influence its pursuit of RE innovation following such events. The results of these individual DiD analyses are compiled in Table 9. For instance, the DiD analysis for disaster D1, as indicated in column D1 of Table 9, shows that the interaction term including treatment, post-period effect, and the firm's history of natural disasters yielded a coefficient of -1.102324, with a highly significant p-value (< 0.001). This result suggests a moderating role of a firm's history of natural disasters on its pursuit of RE innovation following such events.

The meta-analysis consolidates these individual analyses, presenting an aggregated effect size of -0.349 (p < 0.001), as detailed in Table 5. This finding underscores the significant impact that a firm's history of natural disasters has on its pursuit of RE innovation post-climatological disaster. The results indicate that firms with a more extensive history of dealing with natural disasters tend to show a decreased level of RE innovation, as evidenced by the negative effect coefficient of -0.349. This finding implies that a firm's past experiences with natural disasters could lead to a more conservative approach, focusing on risk mitigation and resilience rather than pursuing RE innovation.

Figure 11 displays a forest plot illustrating the effect size of each study with its confidence interval, offering a representation of the individual contributions to the aggregated result. The I^2 statistic of 72.2% and a p-value of less than 0 reflect substantial variability in the moderating effect of a firm's history of natural disasters. The variability in these findings indicates that the specific nature and frequency of past disasters experienced by a firm, along with its learning and adaptive strategies, play a crucial role in shaping its behaviour following future climatological disasters.

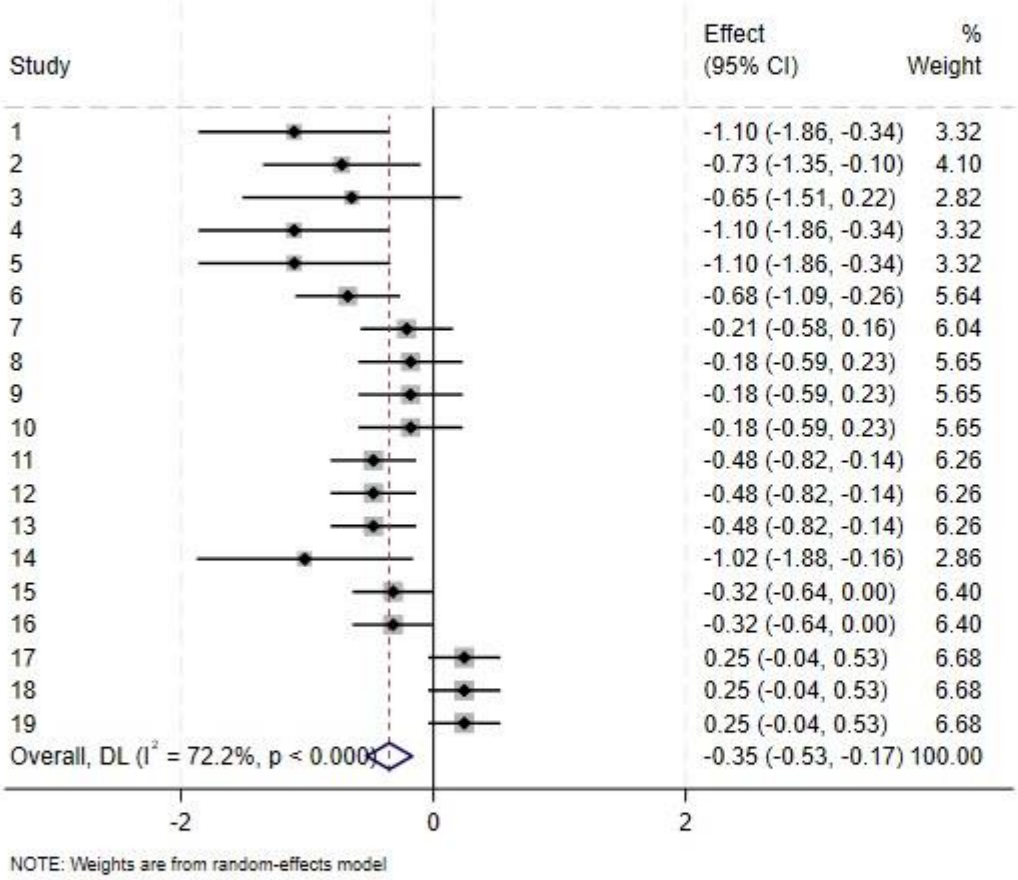
Table 9 Hypothesis 1e - DiD Results across 19 Disasters

Model	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
Innovation	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Treat	-0.37	1.733298***	1.232301*	-0.37	-0.37	0.5715578*	1.257561***	1.246859***	1.246859***	1.246859***	1.560026***	1.560026***	1.560026***	2.451718***	1.591944***	1.591944***	2.469392***	2.469392***	2.469392***
Period	0.8911312**	1.24832***	1.204707***	0.8911312**	0.8911312**	-0.18	-0.8210842***	-0.8758032***	-0.8758032***	-0.8758032***	-0.15	-0.15	-0.15	-0.4585963**	-0.4	-0.4	-0.8221459***	-0.8221459***	-0.8221459***
History	0.6374051***	0.4433474***	0.259	0.6374051***	0.6374051***	0.442384**	0.25	-0.09	-0.09	-0.09	-0.02	-0.02	-0.02	0.4330381***	0.092	0.092	-0.2990446**	-0.2990446**	-0.2990446**
Treat × Period	3.02216***	1.714113***	1.664	3.02216***	3.02216***	1.724036***	1.15712***	1.265624**	1.265624**	1.265624**	1.623492***	1.623492***	1.623492***	1.553935***	1.219295**	1.219295**	0.104	0.104	0.104
Treat × Period × History	-1.102324***	-0.7250856**	-0.65	-1.102324***	-1.102324***	-0.6782232***	-0.21	-0.18	-0.18	-0.18	-0.4756518***	-0.4756518***	-0.4756518***	-1.018829**	-0.3185462*	-0.3185462*	0.2455754*	0.2455754*	0.2455754*
Size	0.1234665*	0.1388135***	0.1729615***	0.1234665*	0.1234665*	0.2305949***	0.2200023***	0.0953556*	0.0953556*	0.0953556*	0.2693134***	0.2693134***	0.2693134***	0.2383821***	0.1869401***	0.1869401***	0.1877194***	0.1877194***	0.1877194***
Lifecycle																			
Decline	0.8629135*	1.011879***	1.270655***	0.8629135*	0.8629135*	0.31	0.071	0.409	0.409	0.409	0.525	0.525	0.525	1.251748***	0.9294192**	0.9294192**	0.7125811**	0.7125811**	0.7125811**
Growth	0.191	0.297	0.313	0.191	0.191	0.3673733*	0.4536746**	0.31	0.31	0.31	0.089	0.089	0.089	0.5646878**	0.061	0.061	0.024	0.024	0.024
Introduction	0.384	0.459	0.7595815**	0.384	0.384	0.8007278**	0.8253459***	0.6655695**	0.6655695**	0.6655695**	1.040438***	1.040438***	1.040438***	1.055259***	0.255	0.255	0.7012151**	0.7012151**	0.7012151**
Shakeout	0.509	0.7773221**	0.9365624**	0.509	0.509	0.7192781**	0.7694334***	0.9125534***	0.9125534***	0.9125534***	0.8187672***	0.8187672***	0.8187672***	1.220264***	0.456	0.456	0.272	0.272	0.272
Age	0.0341305*	-0	0.017	0.0341305*	0.0341305*	-0.01	-0.01	0.011	0.011	0.011	0.012	0.012	0.012	-0.02	-0	-0	0.002	0.002	0.002
Constant	-8.123359***	-8.010577***	-8.463084***	-8.123359***	-8.123359***	-9.015916***	-8.19601***	-5.773034***	-5.773034***	-5.773034***	-9.942637***	-9.942637***	-9.942637***	-9.125308***	-8.135963***	-8.135963***	-7.88746***	-7.88746***	-7.88746***
Wald χ^2	71.96***	223.73***	80.61***	71.96***	71.96***	71.1***	81.43***	60.76***	60.76***	60.76***	105.47***	105.47***	105.47***	83.28***	69.29***	69.29***	95.29***	95.29***	95.29***
N	3056	2800	2376	3056	3056	5668	4512	3452	3452	3452	4520	4520	4520	5460	5688	5688	5472	5472	5472

Note: *** p<.01, ** p<.05, * p<.1

Source: Author's analysis using STATA

Figure 11 Hypothesis 1e - Forest Plot of Meta Analysis



Source: Author's analysis using STATA

Shifting focus to the market-driven impacts of climate change on the pursuit of RE innovation in the context of climatological disasters, the research builds on three market constructs outlined in Chapter 3. These constructs are operationalised into Group 2 hypotheses, each aiming to explore the influence of a specific market construct on the pursuit of RE innovation following climatological disasters. The analysis is two-fold: it assesses the direct, nature-driven impacts of climatological disasters alongside the indirect, market-driven effects conveyed through these constructs.

The first hypothesis in Group 2 (Hypothesis 2a) explores the influence of peers' pursuit of RE innovation on a firm's own pursuit of RE innovation, particularly following climatological disasters. This hypothesis examines the competitive dynamics within the industry, focusing on how widespread pursuit of RE innovation among peer firms might affect an individual firm's pursuit of RE innovation. The findings from each of the 19 individual DiD studies, as shown in Table 10, offer insights into how the pursuit of RE innovation by peers interacts with the direct effects of different climatological disasters. These individual studies provide a detailed examination of the dynamics of each specific disaster.

To synthesise these individual analyses, a meta-analysis was conducted, the results of which are detailed in Table 5. This analysis reveals an overall effect size of -0.076, with a p-value of less than 0.001. The negative effect size suggests that as peers increase their pursuit of RE innovation, there is a corresponding decrease in the firm's innovation post-climatological disaster. The highly significant p-value underscores the robustness of this finding, indicating a substantial and statistically significant influence of peers' pursuit of RE innovation on a firm's innovation following a climatological disaster.

These findings are represented in Figure 12 through a forest plot, which illustrates the effect size and confidence intervals for each individual study. This representation allows for an easy and intuitive comparison of the contribution of each study to the overall meta-analytic finding. Moreover, the I^2 statistic, reported at 0.00% with a p-value of 0.660 for the Q-test, indicates a remarkably low level of heterogeneity among the study results. This low variability suggests a consistent pattern across the different analyses, reinforcing the support for the hypothesis that the competitive environment in terms of RE innovation plays a significant role in shaping a firm's innovation following climatological disasters.

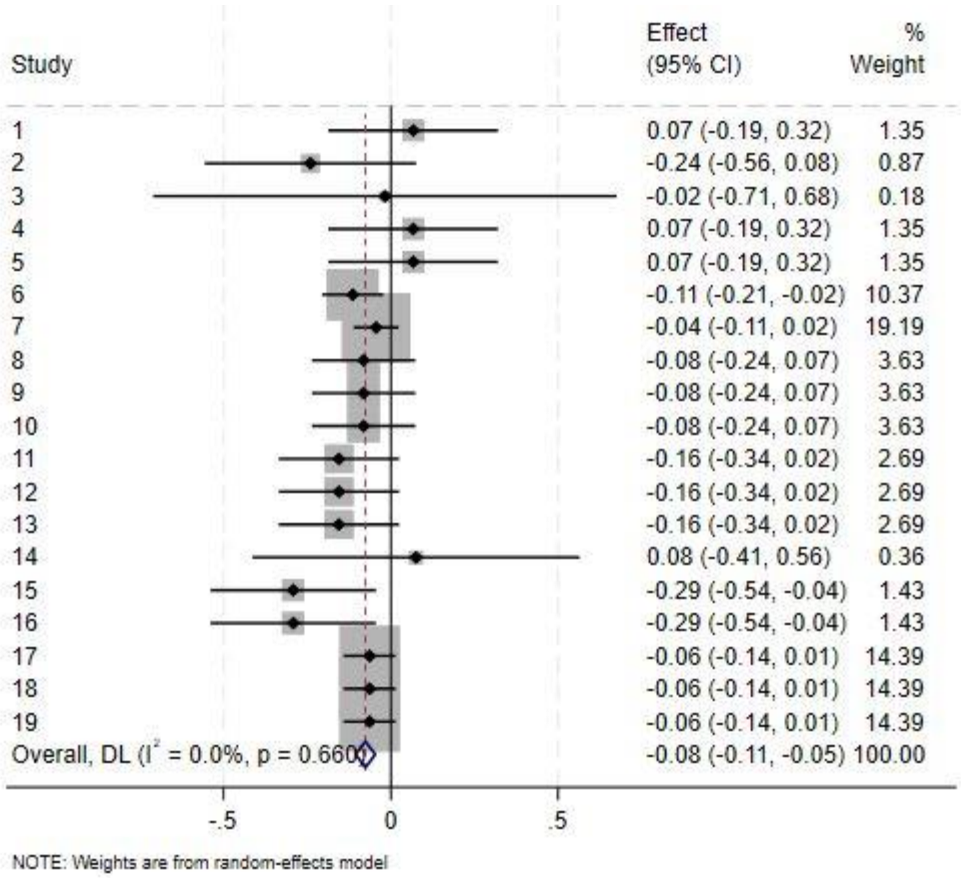
Table 10 Hypothesis 2a - DiD Results across 19 Disasters

Model	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
Innovation	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Treat	0.0863727	1.867602***	1.493455**	0.0863727	0.0863727	0.7385801**	1.103872***	1.108482***	1.108482***	1.108482***	1.457157***	1.457157***	1.457157***	2.236696***	1.710421***	1.710421***	1.826316***	1.826316***	1.826316***
Period	1.03717***	1.28295***	1.228891***	1.03717***	1.03717***	-0.2611062	-0.8514935***	-0.9721311***	-0.9721311***	-0.9721311***	-0.1184147	-0.1184147	-0.1184147	-0.3293165*	-0.3170627	-0.3170627	-0.9066394***	-0.9066394***	-0.9066394***
Peer	0.0089396	0.1565298***	0.1012684*	0.0089396	0.0089396	0.1552485***	0.1036204***	0.0727941	0.0727941	0.0727941	0.0584366	0.0584366	0.0584366	0.0957899**	0.0814119*	0.0814119*	0.0416612*	0.0416612*	0.0416612*
Treat x Period	1.343456**	1.030389**	0.696716	1.343456**	1.343456**	0.901977***	1.040793***	1.148627***	1.148627***	1.148627***	0.8503114**	0.8503114**	0.8503114**	0.9021579**	0.584317	0.584317	0.9968435***	0.9968435***	0.9968435***
Treat x Period x Peer	0.066834	-0.2403025	-0.0174986	0.066834	0.066834	-0.1138571**	-0.0438304	-0.0816846	-0.0816846	-0.0816846	-0.1552396*	-0.1552396*	-0.1552396*	0.0753821	-0.2918074**	-0.2918074**	-0.0633502	-0.0633502	-0.0633502
Size	0.1384578**	0.1588685***	0.1768284***	0.1384578**	0.1384578**	0.2167071***	0.2224439***	0.0991664*	0.0991664*	0.0991664*	0.2948009***	0.2948009***	0.2948009***	0.2645082***	0.22753***	0.22753***	0.2228095***	0.2228095***	0.2228095***
Lifecycle																			
Decline	0.85505*	0.9157833**	1.203839***	0.85505*	0.85505*	0.2235578	-0.0593668	0.3484993	0.3484993	0.3484993	0.3746508	0.3746508	0.3746508	1.180118***	1.128675***	1.128675***	0.8203736**	0.8203736**	0.8203736**
Growth	0.1132705	0.2395929	0.320023	0.1132705	0.1132705	0.4117694**	0.386144*	0.2217963	0.2217963	0.2217963	0.0485308	0.0485308	0.0485308	0.5725117**	0.1620011	0.1620011	-0.0208443	-0.0208443	-0.0208443
Introduction	0.3920236	0.3211223	0.602668	0.3920236	0.3920236	0.6169226*	0.807882***	0.5774597*	0.5774597*	0.5774597*	1.033977***	1.033977***	1.033977***	1.087719***	0.402361	0.402361	0.3845684	0.3845684	0.3845684
Shakeout	0.3788322	0.6473625*	0.7988631**	0.3788322	0.3788322	0.4580631	0.5869787*	0.7286671**	0.7286671**	0.7286671**	0.8046309***	0.8046309***	0.8046309***	1.18064***	0.6285019**	0.6285019**	0.1428658	0.1428658	0.1428658
Age	0.0295324	-0.0029659	0.0116526	0.0295324	0.0295324	-0.0095724	-0.0095213	0.0142586	0.0142586	0.0142586	0.0102842	0.0102842	0.0102842	-0.0218854	0.0032188	0.0032188	-0.0037702	-0.0037702	-0.0037702
Constant	-7.968491***	-8.081797***	-8.327958***	-7.968491***	-7.968491***	-8.449548***	-8.069858***	-5.958117***	-5.958117***	-5.958117***	-10.51383***	-10.51383***	-10.51383***	-9.272861***	-9.207563***	-9.207563***	-8.700786***	-8.700786***	-8.700786***
Wald χ^2	68.08	208.39	71.28	68.08	68.08	61.93	80.51	51.52	51.52	51.52	93.34	93.34	93.34	70.69	64.03	64.03	93.15	93.15	93.15
N	3031	2753	2338	3031	3031	5555	4422	3402	3402	3402	4450	4450	4450	5386	5609	5609	5403	5403	5403

Note: *** p<.01, ** p<.05, * p<.1

Source: Author's analysis using STATA

Figure 12 Hypothesis 2a - Forest Plot of Meta Analysis



Source: Authors analysis using STATA

The second hypothesis in Group 2 (Hypothesis 2b) investigates how investor sentiment influences the pursuit of RE innovation following climatological disasters. Table 11 presents the results of the DiD analyses for each of the 19 disasters. These findings illuminate the interaction between investor sentiment and the immediate impacts of climatological disasters, potentially influencing the direction and efficacy of RE innovation in regions affected by these disasters. This examination offers a nuanced perspective on the interplay between market forces and environmental factors in shaping firms' pursuit of RE innovation.

To synthesise the results from all 19 DiD studies, a meta-analysis was conducted. This meta-analysis indicates an overall effect size of 0.007. However, the associated p-value, exceeding 0.01 as detailed in Table 5, suggests that the cumulative evidence from these studies does not support the hypothesis that investor sentiment significantly influences the pursuit of RE innovation post-climatological disasters. This inference is supported in Figure 13 through a forest plot, which graphically represents the effect size and confidence interval of each contributing study. This presentation enables a clear visualisation of each study's individual impact on the collective effect. Additionally, the I^2 statistic stands at 0.00%, with a p-value of 0.598 for the Q-test. This low I^2 value, coupled with the p-value, indicates a lack of significant variability among the study results, suggesting a high level of consistency across the different analyses. This homogeneity, however, does not translate into a strong collective endorsement of the initial hypothesis, indicating a more complex relationship between investor sentiment and the pursuit of RE innovation in the context of climatological disasters.

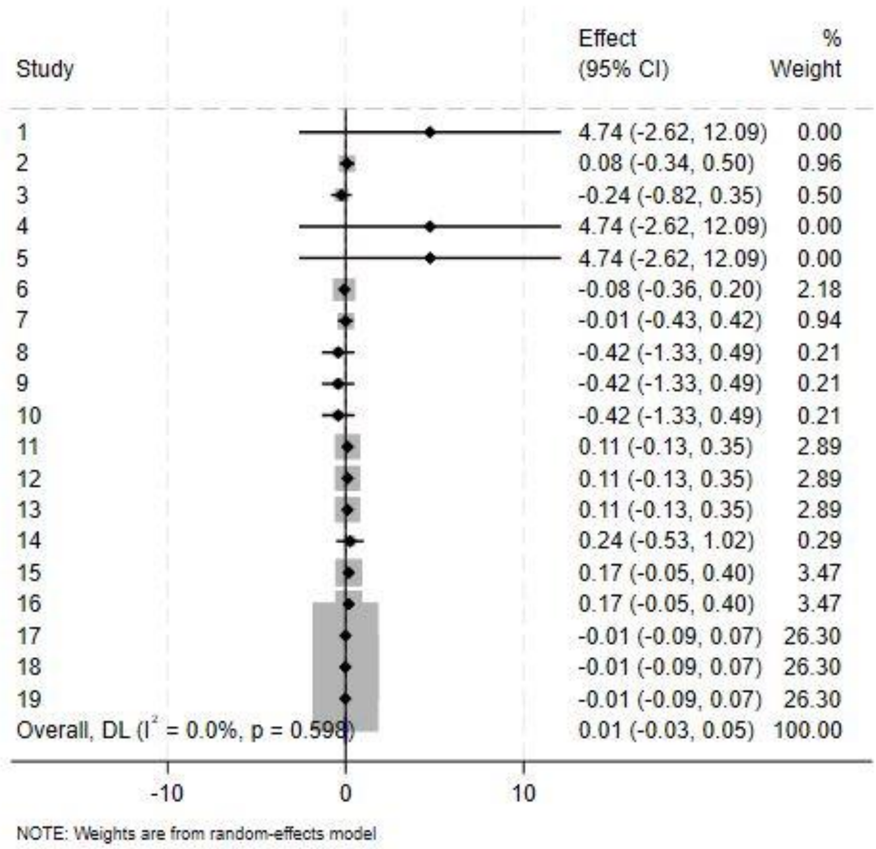
Table 11 Hypothesis 2b - DiD Results across 19 Disasters

Model	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
Innovation	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Treat	0.07986	1.862601***	1.467385**	0.07986	0.07986	0.8572634***	1.279915***	1.13251***	1.13251***	1.13251***	1.527361***	1.527361***	1.527361***	2.206982***	1.7493*	1.7493*	2.006115***	2.006115***	2.006115***
Period	1.071968***	1.432335***	1.317614***	1.071968***	1.071968***	-0.08791	-0.7876474***	-0.9277478***	-0.9277478***	-0.9277478***	-0.11773	-0.11773	-0.11773	-0.3277523*	-0.35554	-0.35554	-0.9166575***	-0.9166575***	-0.9166575***
Investor	-3.30297	0.049	0.088181	-3.30297	-3.30297	-0.01075	-0.04375	0.002627	0.002627	0.002627	0.001655	0.001655	0.001655	0.002281	0.000856	0.000856	0.000802	0.000802	0.000802
Treat x Period	1.306842**	0.792665	0.729396	1.306842**	1.306842**	0.6953178**	0.9582061***	1.073938***	1.073938***	1.073938***	0.5889868*	0.5889868*	0.5889868*	0.8396501*	0.223151	0.223151	0.7557658**	0.7557658**	0.7557658**
Treat x Period x Investor	4.739492	0.078763	-0.23561	4.739492	4.739492	-0.07928	-0.00515	-0.42023	-0.42023	-0.42023	0.109565	0.109565	0.109565	0.242472	0.173033	0.173033	-0.01406	-0.01406	-0.01406
Size	0.1598238**	0.1573519***	0.181302***	0.1598238**	0.1598238**	0.2319405***	0.2480882***	0.098373	0.098373	0.098373	0.2997626***	0.2997626***	0.2997626***	0.27221***	0.2202722***	0.2202722***	0.2287703***	0.2287703***	0.2287703***
Lifecycle																			
Decline	0.9947748**	0.9961473***	1.336247***	0.9947748**	0.9947748**	0.280926	-0.00397	0.369981	0.369981	0.369981	0.402644	0.402644	0.402644	1.170217***	1.048727**	1.048727**	0.566416	0.566416	0.566416
Growth	0.137999	0.251075	0.341833	0.137999	0.137999	0.4145684**	0.4326177*	0.230091	0.230091	0.230091	0.021307	0.021307	0.021307	0.5591337**	0.073717	0.073717	-0.0258	-0.0258	-0.0258
Introduction	0.424864	0.392811	0.6918963*	0.424864	0.424864	0.6178186*	0.7858652***	0.596714*	0.596714*	0.596714*	1.152819***	1.152819***	1.152819***	1.217718***	0.351576	0.351576	0.6309912*	0.6309912*	0.6309912*
Shakeout	0.324495	0.6238942*	0.8082301*	0.324495	0.324495	0.436741	0.5686746*	0.7245746**	0.7245746**	0.7245746**	0.7538057***	0.7538057***	0.7538057***	1.207798***	0.414437	0.414437	0.157459	0.157459	0.157459
Age	0.032491	-0.00193	0.01241	0.032491	0.032491	-0.00913	-0.01206	0.015448	0.015448	0.015448	0.010769	0.010769	0.010769	-0.02345	0.001878	0.001878	-0.00377	-0.00377	-0.00377
Constant	-8.436211***	-8.072161***	-8.467871***	-8.436211***	-8.436211***	-8.676682***	-8.472987***	-5.92518***	-5.92518***	-5.92518***	-10.57974***	-10.57974***	-10.57974***	-9.312002***	-8.881096***	-8.881096***	-8.806989***	-8.806989***	-8.806989***
Wald χ^2	66.89	194.37	67.27	66.89	66.89	51.35	73.1	51.15	51.15	51.15	89.01	89.01	89.01	63.96	60.88	60.88	87.53	87.53	87.53
N	3031	2753	2338	3031	3031	5555	4422	3402	3402	3402	4450	4450	4450	5386	5609	5609	5403	5403	5403

Note: *** p<.01, ** p<.05, * p<.1

Source: Author's analysis using STATA

Figure 13 Hypothesis 2b - Forest Plot of Meta Analysis



Source: Author's analysis using STATA

The last hypothesis in Group 2 (Hypothesis 2c) focuses on the role of media coverage as a market construct influencing the pursuit of RE innovation following climatological disasters. This hypothesis examines how media attention, particularly following climatological disasters, affects the pursuit of RE innovation within firms. It proposes that enhanced media coverage of a firm's climate change impacts can dampen the positive influence on the pursuit of RE innovation in firms that experience such disasters. The study's findings, detailed in Table 12, shed light on the interaction between media coverage and the effects of climatological disasters, potentially affecting the direction and effectiveness of RE innovation in affected regions.

To aggregate the findings from all 19 DiD studies, a meta-analysis was conducted, revealing an overall effect size of 0.086. However, as Table 5 indicates, the p-value exceeding 0.01 suggests that the collective evidence from these studies does not support the hypothesis of the significant influence of media coverage on the pursuit of RE innovation post-climatological disasters. This conclusion is reinforced in Figure 14 with a forest plot, which displays the effect size and confidence interval for each study, allowing for an intuitive understanding of each study's individual contribution to the overall effect. Furthermore, the I^2 statistic is reported at 0.00%, with a p-value of 0.828 for the Q-test, underscoring the lack of significant heterogeneity among the studies.

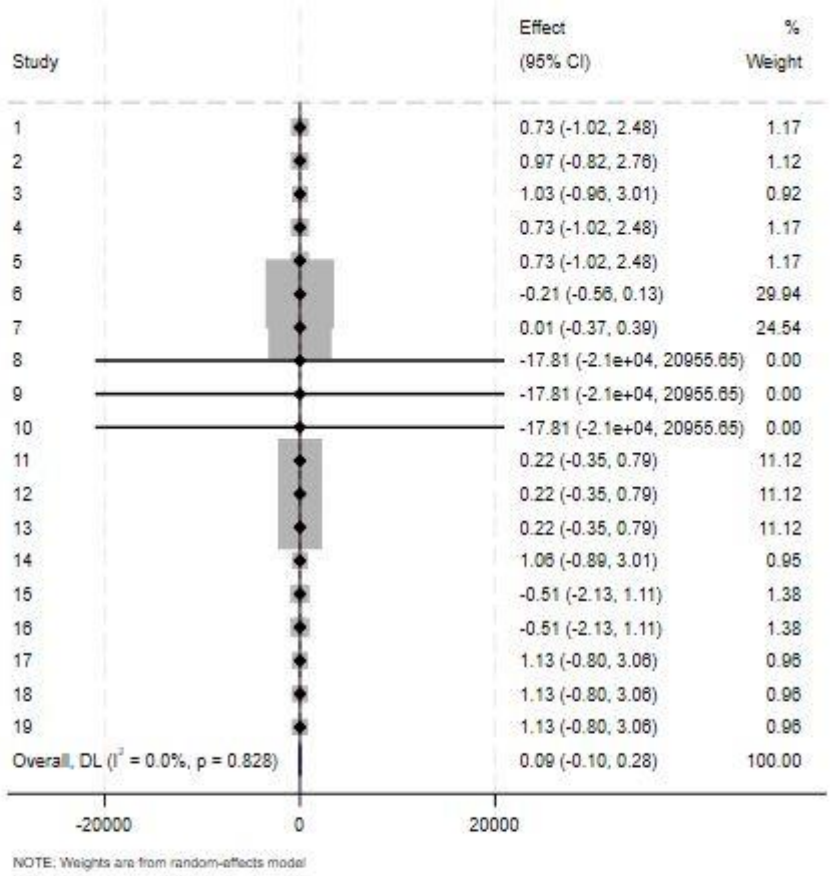
Table 12 Hypothesis 2c - DiD Results across 19 Disasters

Model	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
Innovation	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Treat	0.068255	1.853665***	1.489592**	0.068255	0.068255	0.837772***	1.275297***	1.130466***	1.130466***	1.130466***	1.541968***	1.541968***	1.541968***	2.21198***	1.748312***	1.748312***	2.009986***	2.009986***	2.009986***
Period	1.051715***	1.446462***	1.326924***	1.051715***	1.051715***	-0.087178	-0.7936298***	-0.9257727***	-0.9257727***	-0.9257727***	-0.110443	-0.110443	-0.110443	-0.3252791*	-0.356911	-0.356911	-0.9158875***	-0.9158875***	-0.9158875***
Media	-0.581851	-0.833408	-0.891742	-0.581851	-0.581851	0.0533716	-0.144008	-0.071556	-0.071556	-0.071556	-0.079713	-0.079713	-0.079713	-0.051387	0.0932825	0.0932825	-0.003735	-0.003735	-0.003735
Treat x Period	1.3909**	0.7861452	0.5896334	1.3909**	1.3909**	0.7467948**	0.9728405***	1.072271***	1.072271***	1.072271***	0.5814894*	0.5814894*	0.5814894*	0.8736331**	0.3390612	0.3390612	0.7194147**	0.7194147**	0.7194147**
Treat x Period x Media	0.7307412	0.9661876	1.025044	0.7307412	0.7307412	-0.213562	0.009823	-17.80983	-17.80983	-17.80983	0.2189159	0.2189159	0.2189159	1.058247	-0.509463	-0.509463	1.130413	1.130413	1.130413
Size	0.1450351**	0.1659092***	0.1844836***	0.1450351**	0.1450351**	0.2402979***	0.261007***	0.1072094*	0.1072094*	0.1072094*	0.3062223***	0.3062223***	0.3062223***	0.2822039***	0.2095995***	0.2095995***	0.2320553***	0.2320553***	0.2320553***
Lifecycle																			
Decline	0.8966315*	1.067864***	1.310476***	0.8966315*	0.8966315*	0.4161324	0.1384425	0.3714113	0.3714113	0.3714113	0.4081667	0.4081667	0.4081667	1.161302***	1.000303**	1.000303**	0.5677137	0.5677137	0.5677137
Growth	0.1600707	0.3036448	0.3676087	0.1600707	0.1600707	0.3794165*	0.4306568*	0.2563129	0.2563129	0.2563129	0.0310269	0.0310269	0.0310269	0.5781177**	0.0597848	0.0597848	-0.011807	-0.011807	-0.011807
Introduction	0.4494362	0.4557516	0.7122224*	0.4494362	0.4494362	0.6290318*	0.7846997***	0.614629*	0.614629*	0.614629*	1.144026***	1.144026***	1.144026***	1.250272***	0.3562757	0.3562757	0.6111828*	0.6111828*	0.6111828*
Shakeout	0.4185861	0.6726651*	0.8184284*	0.4185861	0.4185861	0.4394977	0.5790779*	0.7404445**	0.7404445**	0.7404445**	0.7424902***	0.7424902***	0.7424902***	1.216695***	0.4291631	0.4291631	0.1415468	0.1415468	0.1415468
Age	0.0308412	-2.19E-05	0.0140418	0.0308412	0.0308412	-0.009856	-0.012636	0.014445	0.014445	0.014445	0.0109746	0.0109746	0.0109746	-0.022692	0.0009173	0.0009173	-0.004006	-0.004006	-0.004006
Constant	-8.127015***	-8.283281***	-8.536662***	-8.127015***	-8.127015***	-8.845704***	-8.723939***	-6.089793***	-6.089793***	-6.089793***	-10.69941***	-10.69941***	-10.69941***	-9.525814***	-8.664123***	-8.664123***	-8.869428***	-8.869428***	-8.869428***
Wald χ^2	67.98	193.58	67.65	67.98	67.98	52.94	74.19	51.45	51.45	51.45	87.73	87.73	87.73	64.51	59.98	59.98	87.34	87.34	87.34
N	3031	2753	2338	3031	3031	5555	4422	3402	3402	3402	4450	4450	4450	5386	5609	5609	5403	5403	5403

Note: *** p<.01, ** p<.05, * p<.1

Source: Author's analysis using STATA

Figure 14 Hypothesis 2c - Forest Plot of Meta Analysis



Source: Author's analysis using STATA

4.4. Research Quality Results

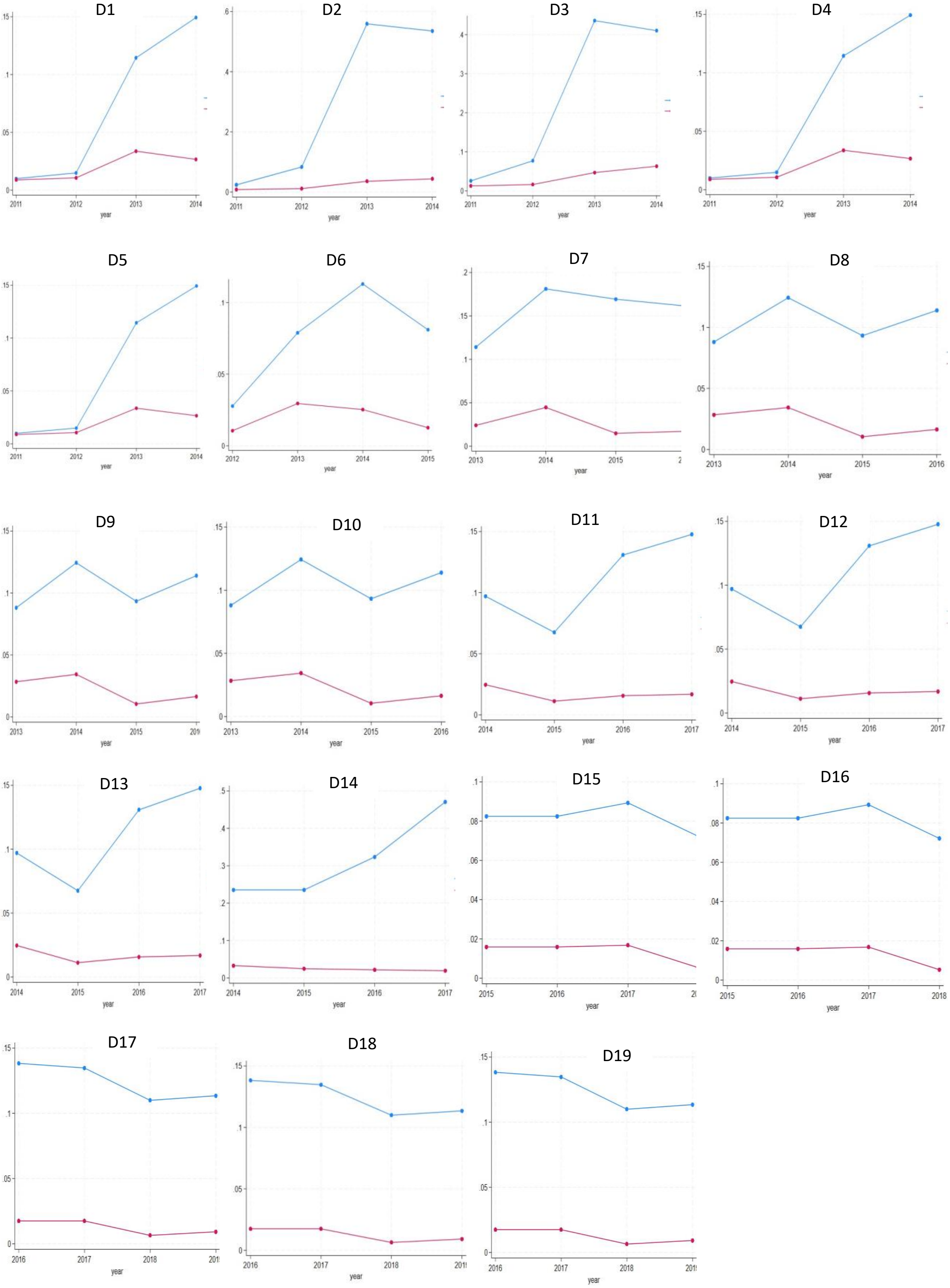
4.4.1. Parallel Trend Assumption

The effectiveness of the DiD methodology significantly depends on the critical parallel trend assumption (Habibi & Feld, 2020). This fundamental assumption posits that prior to any intervention, treatment and control groups should exhibit parallel trends in outcome performance. In simpler terms, it signifies that, in the absence of the intervention, both groups would have undergone similar changes in their outcomes, even if their baseline levels differed (Ryan et al., 2015). This section is dedicated to the empirical validation of this pivotal assumption, achieved through the application of the parallel trend plot method, as described in the methodology section.

To scrutinise the parallel trend assumption, this research employed parallel trend plots, a visual tool that vividly portrays the evolutionary trajectory of the outcome variable—RE innovation, in this case—across time for both the treatment and control groups. These plots serve as valuable instruments to assess whether the parallel trend assumption is valid (Fan & Zheng, 2020). Given that this study encompasses 19 distinct DiD analyses, each corresponding to a specific climatological disaster identified during the study period, the researcher meticulously crafted 19 individual plots. Each plot underscores the trend for a particular disaster, ensuring an evaluation of whether DiD analysis is appropriate for each analysis. Figure 15 offers a consolidated view of the parallel trend plots for all 19 identified disasters, each designated by a unique name.

Within each plot, the blue line corresponds to the trend observed in the treatment group, whereas the red line depicts the trend in the control group. The Y-axis represents RE innovation measured by the number of RE patent applications, while the X-axis displays the years before and after each disaster. The initial two years constitute the pre-treatment period, followed by the subsequent two years post-treatment. When assessing the parallel trend assumption, particular emphasis is placed on the trend during the first two years, which comprise the pre-treatment period. These graphical representations provide a clear depiction of the trajectories observed in both groups concerning RE innovation for each specific disaster. They offer a visual narrative of how RE innovation has evolved over time, illustrating the impact of each distinct disaster on the trajectory of innovation.

Figure 15 Parallel Trend Plots



Source: Author's analysis using STATA

Another assumption of the DiD methodology is known as the common shock assumption, which contemplates the impact of concurrent events that could potentially influence the outcomes of the study. These events, occurring either during or subsequent to the disaster being analysed, pose a risk of confounding the results, casting doubt on the causal relationships established (Dimick & Ryan, 2014). To address and mitigate this concern, this study incorporated the use of multiple treatment studies (19 disasters), encompassing a diverse array of treatment and control groups across various pre- and post-treatment periods. This methodological strategy enhanced the robustness of the findings by reducing the potential influence of extraneous common shocks, thus ensuring a more accurate and reliable interpretation of the data (Meyer, 1995). By systematically varying both the groups and the timing of observations, the researcher strengthened the validity of the DiD analysis, affirming the integrity and credibility of the insights derived from the research.

4.4.2. Model Specification Test

In the pursuit of a robust analysis within the context of this research on the effect of climate change impacts on firms' pursuit of RE innovation, the researcher considered it imperative to rigorously examine the specification of the Poisson regression model. Model specification is a fundamental aspect of econometric analysis, as it directly influences the reliability and validity of research findings. To ensure that the Poisson regression model accurately encapsulates the intricate relationships between explanatory variables and the number of RE patent applications, the researcher applied Ramsey's RESET (Duc Dung et al., 2021; Fuinhas & Marques, 2012).

The results of Ramsey's RESET, displayed in Table 13, hold significant implications for the validation of the Poisson regression model's specification. This diagnostic test scrutinises the null hypothesis, which suggests that the model has no omitted essential variables. When the p-value derived from the RESET test falls below the critical threshold of 0.05, the null hypothesis is rejected, indicating the presence of omitted variables in the model. On the other hand, if the p-value exceeds or equals 0.05, the null hypothesis remains unchallenged, implying the absence of omitted variables. The analysis of RESET test results for all 19 models examined in this study reveals that the Poisson regression model, when applied, was correctly specified. This reassuring outcome underscores the model's ability to capture the underlying data-generating process, reinforcing the integrity of the estimated coefficients and, by extension, the validity and reliability of the research findings.

Table 13 Results of Robustness Tests

Tests	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
Ramsey's RESET test (F value)	10.68	49.88	9.77	10.68	10.68	11.54	17.66	13.29	13.29	13.29	17.56	17.56	17.56	31.49	12.27	12.27	32.12	32.12	32.12
Overdispersion test (t value)	2.66**	0.22	0.88	2.66**	2.66**	4.12**	3.91**	0.76	0.76	0.76	5.00**	5.00**	5.00**	2.62**	2.86**	2.86**	7.84**	7.84**	7.84**
Hausman specification test (Chi-square)	0.59	13.89	-1.05	0.59	0.59	-15	3.711	-0.96	-0.96	-0.96	0.296	0.296	0.296	-1.93	0.454	0.454	-8.93	-8.93	-8.93

Note: *** p<.01, ** p<.05, * p<.1

Source: Author's analysis using STATA

4.4.3. Overdispersion Test

In this section, the researcher delves into the results of an overdispersion test that was conducted to scrutinise the robustness of the statistical models. Overdispersion can sometimes challenge the assumptions of a standard Poisson regression model, raising important questions about the suitability of the chosen analytical approach.

To evaluate the presence of overdispersion, the researcher conducted an overdispersion test, the results of which are presented in Table 13. In this test, the null hypothesis posits equidispersion. If the p-value is less than 0.05, the null hypothesis is rejected, indicating the presence of overdispersion. Conversely, if the p-value is greater than or equal to 0.05, the null hypothesis is not rejected, signifying that equidispersion is present, making the Poisson regression a suitable choice for the analysis.

Regarding the presence of overdispersion, except for D2, D3, D8, D9, and D10, the model for the rest of the disasters exhibits overdispersion. However, it is important to emphasise that this study does not aim to estimate the probabilities of specific count values (such as the probability of zero patent applications). Therefore, it is acceptable to utilise Poisson regression with random effects, as this approach is robust to overdispersion (Wooldridge, 1999). This allowed the researcher to proceed with the analysis confidently, even in the presence of overdispersion in the model for some disasters.

4.4.4. Panel Data Model

In this section, the researcher focuses on an important decision: choosing the appropriate panel data model for the analysis. This involves a choice between fixed effect and random effect models, determined by the widely-used Hausman test. The Hausman test helps identify the model that best aligns with the data and research objectives of the study. During this test, if the p-value exceeds 0.05, it indicates that the random effect model is more suitable than the fixed effect model (Almaqtari et al., 2019).

A comprehensive analysis of the Hausman test results, covering 19 models for the studied disasters as presented in Table 13, strongly suggested that the random effect model is the more fitting choice for this study. In all of these models, the p-value surpasses the 0.05 threshold. Furthermore, the random effect model provides the distinct advantage of accommodating the effects of multiple observations per firm, an essential consideration for this analysis. This model handles time-invariant variables across the sample period, such as the presence of foreign MNEs' subsidiaries. In contrast, the fixed effect model often excludes these vital time-invariant variables, rendering it less suitable for the specific analytical objectives of this research (Mithani, 2017).

4.4.5. Variance Inflation Factor (VIF)

Multicollinearity can pose a significant challenge in interpreting the results of a regression model. When explanatory variables are highly correlated, it becomes difficult to discern their individual contributions to the dependent variable. The model may struggle to attribute the variation in the outcome variable accurately, potentially leading to unreliable coefficient estimates and inflated standard errors.

To assess the presence of multicollinearity in the models, the researcher conducted a VIF analysis. The results of this analysis, encompassing 19 models related to the studied disasters, are presented in Table 14. It is important to note that the critical value of VIF to test for multicollinearity is typically set at 10 (Shan & Troshani, 2014). The results show that the highest average VIF among 19 models is 2.21, which comfortably falls below the widely recognised threshold of 10 that studies suggest as an indication of potential multicollinearity problems (Shan & Troshani, 2014; Un, 2016). These findings serve as a testament to the reliability and soundness of the analysis in this study. By effectively addressing multicollinearity, the researcher could trust that the coefficients derived from the models are robust and dependable, ensuring that the results are both accurate and trustworthy.

Table 14 VIF Test Results

Variable	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF	VIF
Treat	2.3	2.63	2.14	2.3	2.3	3.19	2.13	2.22	2.22	2.22	2.28	2.28	2.28	2.02	2.52	2.52	3.02	3.02	3.02
Period	1.43	1.22	1.15	1.43	1.43	1.55	1.31	1.31	1.31	1.31	1.29	1.29	1.29	1.08	1.28	1.28	1.27	1.27	1.27
Treat × Period	2.38	2.14	2.08	2.38	2.38	2.66	2.54	2.48	2.48	2.48	2.7	2.7	2.7	2.03	6.24	6.24	2.5	2.5	2.5
Size	1.51	1.53	1.54	1.51	1.51	1.51	1.52	1.49	1.49	1.49	1.55	1.55	1.55	1.53	1.57	1.57	1.58	1.58	1.58
Lifecycle base: Advanced																			
Lifecycle: Decline	1.33	1.33	1.33	1.33	1.33	1.28	1.31	1.29	1.29	1.29	1.34	1.34	1.34	1.31	1.38	1.38	1.38	1.38	1.38
Lifecycle: Growth	1.29	1.3	1.29	1.29	1.29	1.21	1.2	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.2	1.2	1.2	1.2	1.2
Lifecycle: Introduction	1.71	1.72	1.7	1.71	1.71	1.56	1.57	1.55	1.55	1.55	1.63	1.63	1.63	1.59	1.6	1.6	1.6	1.6	1.6
Lifecycle: Shakeout	1.16	1.16	1.16	1.16	1.16	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.14	1.14	1.14	1.14	1.14
Age	1.05	1.04	1.05	1.05	1.05	1.07	1.05	1.05	1.05	1.05	1.07	1.07	1.07	1.06	1.1	1.1	1.12	1.12	1.12
Gap	1.07	1.07	1.06	1.07	1.07	1.02	1.02	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
MNE	1.11	1.4	1.15	1.11	1.11	1.03	1.02	1.02	1.02	1.02	1.04	1.04	1.04	1.01	1.04	1.04	1.02	1.02	1.02
Hazardrisk	1.07	1.2	1.06	1.07	1.07	1.19	1.17	1.15	1.15	1.15	1.72	1.72	1.72	1.41	6.24	6.24	1.88	1.88	1.88
History	1.28	1.08	1.1	1.28	1.28	2.31	1.3	1.42	1.42	1.42	1.6	1.6	1.6	1.39	2.42	2.42	2.61	2.61	2.61
Mean VIF	1.44	1.45	1.37	1.44	1.44	1.59	1.4	1.41	1.41	1.41	1.51	1.51	1.51	1.37	2.21	2.21	1.64	1.64	1.64

Source: Author's analysis using STATA

4.5. Chapter Summary

This chapter unveiled the empirical findings of the study, exploring the intricate link between climate change impacts and the pursuit of RE innovation by firms. The foundation for this analysis was established in Chapter 3, through a detailed methodological framework that prepared the ground for a thorough empirical investigation. The emphasis here was on understanding the effects of climate change-induced natural disasters on the pursuit of RE innovation by firms and examining the roles of four critical moderators in this context. Additionally, it investigated how market dynamics influence the impact of these climatological disasters on firms' pursuit of RE innovation. The descriptive statistics offered a comprehensive picture, extending beyond the geographic location and severity of climatological disasters. This section delved into a wide array of variables essential for grasping the dynamics at play, providing a deep dive into both the dependent and independent variables critical to testing the hypotheses.

At the heart of this chapter was the hypothesis testing, utilising the DiD method alongside meta-analysis to consolidate findings from various climatological disasters. This approach facilitated a detailed examination of how climatological disasters, coupled with the moderating effects of market forces, influence firms' pursuit of RE innovation. The findings generally indicated a positive effect of these disasters on the pursuit of RE innovation. They also highlighted the significant moderating role of peer actions. Notably, an analysis of the four moderators revealed how both internal and external factors within firms adjust the impact of climate change-induced natural disasters on the pursuit of RE innovation. Furthermore, the chapter addressed key research quality aspects, such as verifying the parallel trend assumption, model specification, addressing overdispersion, selecting the appropriate panel data model via the Hausman test, and assessing multicollinearity through VIF analysis. These measures guaranteed the thoroughness and reliability of the findings, instilling confidence in the drawn conclusions.

In summary, this chapter not only delivered an exhaustive empirical exploration of how climate change-induced natural disasters propel firms toward the pursuit of RE innovation but also illuminated the multifaceted nature of these relationships. Through this detailed empirical exploration, the study enriches the dialogue on environmental sustainability and corporate innovation, setting a foundation for subsequent research to expand on these insights.

5. Chapter 5 Discussion

5.1. Introduction

Chapter 5 opens the floor for a detailed discussion on the effects of climate change-induced natural disasters on the pursuit of RE innovation by firms and the moderating roles of market-driven impacts in this intricate relationship. This chapter revisits the research questions and hypotheses, analyses the present findings, and compares these insights with existing literature.

The discussion integrates the empirical findings to explore how climate change-induced natural disasters affect firms' pursuit of RE innovation. It also aims to deepen understanding of how environmental and market factors interact to shape firms' pursuit of RE innovation. Through a structured analysis, the chapter contributes to the broader conversation on sustainable corporate practices, highlighting the complex interplay between climate change impacts and the pursuit of RE innovation.

In essence, this chapter sets the stage for an insightful exploration of the dynamics between climate change impacts and firms' pursuit of RE innovation, offering a foundation for future work to build upon in the quest for sustainable development and corporate adaptation to environmental challenges.

5.2. Overview of Research Questions and Hypotheses

This section revisits the core research question and hypotheses that have guided this investigation into the relationship between climate change impacts and firms' pursuit of RE innovation. The core research question delved into understanding the effect of climate change impacts on a firm's pursuit of RE innovation. The study dissected this broad question into more specific sub-questions, addressing the dimensions of climate change impacts. Based on the BTOF, the study explored the influence of nature-driven impacts and market-driven impacts on firms' pursuit of RE innovation.

The researcher began by examining nature-driven impacts, questioning the extent to which environmental changes caused by climate change-induced natural disasters affect a firm's pursuit of RE innovation. This line of inquiry sought to capture the direct effects of climatological disasters on firms' pursuit of RE innovation. Hypothesis 1a posited that climate change-induced natural disasters lead to an increase in the pursuit of RE innovation by firms. This hypothesis aimed to capture the pursuit of RE innovation by firms following environmental disruptions. Following this, the study delved deeper into the nuances of these nature-driven impacts. Hypothesis 1b explored whether firms operating below their aspiration levels exhibit a stronger positive RE innovation post-disaster. Hypothesis 1c compared foreign MNEs' subsidiaries and domestic firms, hypothesising that foreign MNEs' subsidiaries exhibit a less robust positive change in pursuing RE innovation following such disasters. Further, Hypotheses 1d and 1e investigated the moderating roles of natural disaster uncertainty and a firm's history of natural disasters in their pursuit of RE innovation.

The study further incorporated market-driven impacts as interacting factors. The researcher introduced three main market constructs—peers' pursuit of RE innovation, investor sentiment, and media coverage—and examined their roles in shaping firms' pursuit of RE innovation following climatological disasters. Hypothesis 2a explored how peers' pursuit of RE innovation influences a firm's own pursuit of RE innovation in disaster scenarios. Hypothesis 2b investigated the interaction with investor sentiment, hypothesising that increased sentiment might reduce the positive shift in the pursuit of RE innovation post-disaster. Hypothesis 2c examined the impact of media coverage on the firms' pursuit of RE innovation following a disaster.

5.3. Overview of Findings

This section presents a detailed summary of the findings derived from the hypothesis testing in Chapter 4, focusing on the effect of climate change impacts on the pursuit of RE innovation in firms. Regarding nature-driven impacts, Hypothesis 1a's findings demonstrated a significant positive change in the pursuit of RE innovation post-climatological disasters, with a meta-analysis effect size of 0.74 ($p < 0.001$). This suggests that firms are likely to enhance their pursuit of RE innovation following the immediate challenges posed by such environmental changes. However, this trend varied when considering the firm's performance relative to its aspirations. Hypothesis 1b's findings revealed that firms with performance above aspiration levels experienced a less pronounced increase in the pursuit of RE innovation post-disasters, with an effect size of -0.273 ($p < 0.05$).

Furthermore, a notable divergence was observed in foreign MNEs' subsidiaries, which exhibited a lesser increase in the pursuit of RE innovation compared to domestic firms as Hypothesis 1c's findings indicated that foreign MNEs' subsidiaries showed a reduced level of RE innovation pursued compared to domestic firms in disaster scenarios, with a notable effect size of -0.569 ($p < 0.05$). This might reflect different strategic priorities or resource allocations following environmental disruptions. Additionally, the uncertainty stemming from natural disasters had a slightly dampening effect on the pursuit of RE innovation, indicating that unpredictability might temper firms' pursuit of RE innovation. Hypothesis 1d's findings presented a slightly reduced impact on the pursuit of RE innovation, with an effect size of -0.007 ($p < 0.001$), suggesting complexity in firms' pursuit of RE innovation following varying disaster intensities. Moreover, a firm's history of natural disasters seemed to influence its approach, with those having extensive experience adopting a more conservative stance towards innovation. This is suggested by the Hypothesis 1e findings that a firm's history of natural disasters significantly affects its pursuit of RE innovation, with a negative effect size of -0.349 ($p < 0.001$).

The investigation into market-driven impacts also yielded surprising results. In examining the influence of peers, Hypothesis 2a revealed a negative effect of peers' pursuit of RE innovation on a firm's pursuit of RE innovation post-disaster (effect size: -0.076, $p < 0.001$). Increased pursuit of RE innovation by peers led to a decrease in a firm's own pursuit of RE innovation post-disaster, hinting at possible strategic adjustments in areas where peers have already established dominance. Hypothesis 2b explored investor sentiment, showing no significant impact on the pursuit of RE innovation post-disasters (effect size: 0.007, $p > 0.01$), suggesting that external investment climates may not be as influential as expected. Similarly, media coverage did not show a pronounced effect. Hypothesis 2c assessed the role of media coverage, finding a non-significant impact (effect size: 0.086, $p > 0.01$). This indicates that public perception and media scrutiny might not be the primary motivators for firms' pursuit of RE innovation following climatological challenges. The results of the hypotheses testing are summarised in Table 15.

Table 15 Summary of Hypotheses Testing Results

Hypothesis	Hypothesis Description	Result
1a	Assesses the increase in the pursuit of RE innovation by firms following climatological disasters.	Supported
1b	Assesses increased pursuit of RE innovation in firms with performance below aspiration levels following climatological disasters.	Supported
1c	Evaluates the pursuit of RE innovation in foreign MNEs' subsidiaries versus domestic firms following climatological disasters.	Supported
1d	Assesses whether natural disaster uncertainty moderates the impact of climatological disasters on firms' pursuit of RE innovation.	Supported
1e	Investigates whether a firm's history of natural disasters moderates the impact of climatological disasters on the pursuit of RE innovation.	Supported
2a	Assesses whether peer firms' increased pursuit of RE innovation reduces the positive change in the pursuit of RE innovation following climatological disasters.	Supported
2b	Examines whether higher investor sentiment reduces the positive change in the pursuit of RE innovation following climatological disasters.	Not supported
2c	Assesses whether increased media coverage of a firm's climate actions reduces the positive change in the pursuit of RE innovation following climatological disasters.	Not supported

Source: Developed by the author

Overall, these findings offer a complex picture of how climate change impacts affect firms' behaviour, particularly in the realm of RE innovation. The diversity in the significance and direction of these impacts underscores the need for a nuanced understanding of how different factors interact in shaping corporate behaviour towards sustainability and innovation following climate change impacts.

5.4. Comparative Analysis

Exploring Hypothesis 1a reveals a significant finding: after climate change-induced natural disasters, firms are more likely to pursue RE innovations. This shows that when faced with the immediate impacts of climate change, such as disasters, firms are motivated to shift towards more sustainable practices. This research echoes findings from other studies that have noticed a similar trend. For instance, research by Ma et al. (2023) showed that natural disasters push companies towards green innovation, suggesting that these challenging events can lead to positive changes in how companies operate in regard to the environment. Similarly, Marshall et al. (2021) found that after natural disasters, there is more investment in green funds, indicating that investors also see the value in supporting sustainable practices during these times.

However, this push towards RE innovation after disasters contrasts with some studies that suggest companies often become more cautious when faced with climate risks. Research by Huang et al. (2018) pointed out that companies tend to save more money and avoid risks in high-climate-risk situations, which would mean hesitating to invest in new and innovative projects. This difference highlights the complexity of how companies behave following climate change impacts. It seems that the direct impact of a disaster can be a stronger trigger for change than the ongoing, broader threat of climate change.

Additionally, this research offers new insights compared to previous studies that have explored how firms behave following climate change impacts. While some researchers such as Kouloukoui et al. (2019) emphasised the role of regulations in driving companies towards climate change strategies, others such as Sakhel (2017) have pointed out the importance of direct physical risks. This study adds to the conversation by showing that the direct experience of a climatological disaster can significantly motivate firms to pursue RE innovation, suggesting that experiencing climate change impacts firsthand might spur firms into action more effectively than market risks.

For Hypothesis 1b, which examined the impact of a firm's performance relative to its aspirations on the pursuit of RE innovation following climate change-induced natural disasters, the findings reveal a nuanced relationship between a firm's performance relative to its aspirations and its propensity to pursue RE innovations following climatological disasters. In other words, firms that are not meeting their aspirations would be more likely to pursue RE innovations to bridge this gap, especially following climatological disasters. In theory, firms underperforming against their goals are expected to pursue riskier practices, including innovation, to improve their standing. This aligns with the BTOF (Cyert & March, 1963), which posits that the performance-aspiration gap drives firms towards change. However, the findings from this study suggest that while underperforming firms are motivated to pursue RE innovations post-disaster, the relationship is not as straightforward or robust as the theory might predict.

Comparatively, studies such as those by Li et al. (2023) and Ma et al. (2023) have illustrated how environmental pressures can drive firms towards sustainable practices and innovations. These studies, focusing on the broader impact of climate change and natural disasters on sustainable development and green innovation, provided a backdrop against which the findings of this research can be analysed. While these studies supported the idea that environmental challenges stimulate innovation, the specific influence of a firm's performance relative to its aspirations introduces a unique variable into the discussion. Moreover, contrasting with the optimism found in the literature regarding the role of disasters in promoting green innovation, the findings of Hypothesis 1b suggest a more cautious approach by firms. This caution could be attributed to the complexities of implementing RE innovations, including the financial investment required, the uncertainty of returns, and the operational challenges of integrating new technologies.

Shifting the focus to Hypothesis 1c, which examined the differential impact of climate change-induced natural disasters on the pursuit of RE innovation between foreign MNEs' subsidiaries and domestic firms, the findings indicated that foreign MNEs' subsidiaries exhibited less increase in the pursuit of RE innovation compared to domestic firms. This outcome contrasts with several strands of the literature review that highlighted the potential advantages of foreignness, including access to multinational resources, institutional ambiguity navigation, and knowledge transfer capabilities that foreign MNEs might leverage for competitive advantage (Regnér & Edman, 2014). The literature suggested that the foreignness of MNEs' subsidiaries could act as a double-edged sword, offering both advantages due to their social position and disadvantages due to LOF (Zaheer, 1995; Zaheer & Mosakowski, 1997).

Moreover, studies such as those by Sofka et al. (2022) and Amendolagine et al. (2023) have shown that foreign MNEs' subsidiaries can outperform domestic firms in innovation outputs. These findings suggested a potential for foreign MNEs' subsidiaries to lead in green innovation, leveraging their multinational presence and resources. Wang et al. (2023) also suggested that foreign MNEs' subsidiaries typically benefit from their parent companies' resources, leading to more eco-innovative outcomes in emerging economies such as China. Similarly, De Marchi et al. (2022) highlighted that foreign MNEs' subsidiaries often outperform domestic firms in green innovation, especially when they engage in collaborative efforts that leverage both intra-MNE knowledge flows and external partnerships.

However, the reduced level of RE innovation pursued among foreign MNEs' subsidiaries observed in this study might reflect the unique challenges these entities face, as elaborated by Zhou et al. (2023). They argue that intra-MNE knowledge transfer does not automatically ensure the development of local innovation capabilities, particularly in the context of RE innovation where local environmental conditions and regulatory frameworks play a critical role. This insight is crucial, as it underscores the limitations of relying solely on global knowledge networks without adequately considering the local specificities that influence the effectiveness and appropriateness of transferred innovations. The complexities and challenges associated with operating in foreign environments, as encapsulated by the LOF (Baik et al., 2013), might outweigh the potential advantages in the context of RE innovation.

Moreover, the findings align with the discussion by Almodóvar and Nguyen (2022), who demonstrated that domestic firms could effectively compete with foreign MNES' subsidiaries by leveraging external knowledge sources, suggesting that local firms possess inherent advantages in innovation output due to their deeper understanding of the local context. This resonates with the observed scenario where domestic firms outpaced foreign MNEs' subsidiaries in the pursuit of RE innovation post-disaster, potentially due to their greater agility in navigating local regulatory landscapes and tailoring innovations to meet specific local needs.

Additionally, the findings might reflect a deeper strategic prioritisation or resource allocation issue within foreign MNEs' subsidiaries, where the immediate pressures of navigating post-disaster recovery in an unfamiliar environment dampen their capacity or willingness to invest in RE innovations. The observed reduction in the pursuit of RE innovation among foreign MNEs' subsidiaries compared to domestic firms suggests that the advantages typically associated with multinationality and foreignness might not translate straightforwardly into a greater pursuit of RE innovation following environmental disruptions.

Delving into Hypothesis 1d, the study explored the moderating effect of natural disaster uncertainty on the pursuit of RE innovation by firms following climate change-induced natural disasters. This hypothesis is particularly relevant in the context of increasing attention to climate change and its unpredictable implications for human lives and corporate performance. The findings from testing Hypothesis 1d revealed that uncertainty related to natural disasters slightly dampens firms' pursuit of RE innovation, as evidenced by a modestly reduced impact on the pursuit of RE innovation, with an effect size of 0.007 ($p < 0.001$). In other words, while firms are motivated to pursue innovation following the direct impacts of climatological disasters, the unpredictability associated with these events introduces a layer of complexity that slightly restrains their innovation. This suggests that the unpredictability associated with disaster intensity complicates firms' behaviour following environmental challenges.

The literature underscores the significant challenges that climate change uncertainties present for decision-making, as highlighted by the IPCC (2014). These uncertainties introduce complex, ambiguous, and novel risks into corporate behaviour (Drobetz et al., 2018), complicating firms' ability to devise actionable plans for innovation. This complexity is evident in the findings from Hypothesis 1d. This echoes the broader academic discourse, emphasising the practical difficulties in navigating environmental uncertainties and their influence on firms' pursuit of innovation.

Furthermore, research by Kolk and Pinkse (2008) and Dastagir (2015) elucidates the intricate nature of the climatic system and the significant levels of uncertainty introduced into strategic decision-making by the natural variability of nature. This aligns with the observed slight dampening effect on the pursuit of RE innovation following climate change-induced natural disasters, suggesting that firms struggle to manage the impacts effectively due to the complexity and severity of this uncertainty.

The study's focus on the uncertainty associated with climate change-induced disasters fills a notable gap in the existing literature, which has largely overlooked the role of uncertainty in climate change impacts (Dunz et al., 2021; Fabrizi et al., 2018; Kesidou & Demirel, 2012; Kouloukoui et al., 2019; Marshall et al., 2021; Ren et al., 2022; Tsalis & Nikolaou, 2017; Zhou & Wen, 2020). By incorporating this inherent uncertainty, the study contributes to a deeper understanding of how it moderates the relationship between a climate change-induced natural disaster and the pursuit of RE innovation by firms.

Hypothesis 1e explored how a firm's historical experience with natural disasters moderates its pursuit of RE innovations following climate change-induced natural disasters. The hypothesis posits that firms with a significant history of natural disasters would exhibit a distinct approach towards RE innovation, potentially adopting a more conservative stance. The findings confirm this, revealing that firms with extensive experience with natural disasters tend to be more cautious in their pursuit of RE innovation, as indicated by a negative effect size of -0.349 ($p < 0.001$). This suggests that past encounters with natural disasters influence firms to adopt a conservative approach towards RE innovation.

This result is particularly intriguing when juxtaposed with the broader literature on climate change impacts, uncertainty, and corporate behaviour. Augustine et al. (2019) introduced the concept of temporal discontinuity, distinguishing between near and distant futures and their associated uncertainties. However, the findings from Hypothesis 1e align more closely with Raynard et al. (2020), who emphasised temporal continuity, suggesting that past experiences significantly inform current attitudes towards risks, including those related to climate change.

The principle of temporal continuity, supported by Imas (2016) and Lant and Shapira (2008), posits that firms' risk attitudes and strategic decisions are influenced by their past performance and experiences. This resonates with the observed cautious approach towards RE innovation among firms with a history of natural disasters. These firms are likely to draw on their past experiences to inform their present and future strategies, leading to a more conservative innovation stance following new environmental challenges.

Furthermore, the discussion on firm age and the liability of newness (George, 2005) introduces an additional layer of complexity. While younger firms might exhibit greater flexibility and a propensity to pursue modern technologies, including RE innovations, the findings suggest that the accumulated experience of older firms, especially those with direct experience of natural disasters, results in a more cautious innovation approach. This caution could stem from the need for reinvestment in updating existing facilities, as highlighted by Wagner (2011), or from a deeper understanding of the complexities and uncertainties associated with climate change-induced natural disasters.

Oetzel and Oh's (2021) exploration of organisational experience with natural disasters through the frequency and magnitude of such events provides a quantitative measure of this experience. However, the findings from Hypothesis 1e suggest that the impact of natural disaster experience on the pursuit of RE innovation is not merely quantitative but also qualitative, affecting firms' strategic orientation and risk assessment in nuanced ways. This insight adds depth to our understanding of how firms navigate the precarious landscape of climate change, emphasising the importance of considering historical experiences in devising future innovation.

Turning our attention to Group 2 hypotheses, Hypothesis 2a delved into the dynamics of competitive influence among firms, specifically examining how the pursuit of RE innovation by peers affects a firm's own pursuit of RE innovation following climate change-induced natural disasters. Consistent with the anticipation that a rise in RE innovation among peer firms would moderate a firm's drive to pursue RE innovation post-disaster, the results demonstrate that peers' pursuit of RE innovation negatively affects a firm's pursuit of RE innovation following a climatological disaster (effect size: -0.076, $p < 0.001$). This suggests that a firm may decrease its pursuit of RE innovation when its peers have already established a dominant position in this area post-disaster, indicating a strategic retreat or realignment in a competitive landscape.

This outcome presents an interesting contrast to the literature that highlights the role of peer competition and mimetic pressure as significant drivers for green innovation. Studies by Huang et al. (2022) and Dai et al. (2015) emphasised that competition and the actions of market leaders can push firms towards high-quality green innovation to sustain or gain competitive advantage. Similarly, the work of Weigelt and Shittu (2016) and Hua-Hung et al.

(2015) found that competitive pressure and peers' investment decisions significantly influence firms' investments in clean energy sources and green innovation pursuit.

However, the findings from Hypothesis 2a suggest that the competitive dynamics in the context of RE innovation post-climatological disasters might operate differently. Instead of motivating firms to increase their pursuit of RE innovation to match or surpass their peers, increased pursuit of RE innovation by peers seem to deter firms from pursuing similar innovation paths. This could be due to several reasons explored in the literature, such as the strategic considerations highlighted by Zhao et al. (2021) and Husted et al. (2016), where firms may choose to avoid direct competition in areas where peers have already made significant advancements, especially in the volatile and uncertain environment following a natural disaster. Furthermore, the research by Mbanyele et al. (2023) sheds light on how peer performance, particularly in the short term, can influence firms' green innovation policies, including RE innovation. Their findings suggest that higher peer performance could lead to a reduction in a firm's green innovation output and quality, as firms might cut R&D expenses to manipulate short-term performance.

Hypothesis 2b examined the impact of investor sentiment on the pursuit of RE innovation following climate change-induced natural disasters. Despite the anticipated influence of investor sentiment in shaping firms' pursuit of RE innovation, the findings challenge this expectation. The investigation reveals that investor sentiment has no significant impact on the pursuit of RE innovation post-climatological disasters (effect size: 0.007, $p > 0.01$), suggesting that the external investment climate, shaped by investor sentiment, might not be as pivotal in pursuing RE innovation as previously considered. This outcome challenges prior expectations informed by the literature, which typically emphasised the role of investor sentiment in corporate innovation, particularly in sustainability practices (Cheong et al., 2017; Naughton et al., 2019). Further research by Dang and Xu (2018), Lin (2023), and Majid et al. (2023) supported the notion that positive investor sentiment can facilitate innovation by easing financial constraints and enhancing R&D investments.

Several factors beyond direct investor sentiment impact contributed to this unexpected result. These factors include economic and political fluctuations, the role of disasters as focusing events, and variations in investor proximity and profile. Economic conditions, such as market instabilities and low oil prices during the study period, are likely to have overshadowed the impact of investor sentiment (Umar et al., 2021). For instance, the notable decrease in oil prices between 2014 and 2016 made fossil fuels more economically attractive compared to renewable sources, reducing incentives for firms to invest in RE innovation (Prest, 2018). Additionally, the fluctuating nature of government policies, extending beyond climate-related issues, may have created a cautious investment environment. As highlighted by Leyva-de la Hiz et al. (2019), firms in volatile institutional contexts often hesitate to invest in green innovations due to the unpredictability of external factors, including the changing policy landscape. Furthermore, the double externality problem, where the benefits of RE innovation spill over beyond the innovating firm while the costs are borne solely by them, is likely to mitigate the direct influence of investor sentiment (Castellacci & Lie, 2017; Jakobsen & Clausen, 2016).

Moreover, disasters themselves can serve as focusing events, capturing the attention and resources of firms and diluting the impact of investor sentiment. The influence of environmental policies and the media on investor sentiment during these events further complicates this relationship, underscoring a multifaceted interplay that may not significantly affect RE innovation as previously understood (Sun et al., 2022; Umar et al., 2021; Yeo & Knox, 2019;).

Furthermore, the proximity of investors to disaster zones and their portfolio compositions can influence their sentiment, with retail investors reacting to short-term weather events more than institutional investors, who may not respond systematically to such events (Ginglinger, 2020). These aspects warrant deeper investigation to clarify the specific interactions between investor sentiment and firms' pursuit of RE innovation in scenarios marked by climate change-induced natural disasters.

Overall, these findings underscore the need for a more nuanced examination of how investor sentiment interacts with other critical factors during periods of environmental crisis, suggesting that beyond transient sentiment, firms are likely to prioritise strategic long-term objectives, technological capabilities, and regulatory demands, which could be more pivotal in their decision-making processes regarding RE innovation post-disaster.

Approaching the final hypothesis under investigation, Hypothesis 2c centred on the role of media coverage in influencing the pursuit of RE innovation by firms following climate change-induced natural disasters. Despite the substantial emphasis in the literature on the media's capacity to shape public awareness and influence corporate behaviour towards environmental issues, the findings from this hypothesis present an unexpected narrative. Media coverage was found to have a non-significant impact on firms' pursuit of RE innovation (effect size: 0.086, $p > 0.01$), suggesting that the anticipated mechanism through which media scrutiny affects firms' pursuit of RE innovation might not be as effective in the context of climatological challenges as previously thought. This outcome prompts a reflection on the complex dynamics between media coverage and corporate pursuit of innovation, particularly in the realm of RE. The literature underscores the media's pivotal role as a highly influential stakeholder in directing public attention towards climate change impacts (Tavakolifar et al., 2021; Zhang et al., 2022; Zobeidi et al., 2022) and its ability to reduce information asymmetry between stakeholders and firms (Graf-Vlachy et al., 2020).

A plausible explanation for this finding is the potential dilution of media coverage's impact due to the overlapping of various significant events. During climatological disasters, media outlets and public attention are inundated with a myriad of urgent and competing narratives. This focus can shift public and corporate attention away from long-term RE innovation goals to more immediate concerns. Research suggests that while climatological disasters are highly salient events that attract substantial public attention, the nature of this attention is complex and multifaceted (Yeo & Knox, 2019). Disasters might elevate public awareness and scrutiny of corporate environmental practices; however, the intensity and direction of this scrutiny can vary, potentially affecting firms' behaviour differently. Increased public attention during and after natural disasters can create pressures that either facilitate or hinder firms' efforts to secure capital for ongoing operations and innovation (Gill, 2022). This variability in public response can influence how firms prioritise their behaviour, including the pursuit of RE innovation. This nuanced dynamic indicates that while media coverage remains a critical factor in shaping corporate behaviour, its effectiveness in driving RE innovation post-disaster is contingent on a complex array of factors including the nature of competing news, public sentiment, and the broader socio-economic context. This complexity necessitates a deeper exploration of the conditions under which media coverage most effectively influences the pursuit of RE innovation.

In summary, it is evident that the dynamic interplay between climate change impacts and firms' pursuit of RE innovations presents a complex landscape. This analysis underscored the multifaceted nature of corporate sustainability behaviour following climate change impacts, revealing that while direct experiences and competitive pressures can significantly motivate firms to pursue RE innovation, the expected roles of external stakeholder pressures may not always align with actual pursuit of RE innovation. These insights enrich our understanding of the drivers behind RE innovation in a changing climate, highlighting the importance of integrating multiple perspectives to fully grasp the challenges and opportunities of sustainable corporate behaviour in the context of climate change.

5.5. Chapter Summary

Chapter 5 offered a comprehensive analysis of how climate change impacts influence firms' pursuit of RE innovations. This chapter shed light on the complex dynamics that shape corporate behaviour towards sustainability following climate change impacts. The findings illuminate the significant role of nature-driven impacts, particularly climate change-induced natural disasters, in motivating firms’ pursuit of RE innovation. However, this motivation is nuanced by several factors, including a firm's performance-aspiration gap, the differing behaviour between foreign MNEs’ subsidiaries and domestic firms, the multifaceted nature of natural disaster uncertainty, and the firm’s history of natural disasters. These insights underscore the varied behaviours firms employ to address the direct and indirect impacts of climate change on their innovation agendas.

Notably, the study unveiled the significant effect of peers' pursuit of RE innovation, suggesting a competitive dynamic that influences firms' pursuit of RE innovation. This peer influence introduces a critical dimension to understanding how firms navigate the landscape of RE innovation following climate change impacts, pointing to the importance of industry norms and competitive positioning in shaping innovation. Contrary to initial expectations, certain market-driven impacts—namely investor sentiment and media coverage—demonstrated a limited direct influence on the pursuit of RE innovation post-climatological disaster.

In conclusion, Chapter 5 not only advances the understanding of the relationship between climate change impacts and the pursuit of RE innovation by firms but also paves the way for future research. It calls for a deeper exploration of the underlying mechanisms and contextual influences on corporate sustainability strategies, aiming to develop more effective approaches to encourage environmental innovation within the corporate sector. As the dialogue on sustainability and RE innovation continues to evolve, this study offers valuable insights and directions for ongoing and future research endeavours.

6. Chapter 6 Concluding Remarks

6.1. Introduction

This study investigated how climate change impacts influence firms' pursuit of RE innovation, with a primary focus on climate change-induced natural disasters. Additionally, it examined the moderating effects of market-driven impacts on this relationship. Chapter 6 synthesises the insights derived from this analysis, consolidating the main findings, discussing their theoretical, practical, and policy implications, and outlining future research directions based on the identified limitations. This chapter provides a concluding reflection on the broader significance of the research within the context of climate change and corporate sustainability.

The chapter begins by summarising the main findings, focusing on how climate change-induced natural disasters influence firms to pursue RE innovation. It explains how nature-driven impacts, combined with market-driven impacts, guide firms' pursuit of RE innovations. This overview highlights the behaviour following climatological disasters and explores the wider influences that shape how companies approach sustainability and innovation following environmental changes.

From there, the discussion moves to the theoretical implications, enriching the dialogue on how external pressures and internal dynamics interact to shape firms' pursuit of RE innovation. This study contributes to a deeper understanding of the complex interplay between nature-driven and market-driven impacts of climate change on the pursuit of RE innovation, employing the BTOF as a foundational framework. Following this, the chapter revisits the practical and policy implications derived from the findings, emphasising strategic actions and policy recommendations that firms, stakeholders, and policy-makers can adopt to enhance sustainability.

The chapter then explores the limitations of the study and outlines directions for future research. It also reflects on the researcher's PhD journey, acknowledging both challenges and achievements encountered along the way. The chapter concludes with a call to action for unified efforts towards sustainability, emphasising the study's contribution to the ongoing conversation about navigating and mitigating climate change impacts through corporate innovation and policy support. This reflection underscores the importance of pursuing RE innovation not only as a behavioural response following climatological challenges but as a strategic priority for a sustainable future.

6.2. Summary of Findings

This study delved into the complex impacts of climate change on firms' pursuit of RE innovation, driven by the overarching question: 'How do climate change impacts affect a firm's pursuit of RE innovation?' Specifically, this chapter synthesises insights derived from investigating two critical sub-questions:

1) How do nature-driven impacts, exemplified by climate change-induced natural disasters, affect a firm's pursuit of RE innovation?

2) How do market-driven impacts of climate change act as a moderating factor in the relationship between nature-driven impacts and a firm's pursuit of RE innovation?

Guided by these fundamental questions, this section distils the core findings of the study, emphasising how firms behave following various impacts of climate change in their pursuit of RE innovation. This study uncovered that firms are prompted to pursue RE innovation following climatological disasters. This behaviour is largely driven by the urgent need to mitigate the risks associated with climate change and to capitalise on emerging opportunities for sustainable growth. The extent of this innovation boost varies significantly among firms. Those with performance levels already exceeding their aspirations show a more tempered increase in RE innovation post-climatological disaster. This suggests that firms well ahead of their performance aspirations might evaluate the risks and benefits of RE innovation investments differently compared to those striving to meet their aspirations.

This study also shed light on the differing behaviours between domestic firms and foreign MNEs' subsidiaries. The latter group exhibits a less pronounced increase in the pursuit of RE innovation, possibly reflecting diverse strategic orientations and resource availability. This distinction underscores the complex layers of decision-making that influence firms' behaviour in multinational contexts. The analysis further demonstrated that firms confronted with high levels of uncertainty from natural disasters tend to moderate their pursuit of RE innovation, reflecting a cautious approach to navigating unpredictable environmental challenges.

Similarly, firms with extensive histories of facing natural disasters often adopt a conservative stance towards RE innovation. This tendency suggests that past experiences with environmental adversities shape firms' behaviour, making them more circumspect in their approach to pursuing RE innovation following new climatic threats.

Moreover, an intriguing aspect of market influence was observed in the behaviour among peer firms. Increased pursuit of RE innovation by peers tends to discourage rather than inspire similar behaviour, suggesting that firms might seek to differentiate rather than conform. While investor sentiment and media coverage were anticipated to play a significant role, their actual impacts on the pursuit of RE innovation post-climatological disaster are less pronounced than expected.

Collectively, these insights not only addressed the specific research questions but also highlighted the intricate dynamics that characterise firms' behaviour following climatological challenges. This research deepens our understanding of how firms manage both environmental sustainability and RE innovation, providing valuable lessons for both corporate leaders and policy-makers aiming to enhance corporate resilience and sustainability in an era of climate uncertainty.

6.3. Theoretical Implications of the Research

The theoretical implications of this study offer significant contributions to the existing body of knowledge on climate change impacts and firms’ pursuit of RE innovation. This research enriches the theoretical landscape by elucidating the mechanisms through which nature- and market-driven impacts of climate change influence firms' pursuit of RE innovation. Drawing upon the BTOF, this study underscored the complex interplay between environmental threat posed by climatological disasters, corporate aspirations, and innovation behaviour. Specifically, the study demonstrated how the occurrence of climatological disasters can lead firms to intensify their pursuit of RE innovation to achieve their aspirations and mitigate risks. Conversely, it also showed that these disasters can constrain the pursuit of RE innovation, as firms navigate the complex landscape of climate change impacts.

First, the empirical evidence that climate change-induced natural disasters significantly influence firms' pursuit of RE innovation provides a strong theoretical implication for the BTOF. It illustrated how external environmental threats, such as climatological disasters, act as critical catalysts for the pursuit of RE innovation, pushing firms beyond their conventional operational strategies to embrace RE innovation. Echoing Mithani et al. (2021), the findings revealed that while these disasters pose significant threats, they also present opportunities for innovation. Additionally, Lee et al. (2021) and Ren et al. (2022) highlighted the potential of natural disasters to modify energy consumption behaviours and foster technological advancements. By demonstrating how climatological disasters propel firms' pursuit of RE innovation, this study contributes to the discourse on the complex interplay between direct environmental impacts and corporate green innovation, underscoring the idea that firms are more likely to pursue sustainable practices following immediate and tangible environmental threats.

Second, this study's integration of the BTOF and the threat rigidity model provided a robust analytical framework that enhances our understanding of corporate behaviour under the pressures of climate change-induced natural disasters. By synthesising these models, the research filled a significant gap identified in the literature regarding the role of uncertainty in climate change impacts, as noted by researchers such as Dunz et al. (2021) and Fabrizi et al. (2018). This study contributed novel insights by explicitly linking the performance-aspiration gaps and perceptions of external threats with firms' behaviour following environmental stress, particularly in the pursuit of RE innovation. This enriched theoretical perspective not only deepens the understanding of how firms navigate the complexities of climate-induced uncertainties but also provides a comprehensive view of how these uncertainties interact with firm-specific characteristics to shape their behaviours. Such contributions are crucial for advancing the theoretical discourse on climate change adaptation and green innovation.

Lastly, the introduction of a firm's history of natural disasters as a novel moderator in this study significantly enhanced the understanding of how historical experiences with environmental challenges influence the pursuit of innovation. By integrating firm age with the magnitude and frequency of natural disasters, this research offered a nuanced perspective on the temporal dimension of corporate behaviour following climate change impacts. This innovative approach addressed the ongoing academic debate about the advantages or disadvantages of newness in firms, as discussed by scholars such as Gimenez-Fernandez et al. (2020) and Wagner (2011). Additionally, existing literature, including studies by Oetzel and Oh (2021), has typically used the count of natural disasters occurring within a country as a proxy to measure organisational experience with these events. While informative, this approach does not differentiate between disasters of varying severity and thus does not fully capture the depth of organisational experience. By combining the firm age with the magnitude and frequency of natural disasters, this study provided a comprehensive measure that captures the cumulative impact of a firm’s historical exposure to climate-related events, contributing to a richer theoretical understanding within the BTOF framework. This approach not only bridged the gap in existing research concerning the relationship between firm history and innovation but also highlighted how past experiences can shape a firm’s behaviour in response to future environmental challenges.

In summary, this study enriched our theoretical understanding of firms’ behaviour following climate change impacts, particularly in the realm of RE innovation. It did so by dissecting the impacts of climate change on firms’ pursuit of RE innovation, with a nuanced examination of climatological disasters' direct effects and the roles of market dynamics. By integrating market-driven impacts into the model designed for climate change-induced natural disasters, this research delineated how these impacts distinctly influence firms' pursuit of RE innovation post-climatological disaster. This comprehensive approach not only clarified the direct influence of climatological disasters on the pursuit of RE innovation but also shed light on how market mechanisms can modulate this relationship, offering a more holistic view of the firms’ pursuit of RE innovation following climate change impacts. Specifically, this research underscored the broader implications for green innovation, positioning RE innovation as a critical component of firms' practices to meet sustainability goals, such as those outlined in SDG 7 and SDG 13.

6.4. Practical Implications of the Research

The findings of this study offer several practical implications for firms and stakeholders engaged in RE innovation and broader sustainability initiatives. These implications are designed to inform practices that enhance the pursuit of RE innovation following climate change impacts, thereby contributing to sustainable development.

Implications for Firms

Strategic emphasis on RE innovation post-disaster: This study emphasises that climate change-induced natural disasters, while often devastating, present significant opportunities for firms to advance RE innovations. These findings advocate that firms should not merely view RE innovation as a response to regulatory pressures or market trends but as an essential component of their behaviour following environmental changes. Following such disasters, firms have the opportunity to redefine their operational strategies by intensifying their focus on sustainability and resilience. Investing in RE innovation can serve as a dual benefit—mitigating future environmental risks and positioning the firm as a leader in sustainability. This proactive approach is particularly crucial for firms operating below their aspiration levels, as it provides a pathway to bridge the gap between current performance and their aspirations. By actively engaging in RE innovation, firms can not only address environmental challenges in the short run but also contribute to long-term environmental sustainability.

Leveraging local insights: The research highlights that domestic firms behave more effectively following climatological disasters compared to foreign MNEs' subsidiaries, likely due to their deeper understanding of local conditions. These firms should leverage this local expertise to pursue and implement RE innovations that are tailored to their specific regional challenges. This proactive approach not only helps in addressing immediate environmental impacts but also sets a precedent for innovation that aligns closely with regional sustainability goals. By doing so, domestic firms can emerge as leaders in the local RE sector, demonstrating the strategic importance of localised innovations in building resilience against future environmental challenges.

Partnerships with local entities: MNEs should actively seek partnerships with local firms, governments, and research institutions to enhance their behaviour following climatological disasters. These collaborations are crucial for MNEs to overcome the challenges identified in the study, such as less robust changes in RE innovation post-disaster. Partnering with local entities can facilitate knowledge transfer, foster a better understanding of local conditions, and enhance the effectiveness of RE innovation. Engaging with local stakeholders not only helps in tailoring solutions that are culturally and contextually appropriate but also enhances corporate social responsibility and supports community resilience.

Integrating climate uncertainties into strategic planning: Emphasising the integration of natural disaster uncertainty into corporate strategic planning is crucial, given the findings that such uncertainties significantly affect firms' pursuit of RE innovation following climatological disasters. Firms should systematically include natural disaster risk assessments in their strategic planning processes. This proactive approach enables businesses to anticipate potential disruptions and prepare more effectively for the impacts of climate change-induced natural disasters. By embedding this uncertainty into their strategic frameworks, firms can develop more robust risk management strategies that enhance their resilience.

Leveraging the history of natural disasters: This study underscores the significant impact a firm's historical experience with natural disasters has on its pursuit of RE innovation following environmental challenges. Firms that have faced natural disasters in the past often develop unique insights and capabilities that can be critical in shaping their future behaviour to pursue RE innovation. These firms should proactively incorporate their historical experiences into their strategic planning processes, using this accumulated knowledge to anticipate potential challenges. This approach not only enhances a firm's resilience but also cultivates a culture of continuous innovation, particularly in the development and implementation of RE innovation. By systematically analysing past responses and outcomes, firms can refine their risk management frameworks and innovate more effectively in response to the evolving nature of climate change-induced natural disasters. This strategic use of historical data enables firms to build on their past experiences to improve their adaptive capabilities and readiness for future environmental disruptions, aligning their operational strategies with sustainability more effectively.

Responding to competitive pressures: The study revealed that a firm's pursuit of RE innovation following climatological disasters is significantly influenced by the pursuit of RE innovation of its peers, as demonstrated through the negative effect observed when peers intensify their RE innovation. This suggests that firms should not merely react to the competitive landscape but strategically analyse and integrate these insights into their behaviour. Firms observing active RE innovation among their peers should focus on differentiation. This could mean investing in distinct RE technologies or implementing innovative practices that offer competitive advantages in sustainability, which were not previously prioritised by their peers. This competitive interplay underscores the need for firms to actively monitor and respond to the sustainability initiatives of their industry peers. By systematically analysing the RE innovation trends adopted by competitors, firms can identify both gaps in their own approaches and opportunities for differentiation. This vigilance allows them to not only match but potentially surpass industry standards, positioning themselves as leaders in the sustainability domain. Firms should consider adopting best practices demonstrated by market leaders and look for innovative ways to enhance their own RE solutions. Emphasising continuous improvement and proactive adaptation in response to competitive pressures can drive firms to elevate their sustainability practices, ultimately leading to enhanced market positioning and business resilience against future environmental challenges.

Implications for Stakeholders

Engaging in constructive dialogue: The study underscores the role of investors and the media in influencing firms' pursuit of RE innovation following climatological disasters, though the expected impacts were not as significant as hypothesised. This suggests that while stakeholders such as investors and media entities are pivotal, their impact could be optimised through more strategic engagement practices. Rather than solely relying on sentiment, stakeholders should engage in direct, constructive dialogues with firms, focusing on collaborative approaches to foster RE innovation. Industry associations and academic institutions, for instance, can play a crucial role in transferring knowledge and technical expertise to firms. They can also facilitate collaborations between firms to pursue RE innovations that meet specific organisational needs. Additionally, stakeholders can influence policy to create a more favourable regulatory environment for RE innovation following environmental challenges. This could include advocating for policies that bolster investments in RE innovations. Engaging in such dialogues can help align firms' behaviour with the sustainability goals of broader stakeholder groups, ensuring that initiatives are not only implemented but are effective in addressing climate change impacts.

Promoting transparency and accountability: Given the positive relationship identified between climatological disasters and the subsequent pursuit of RE innovation by firms, it is crucial for stakeholders to emphasise transparency and accountability in reporting these efforts. Encouraging firms to disclose their sustainability initiatives, performance metrics, and innovation outcomes can enhance trust and facilitate informed decision-making among investors. Such transparency not only ensures that firms are genuinely committed to sustainability but also provides external stakeholders with the necessary information to evaluate the impact of these innovations. Additionally, as the study highlights the impact of a firm's history of natural disasters on its pursuit of RE innovation, reporting should include how past experiences are influencing current pursuit of RE innovation. This detailed reporting will enable investors to make more informed decisions and support firms that are effectively using their historical experiences to guide their innovative responses to climate change. By fostering a culture of accountability, firms will be likely to pursue RE innovations more proactively, motivated by competitive advantages gained through investor support and market differentiation.

In conclusion, the practical implications derived from this study highlight the pursuit of RE innovation following climate change impacts. By understanding how climatological disasters influence firms' pursuit of RE innovation, firms can better prepare and align their operations to enhance sustainability. This insight not only aids firms in navigating the complexities of environmental challenges but also equips stakeholders to support and drive meaningful advancements in green innovation, ensuring a proactive response to climate change.

6.5. Policy Implications of the Research

This section outlines several policy recommendations that leverage the findings of this study, demonstrating how targeted policy support can profoundly influence firms' behaviour following climate change impacts. These recommendations aim to guide policy-makers in creating frameworks that not only address the immediate needs of firms following climatological disasters but also support long-term sustainable development.

Policy support for RE innovation: Enhancing RE innovation through performance-aspiration frameworks can significantly bolster firms' behaviour following climatological disasters. Policy initiatives should be specifically designed to support firms that are currently performing below their aspiration levels, as these firms are more likely to intensify their pursuit of RE innovation following environmental challenges. Financial incentives, such as RE grants, could be linked directly to the development and implementation of RE technologies. Additionally, providing technical support and resources to help firms effectively identify opportunities for RE innovation can guide them in aligning their operation with sustainability goals. These policy measures would not only motivate firms to close the performance-aspiration gap but also foster a competitive environment that propels the entire industry towards greater innovation and sustainability in response to climate change impacts. Furthermore, successfully implementing these policies contributes directly to SDG 7 by promoting widespread adoption of RE solutions, and to SDG 13 by equipping firms to better mitigate the impacts of climatic disturbances, enhancing overall resilience and sustainability in their operations.

Tailored support for domestic firms and MNEs: Given the differential impact of climate change-induced natural disasters on domestic firms and foreign MNEs' subsidiaries, as identified in the study, policy-makers need to implement tailored support policies. Domestic firms, which have shown greater pursuit of RE innovation after climatological disasters, should be supported through incentives for local RE projects, grants for R&D in low-carbon technologies, and simplified regulatory frameworks that facilitate rapid innovation. For foreign MNEs' subsidiaries, which exhibit less pronounced RE innovation post-disaster, policy interventions could focus on facilitating partnerships with local businesses and institutions. This might include establishing platforms for technology transfer, providing financial incentives for multinational-local joint ventures, and easing market entry barriers to encourage the adaptation of global solutions to local environmental challenges. Such targeted policies can help bridge the differences between domestic firms and MNEs, ensuring both can contribute effectively to the RE innovation landscape.

Strategic policy framework for managing natural disaster uncertainty: Reflecting the findings that natural disaster uncertainty can subtly influence the firms' pursuit of RE innovation post-climatological disasters, it is imperative for policy-makers to develop comprehensive guidelines that assist firms in integrating natural disaster risk assessments into their strategic planning. This policy initiative should focus on providing firms with access to up-to-date, region-specific natural disaster data and predictive tools that enable proactive risk management. Additionally, the government could facilitate targeted workshops and training sessions specifically designed to enhance corporate capabilities in integrating risk assessments with RE projects. Supporting the development and deployment of resilient RE technologies through subsidies or R&D grants can further empower firms to innovate within a framework that acknowledges and mitigates the risks posed by climatological uncertainties. This approach not only enhances corporate resilience but also aligns with broader sustainability goals, helping firms to navigate the complexities of climate change impacts more effectively.

Policy support for collaborative RE innovation: In line with the findings that industry peers' and competitive pressures shape firms' pursuit of RE innovation, particularly after climatological disasters, policy-makers should cultivate an ecosystem that prioritises knowledge sharing and collaborative innovation within the RE sector. Initiatives should focus on establishing robust public-private partnerships that not only facilitate but actively encourage collaborative R&D among domestic firms, MNEs, and research institutions. Policy-makers could also consider funding schemes that reward collective efforts. Such a policy framework should aim to bolster communal knowledge bases and reduce innovation redundancy. By fostering a collaborative culture that aligns with sustainability goals, these initiatives will propel progress towards SDG 7 by ensuring energy security, reducing carbon emissions, and supporting sustainable development practices across industries.

Strengthening transparency and disclosure in RE innovation: As highlighted by the findings that peers significantly affect a firm's pursuit of RE innovation, policy-makers should enforce stringent disclosure requirements for firms' RE innovation efforts. This policy could mandate detailed reporting on RE innovation projects, outcomes, and the extent of adoption of new technologies. Such transparency not only fosters a competitive market environment but also empowers stakeholders, including investors and consumers, to make informed decisions based on a firm's commitment to sustainability. To further reinforce this framework, policy-makers can develop comprehensive industry benchmarks for RE innovation that reflect current and aspirational standards for sustainability practices. These benchmarks should be regularly updated to reflect technological advancements and market trends, providing firms with clear targets for their pursuit of innovation. Additionally, policy incentives such as tax benefits or subsidies could be offered to firms that not only meet but exceed these benchmarks, encouraging them to pursue higher standards of innovation. By integrating these benchmarks into regulatory frameworks, policy-makers can ensure that firms not only aim to match but also strive to surpass their peers in RE innovation, thus accelerating progress towards achieving SDGs 7 and 13 by enhancing energy security and fostering sustainable development.

In conclusion, this study revealed significant insights into how climate change impacts drive the pursuit of RE innovation among firms. By offering targeted policy recommendations based on these insights, governments can ensure significant strides towards sustainable development goals, particularly SDG 7 and SDG 13, enhancing energy security and promoting low-carbon practices across industries.

6.6. Limitations of the Study

The exploration into the impacts of climate change on firms' pursuit of RE innovation in this study presented significant findings while also encountering limitations that offer avenues for future research. The limitations identified stem from the study's scope, data characteristics, and methodological approaches. These limitations, in turn, naturally lead to several directions for future research, each aimed at addressing these gaps and extending the understanding of this complex subject area.

- Scope of data and generalisability: The research primarily focused on publicly traded firms within the U.S., leveraging data from established databases and reports. This concentration on a single country, albeit with a significant role in global climate dynamics and innovation, limits the generalisability of the findings to other regions with different regulatory, environmental, and economic contexts. Additionally, the geographic concentration of climatological disasters in the Western region of the U.S., particularly in California, presents a limitation for the generalisability of the results. The analysis revealed that a significant majority of the disasters examined occurred in California. This regional concentration not only highlights the heightened susceptibility of California to climatological disasters but also introduces potential biases in the findings. The predominance of these events in California means that the data may not be representative of other regions with different economic, environmental, and regulatory contexts. This regional focus may limit the generalisability of the findings to areas less affected by such disasters or those with different socio-economic dynamics. Moreover, the exclusion of privately held firms, which may pursue distinct practices following climate change impacts (Mithani et al., 2021), narrows the breadth of the study's implications. Future studies could expand this scope by incorporating a broader array of firms, including privately held entities and startups, across diverse regions. This expansion would enable a comparison of RE innovation pursued by firms under varying regulatory and market conditions, enhancing the study's generalisability.
- Measurement of variables: While the study employed robust measures such as the number of patent applications for the pursuit of RE innovation and utilised recognised databases for collecting climate change impact data, these proxies come with inherent

limitations. The number of patent applications, for instance, may not fully capture the qualitative aspects of innovation or the actual pursuit of RE technologies. Future research could benefit from a mixed-methods approach, incorporating qualitative assessments, interviews, and case studies to gain deeper insights into firms' motivations, challenges, and strategic considerations in pursuing RE innovation. Additionally, developing more granular measures of climate change impacts could provide a clearer understanding of how specific aspects of climate change impacts influence firms’ pursuit of RE innovation.

- Temporal lag in RE innovation: Acknowledging the time lag between the initiation of environmental investments such as RE innovation and their manifestation in patent applications (Ren et al., 2022), the study attempted to account for this delay by aligning with established practices in the literature (Costantini et al., 2017; Dang & Xu, 2018; Un, 2011, 2016). However, the exact timeframe for innovation development to patent filing can vary significantly across firms and industries, potentially affecting the precision of the study's temporal analysis. Future research could employ longitudinal designs to track innovation projects from inception through development and to market launch. This would offer a more accurate timeline of the innovation process and its outcomes. Such studies could illuminate the long-term effects of climatological disasters on corporate innovation, particularly in how firms adapt and sustain their commitment to RE innovation across different phases of their lifecycle.

- External pressures and stakeholder prioritisation: This study assumed that firms treat all stakeholders equally in their decision-making processes. However, in practice, firms often prioritise certain stakeholder groups over others depending on various factors such as industry norms, regulatory demands, and internal strategic goals (Kolk & Pinkse, 2007). According to the BTOF, decision-makers operate within the bounded rationality, meaning they balance socioeconomic trade-offs among the stakeholders the firm relies upon for resources (Hemphill et al., 2013; Harrison et al., 2015). Realistically, firms are unlikely to treat all stakeholders equally due to differing levels of influence and importance, especially when it comes to resource allocation for strategic planning. This unequal treatment is driven by the fact that certain stakeholders, such as regulatory bodies or major investors, may have more immediate influence over a firm’s actions compared to others such as customers or local communities.

Further, managerial priorities often shift based on the firm's dependencies on these stakeholders for future resources and the pressures they exert in terms of compliance, market demand, or financial investment (Hemphill et al., 2013). Therefore, this variation in stakeholder prioritisation may significantly influence a firm's pursuit of RE innovation, a dynamic that remains unexplored within the current research framework. Future research should investigate how firms prioritise different stakeholders in their strategic planning for RE innovation. Specifically, future studies could explore how firms balance the conflicting demands of key stakeholders—such as regulatory bodies that push for stricter environmental regulations, versus investors who may prioritise financial returns over environmental considerations. Understanding how firms navigate these trade-offs could provide deeper insights into the barriers and drivers of RE innovation. Additionally, studying stakeholder prioritisation across different industries would reveal whether certain sectors are more influenced by particular stakeholder groups than others, helping to identify the most impactful drivers of innovation in various contexts.

- Complexity of climate change impacts: The interaction among the climate change impacts and their cumulative effects on firms' pursuit of RE innovation are complex and multifaceted. The study's methodological approach, although comprehensive, may not have fully captured the dynamic interplay and feedback loops between different impacts of climate change and firms' behaviour. Future research directions could include the application of systems thinking and simulation models to explore the complex interactions among various climate change impacts. This approach would help uncover the cumulative effects on firms' pursuit of RE innovation and offer a more holistic understanding of how companies navigate the challenges posed by climate change.

6.7. Future Research Directions

This section aims to expand the scope of investigation into the complexities surrounding RE innovation following climate change impacts. In addition to exploring new research directions based on the limitations of this study discussed in the previous section, there is a critical need for future research to revisit and further investigate the hypotheses presented in this study. The nuances observed in the impact of nature-driven and market-driven factors on firms' pursuit of RE innovation present fertile ground for deeper exploration.

- Exploring demand and supply dynamics: Expanding on the examination of demand and supply dynamics within the RE sector could provide comprehensive insights into the interplay between market forces and corporate pursuit of RE innovation. By analysing both demand-side factors, such as consumer preferences for sustainable products and willingness to pay for green technology, and supply-side factors, including production costs, technological advancements, and supply chain efficiencies, researchers can gain a deeper understanding of what drives RE innovation. This dual focus could reveal how shifts in consumer demand for sustainable and energy-efficient products stimulate firms to prioritise and accelerate RE innovation. Additionally, understanding supply chain dynamics, such as the availability of raw materials, the role of global trade policies, and logistics challenges, is crucial. These elements critically shape the accessibility, cost, and eventual adoption of RE technologies across different markets.
- International and interregional spillovers: Researching how climate change impacts in one region can affect RE innovation in another might illuminate the interconnectedness of global markets. Understanding these spillover effects could assist policy-makers and business leaders in developing more globally coordinated climate actions. This line of inquiry would help to uncover the extent to which climatological disasters and subsequent RE innovations are not contained within geographical boundaries but have broader, global ramifications. By studying these spillover effects, researchers can provide valuable insights into how regional climate events influence RE innovation in interconnected markets. Such research could involve analysing how RE innovation in one country might inspire or facilitate similar innovations in neighbouring countries or regions through trade relationships. It could also explore the role of MNEs in transferring RE technologies across borders following climate-induced challenges. Understanding these dynamics is critical for policy-makers and business leaders as they seek to develop more globally coordinated responses to climate change.
- Policy impact variability: Exploring the variability in policy-driven impacts of climate change on RE innovation is critical, particularly across different U.S. states and between state and federal levels. This research could delve into how diverse regulatory frameworks and climate-related policy initiatives influence the pace and nature of RE innovation. By comparing the effectiveness of various policy instruments such as subsidies, tax incentives, and carbon pricing mechanisms, researchers can identify which policies most significantly drive or hinder RE innovation. Such studies would be invaluable in assessing the direct and

indirect effects of policy environments on the pursuit of RE technologies. They could also explore how state-specific characteristics, such as economic status, political inclinations, and natural resource availability, interact with policies to affect RE innovation outcomes. The insights gained from this comparative analysis could guide more tailored and impactful regulatory interventions. By understanding the nuances of how different policies perform in diverse contexts, policy-makers can craft strategies that support a more coordinated and effective response to the climate crisis, aligning local actions with national and international sustainability goals.

By exploring these areas, future research has the opportunity to build a more comprehensive understanding of how firms navigate the complexities of climate change, ultimately contributing to more effective and targeted strategies for promoting RE innovation.

6.8. Researcher's Reflection

This thesis marks not just the culmination of years of diligent study but also signifies a period of significant personal and professional growth. My academic journey began with a Master's degree in Accounting, where I deeply engaged with the quantitative facets of business and finance. Building on this analytical foundation, I pursued a postgraduate diploma in Business, which expanded my understanding of complex business operations and strategic decision-making. The focus of my PhD on the impacts of climate change and the pursuit of RE innovation by firms stems from an increasing realisation of the urgent need for sustainable practices within the business sector. This evolved into a comprehensive study that has, in many ways, reshaped my approach to research and the challenges it entails.

Reflecting on my PhD journey, the process of data collection emerged as a significant challenge that demanded considerable time and meticulous effort. Access limitations to certain datasets on Compustat through Massey University's subscription confined my analysis primarily to the U.S. Although this provided a valuable context for studying the nuances of climate change impacts and innovation, it restricted the potential for a broader comparative analysis with other countries. Moreover, certain data, such as those on the pursuit of RE innovation, were not readily available and required laborious manual collection. This involved linking U.S. patent applications to relevant publicly listed firms over a period from 2011 to

2019, a process that was both time-consuming and intricate. Additionally, initial variables intended for analysis were narrowed down from several market constructs to just three due to data availability issues, forcing the omission of certain variables such as customers and shareholders from the analysis. Furthermore, while I initially included the policy-driven impacts of climate change and their moderating role in my study, the insignificance of these results led me to remove them from this thesis. However, I plan to explore this complex interplay further in my post-PhD work. These challenges have immensely contributed to my growth. As I move forward, I carry with me not only the insights and skills developed through this challenging yet rewarding journey but also a profound gratitude for the intellectual growth, professional development, and personal resilience fostered during these transformative years.

6.9. Final Thoughts

This study marks a significant step in our understanding of how climate change-induced natural disasters influence corporate pursuit of RE innovation. It reveals a landscape where adversity spurs innovation, where the challenges posed by climate change impacts prompt firms to reconsider their roles in a sustainable future. This research has shed light on the complexities of corporate behaviour following environmental challenges. The evidence presented emphasises the necessity for firms to pursue RE innovation as a strategic priority following climatological disasters. This approach is not just about mitigating risks but also about seizing the opportunities to lead in sustainability and resilience. The study advocates for businesses to see beyond immediate challenges, integrating RE innovation into their long-term strategies to enhance their competitiveness and commitment to the natural environment.

Looking ahead, this research calls for a unified effort to address the challenges of climate change impacts. It is a call for firms to act not just following external pressures but as proactive participants in the journey towards sustainability. It highlights the need for strategic foresight, policy support, and market responsiveness to collectively move towards a more sustainable and resilient future.

The role of policy in supporting this transition is clear. It is imperative for policy-makers to establish an environment that motivates firms to innovate in the field of RE. Yet, the insights from this study highlight the necessity for targeted policy support, rather than a one-size-fits-all approach. Crafting policies should be about more than just nudging companies towards sustainability; it is about offering them a scaffold on which to build their innovative capacities. This means recognising the diverse needs and challenges faced by firms and tailoring policy instruments accordingly to foster a conducive ecosystem for innovation and sustainable growth.

In sum, this study contributes to the ongoing conversation about climate change impacts, corporate innovation, and sustainability. It is a call to action for firms, policy-makers, and society to come together in pursuit of a sustainable future. As we look towards the future, this research serves as a reminder of our responsibility to foster an environment where RE innovation is not just encouraged but embraced as a fundamental aspect of our behaviour following climate change impacts.

References

Aguilera, R. V., Desender, K., Bednar, M. K., & Lee, J. H. (2015). Connecting the Dots: Bringing External Corporate Governance into the Corporate Governance Puzzle. *Academy of Management Annals*, *9*(1), 483-573. https://doi.org/10.1080/19416520.2015.1024503

Ai, L., & Gao, L. S. (2023). Firm-level risk of climate change: Evidence from climate disasters. *Global Finance Journal*, *55*, 100805.

Albertini, E. (2014). *A Descriptive Analysis of Environmental Disclosure: A Longitudinal Study of French Companies* (01674544).

Almaqtari, F. A., Al-Homaidi, E. A., Tabash, M. I., & Farhan, N. H. (2019). The determinants of profitability of Indian commercial banks: A panel data approach. *International Journal of Finance & Economics*, *24*(1), 168-185. https://doi.org/10.1002/ijfe.1655

Almodóvar, P., & Nguyen, Q. T. K. (2022). Product innovation of domestic firms versus foreign MNE subsidiaries: The role of external knowledge sources. *Technological Forecasting & Social Change*, *184*. https://doi.org/10.1016/j.techfore.2022.122000

Amendolagine, V., Hansen, U. E., Lema, R., Rabellotti, R., & Ribaudo, D. (2023). Do green foreign direct investments increase the innovative capability of MNE subsidiaries?. *World Development*, *170*. https://doi.org/10.1016/j.worlddev.2023.106342

Amore, M. D., & Bennedsen, M. (2016). Corporate governance and green innovation. *Journal of Environmental Economics and Management*, *75*, 54-72. https://doi.org/10.1016/j.jeem.2015.11.003

Aragón-Correa, J. A., Marcus, A., & Hurtado-Torres, N. (2016). The Natural Environmental Strategies of International Firms: Old Controversies and New Evidence on Performance and Disclosure. *Academy of Management Perspectives*, *30*(1), 24-39. https://doi.org/10.5465/amp.2014.0043

Augustine, G., Soderstrom, S., Milner, D., & Weber, K. (2019). Constructing a Distant Future: Imaginaries in Geoengineering. *Academy of Management Journal*, *62*(6), 1930-1960. https://doi.org/10.5465/amj.2018.0059

Azevedo, V., Kaserer, C., & Campos, L. M. S. (2021). Investor sentiment and the time-varying sustainability premium. *Journal of Asset Management*, *22*(7), 600-621. https://doi.org/10.1057/s41260-021-00233-1

Backman, C. A., Verbeke, A., & Schulz, R. A. (2017). The Drivers of Corporate Climate Change Strategies and Public Policy: A New Resource-Based View Perspective. *Business and Society*, *56*(4), 545-575. https://doi.org/10.1177/0007650315578450

Bae, J. W., & Kim, S. J. (2022). How Do Active Firms Implementing Corporate Environmental Responsibility Take Technological Approaches to Environmental Issues? A Resource-Allocation Perspective. *Sustainability (Switzerland)*, *14*(14). https://doi.org/10.3390/su14148606

Baik, B., Kang, J.-K., Kim, J.-M., & Lee, J. (2013). The liability of foreignness in international equity investments: Evidence from the US stock market. *Journal of International Business Studies*, *44*(4), 391-411. https://doi.org/10.1057/jibs.2013.13

Baker, M., & Wurgler, J. (2006). Investor Sentiment and the Cross-Section of Stock Returns. *The Journal of Finance*, *61*(4), 1645-1680.

Bansal, P., & Roth, K. (2000). Why Companies Go Green: A Model of Ecological Responsiveness. *The Academy of Management Journal*, *43*(4), 717-736.

Battilana, J., Obloj, T., Pache, A.-C., & Sengul, M. (2022). Beyond shareholder value maximization: Accounting for financial/social trade-offs in dual-purpose companies. *Academy of Management Review*, *47*(2), 237-258. https://doi.org/10.5465/amr.2019.0386

Bayer, P., Dolan, L., & Urpelainen, J. (2013). Global patterns of renewable energy innovation, 1990–2009. *Energy for Sustainable Development*, *17*(3), 288-295. https://doi.org/10.1016/j.esd.2013.02.003

Becchetti, L., Ciciretti, R., Hasan, I., & Licata, G. L. (2022). Environmental reputational risk, negative media attention and financial performance. *Financial Markets, Institutions and Instruments*, *31*(4), 123-145-145. https://doi.org/10.1111/fmii.12163

Belasen, A. R., & Polachek, S. W. (2009). How Disasters Affect Local Labor Markets: The Effects of Hurricanes in Florida. *The Journal of Human Resources*, *44*(1), 251-276.

Bell, A., Fairbrother, M., & Jones, K. (2019). Fixed and random effects models: making an informed choice. *Quality & quantity*, *53*, 1051-1074.

Berger, L., Emmerling, J., & Tavoni, M. (2017). Managing Catastrophic Climate Risks under Model Uncertainty Aversion. *Management Science*, *63*(3), 749-765.

Berkan, A., Leonardo, B., & Stefano, M. (2021). Media coverage, corporate social irresponsibility conduct, and financial analy'ts' performance. *Corporate Social Responsibility & Environmental Management*, *28*(5), 1456-1470. https://doi.org/10.1002/csr.2176

Bernardo, C., Vasca, F., Wang, L., Hong, Y., Shi, G., & Altafini, C. (2021). Achieving consensus in multilateral international negotiations: The case study of the 2015 Paris Agreement on climate change. *Science Advances*, *7*(51). https://doi.org/10.1126/sciadv.abg8068

Bettinazzi, E. L., Massa, L., & Neumann, K. (2020). Sustainability as a competitive tool for the brave? Or for the best? A behavioral theory perspective. *Organization & Environment*, *33*(3), 408-436.

Boeren, E. (2018). The Methodological Underdog: A Review of Quantitative Research in the Key Adult Education Journals. *Adult Education Quarterly*, *68*(1), 63-79. https://doi.org/10.1177/0741713617739347

Bointner, R. (2014). Innovation in the energy sector: Lessons learnt from R&D expenditures and patents in selected IEA countries. *Energy Policy*, *73*, 733-747. https://doi.org/10.1016/j.enpol.2014.06.001

Bolton, P., & Kacperczyk, M. (2020). Do investors care about carbon risk?. *Journal of Financial Economics*. https://doi.org/10.1016/j.jfineco.2021.05.008

Bölük, G., & Mert, M. (2014). Fossil & renewable energy consumption, GHGs (greenhouse gases) and economic growth: Evidence from a panel of EU (European Union) countries. *Energy*, *74*, 439-446. https://doi.org/10.1016/j.energy.2014.07.008

Boudreaux, C. J., Jha, A., & Escaleras, M. (2022). Weathering the storm: How foreign aid and institutions affect entrepreneurship activity following natural disasters. *Entrepreneurship Theory and Practice*, *46*(6), 1843-1868.

Brogi, M., & Lagasio, V. (2019). Environmental, social, and governance and company profitability: Are financial intermediaries different?. *Corporate Social Responsibility & Environmental Management*, *26*(3), 576-587. https://doi.org/10.1002/csr.1704

Bromiley, P. (1991). Testing a causal model of corporate risk taking and performance. *Academy of Management Journal*, *34*(1), 37-59. https://doi.org/10.2307/256301

Bromiley, P., & Harris, J. D. (2014). A comparison of alternative measures of organizational aspirations. *Strategic Management Journal*, *35*(3), 338-357. https://doi.org/10.2307/24037195

Brunnermeier, S. B., & Cohen, M. A. (2003). Determinants of Environmental Innovation in US Manufacturing Industries. *Journal of Environmental Economics and Management*, *45*(2), 278-293.

Burke, J. J. (2022). Do Boards Take Environmental, Social, and Governance Issues Seriously? Evidence from Media Coverage and CEO Dismissals. *Journal of Business Ethics*, *176*(4), 647-671. https://doi.org/10.1007/s10551-020-04715-x

Busch, T., & Hoffmann, V. H. (2007). Emerging carbon constraints for corporate risk management. *Ecological Economics*, *62*(3), 518-528. https://doi.org/10.1016/j.ecolecon.2006.05.022

Cai, W., & Li, G. (2018). The drivers of eco-innovation and its impact on performance: Evidence from China. *Journal of cleaner production*, *176*, 110-118.

Cai, W.-g., & Zhou, X.-l. (2014). On the drivers of eco-innovation: empirical evidence from China. *Journal of Cleaner Production*, *79*, 239-248. https://doi.org/10.1016/j.jclepro.2014.05.035
Callaway, B., & Sant'Anna, P. H. C. (2021). Difference-in-Differences with multiple time periods. *Journal of Econometrics*, *225*(2), 200-230. https://doi.org/10.1016/j.jeconom.2020.12.001
Cameron, A. C., & Trivedi, P. K. (2013). *Regression analysis of count data* (Vol. 53). Cambridge University Press.
Campa, P. (2018). Press and leaks: Do newspapers reduce toxic emissions?. *Journal of Environmental Economics and Management*, *91*, 184-202. https://doi.org/10.1016/j.jeem.2018.07.007
Candau, F., & Dienesch, E. (2017). Pollution Haven and Corruption Paradise. *Journal of Environmental Economics and Management*, *85*, 171-192. https://doi.org/10.1016/j.jeem.2017.05.005
Castellacci, F., & Lie, C. M. (2017). A taxonomy of green innovators: Empirical evidence from South Korea. *Journal of Cleaner Production*, *143*, 1036-1047. https://doi.org/10.1016/j.jclepro.2016.12.016
Centre for Research on the Epidemiology of Disasters [CRED]. (n.d.). EM-DAT: The International Disaster Database. Retrieved May 7, 2024, from https://www.emdat.be/
Cevik, S., & Miryugin, F. (2023). Rogue Waves: Climate change and firm performance. *Comparative Economic Studies*, *65*(1), 29-59.
Chang, C. H. (2011). The influence of corporate environmental ethics on competitive advantage: The mediation role of green innovation. *Journal of business ethics*, 104, 361-370.
Chen, W. (2008). Determinants of Firms' Backward- and Forward-Looking R&D Search Behavior. *Organization Science*, *19*(4), 609-622. https://doi.org/10.1287/orsc.1070.0320
Chen, W., & Miller, K., D. (2007). Situational and Institutional Determinants of Fi'ms' R&d Search Intensity. *Strategic Management Journal*, *28*(4), 369-381. https://doi.org/10.2307/2014244610.1002/smj.594
Chen, Y. (2008). The Driver of Green Innovation and Green Image – Green Core Competence. *Journal of Business Ethics*, *81*(3), 531-543. https://doi.org/10.1007/s10551-007-9522-1
Chen, Y. (2008). The Positive Effect of Green Intellectual Capital on Competitive Advantages of Firms. *Journal of Business Ethics*, *77*(3), 271-286. https://doi.org/10.1007/s10551-006-9349-1
Chen, Y., Ghosh, M., Liu, Y., & Zhao, L. (2019). Media Coverage of Climate Change and Sustainable Product Consumption: Evidence from the Hybrid Vehicle Market. *Journal of Marketing Research (JMR)*, *56*(6), 995-1011. https://doi.org/10.1177/0022243719865898
Chen, Y., Lai, S.-B., & Wen, C.-T. (2006). The Influence of Green Innovation Performance on Corporate Advantage in Taiwan. *Journal of Business Ethics*, *67*(4), 331-339. https://doi.org/10.1007/s10551-006-9025-5
Chen, Z., Jin, J., & Li, M. (2022). Does media coverage influence firm green innovation? The moderating role of regional environment. *Technology in Society*, *70*. https://doi.org/10.1016/j.techsoc.2022.102006
Cheong, C. W. H., Sinnakkannu, J., & Ramasamy, S. (2017). Reactive or proactive? Investor sentiment as a driver of corporate social responsibility. *Research in International Business and Finance*, *42*, 572-582. https://doi.org/10.1016/j.ribaf.2017.07.002
Chien, F., Chau, K. Y., Ajaz, T., Andlib, Z., Ahmad, P., & Sharif, A. (2021). The role of technology innovation, renewable energy and globalization in reducing environmental degradation in Pakistan: A step towards sustainable environment. *Renewable Energy*, *177*, 308-317-317. https://doi.org/10.1016/j.renene.2021.05.101
Child, J., & Tsai, T. (2005). The Dynamic Between Fi'ms' Environmental Strategies and Institutional Constraints in Emerging Economies: Evidence from China and Taiwan. *Journal of Management Studies*, *42*(1), 95-125. https://doi.org/10.1111/j.1467-6486.2005.00490.x
Christmann, P. (2000). Effects "f "Best Practi"es" of Environmental Management on Cost Advantage: The Role of Complementary Assets"". *Academy of Management Journal*, *43*(4), 663-680. https://doi.org/10.5465/1556360

Cook, T. D., Campbell, D. T., & Shadish, W. (2002). *Experimental and quasi-experimental designs for generalized causal inference (Vol. 1195)*. Boston, MA: Houghton Mifflin.

Costantini, V., Crespi, F., & Palma, A. (2017). Characterizing the policy mix and its impact on eco-innovation: A patent analysis of energy-efficient technologies. *Research Policy*, *46*(4), 799-819. https://doi.org/10.1016/j.respol.2017.02.004

Cyert, R. M., & March, J. G. (1963). *A behavioral theory of the firm*. Prentice-Hall.

Dai, J., Cantor, D. E., & Montabon, F. L. (2015). How Environmental Management Competitive Pressure Affects a Focal Firm's Environmental Innovation Activities: A Green Supply Chain Perspective. *Journal of Business Logistics*, *36*(3), 242-259. https://doi.org/10.1111/jbl.12094

Dai, D., & Xue, Y. (2022). The impact of green innovation on a firm's value from the perspective of enterprise life cycles. *Sustainability*, *14*(3), 1226.

Dang, T. V., & Xu, Z. (2018). Market Sentiment and Innovation Activities. *Journal of Financial & Quantitative Analysis*, *53*(3), 1135-1161. https://doi.org/10.1017/S0022109018000078

Dang, Y., Sun, J., & Zhao, Y. (2023). Retail shareholder activism and corporate innovation: evidence from investor interaction platforms in China. *Quality & Quantity: International Journal of Methodology*, 1-32. https://doi.org/10.1007/s11135-023-01717-5

Dash, S. R., & Maitra, D. (2018). Does sentiment matter for stock returns? Evidence from Indian stock market using wavelet approach. *Finance Research Letters*, *26*, 32-39. https://doi.org/10.1016/j.frl.2017.11.008

Dastagir, M. R. (2015). Modeling recent climate change induced extreme events in Bangladesh: A review. *Weather and Climate Extremes*, *7*, 49-60. https://doi.org/10.1016/j.wace.2014.10.003

De Marchi, V., Cainelli, G., & Grandinetti, R. (2022). Multinational subsidiaries and green innovation. *International Business Review*, *31*(6). https://doi.org/10.1016/j.ibusrev.2022.102027

Deb, P., & Norton, E. C. (2018). *Modeling Health Care Expenditures and Use* (Vol. 39). https://doi.org/10.1146/annurev-publhealth040617-013517

Deeks, J. J., Altman, D. G., & Bradburn, M. J. (2001). Statistical methods for examining heterogeneity and combining results from several studies in meta-analysis. In *Systematic reviews in health care: meta-analysis in context* (pp. 285-315). BMJ Publishing Group.

Deeks, J. J., Higgins, J. P., Altman, D. G., & Group, C. S. M. (2019). Analysing data and undertaking meta-analyses. Cochrane handbook for systematic reviews of interventions. In J. Chandler, M. Cumpston, J. P. T. Higgins, T. Li, M. J. Page, J. Thomas, & V. A. Welch (Eds.), *Cochrane handbook for systematic reviews of interventions* (Second edition ed., pp. 241-284). Wiley-Blackwell.

Dhasmana, S., Ghosh, S., & Kanjilal, K. (2023). Does investor sentiment influence ESG stock performance? Evidence from India. *Journal of Behavioral and Experimental Finance*, *37*. https://doi.org/10.1016/j.jbef.2023.100789

Dickinson, V. (2011). Cash Flow Patterns as a Proxy for Firm Life Cycle. *The Accounting Review*, *86*(6), 1969-1994. https://doi.org/10.2308/accr-10130

Dimick, J. B., & Ryan, A. M. (2014). Methods for evaluating changes in health care policy: The difference-in-differences approach. *JA–A - Journal of the American Medical Association*, *312*(22), 2401-2402-2402. https://doi.org/10.1001/jama.2014.16153

Dong, J. Q., Karhade, P. P., Rai, A., & Xu, S. X. (2021). How firms make information technology investment decisions: Toward a behavioral agency theory. *Journal of Management Information Systems*, *38*(1), 29-58.

Drobetz, W., El Ghoul, S., Guedhami, O., & Janzen, M. (2018). Policy uncertainty, investment, and the cost of capital. *Journal of Financial Stability*, *39*, 28-45. https://doi.org/10.1016/j.jfs.2018.08.005

Duc Dung, L., Roberto Leon, G., & Joseph Upile, M. (2021). Modeling count data for health care utilization: an empirical study of outpatient visits among Vietnamese older people. *BMC*

Medical Informatics and Decision Making, *21*(1), 1-14. https://doi.org/10.1186/s12911-021-01619-2
Dukangqi, L., & Weitao, S. (2022). Regional Happiness and Corporate Green Innovation: A Financing Constraints Perspective. *Sustainability*, *14*(2263), 2263-2263. https://doi.org/10.3390/su14042263
Dunz, N., Naqvi, A., & Monasterolo, I. (2021). Climate sentiments, transition risk, and financial stability in a stock-flow consistent model. *Journal of Financial Stability*, *54*. https://doi.org/10.1016/j.jfs.2021.100872
Eiadat, Y., Kelly, A., Roche, F., & Eyadat, H. (2008). Green and competitive? An empirical test of the mediating role of environmental innovation strategy. *Journal of World Business*, *43*(2), 131-145. https://doi.org/10.1016/j.jwb.2007.11.012
Energy Information Administration [EIA]. (2023, December). Monthly Energy Review, U.S. Energy Information Administration, Washington, DC.
Fabrizi, A., Guarini, G., & Meliciani, V. (2018). Green patents, regulatory policies and research network policies. *Research Policy*, *47*(6), 1018-1031. https://doi.org/10.1016/j.respol.2018.03.005
Fan, L., Yang, K., & Liu, L. (2020). New media environment, environmental information disclosure and firm valuation: Evidence from high-polluting enterprises in China. *Journal of Cleaner Production*, *277*. https://doi.org/10.1016/j.jclepro.2020.123253
Fan, Y., & Zheng, S. (2020). Dockless bike sharing alleviates road congestion by complementing subway travel: Evidence from Beijing. *Cities*, *107*. https://doi.org/10.1016/j.cities.2020.102895
Fawzy, S., Osman, A. I., Doran, J., & Rooney, D. W. (2020). Strategies for mitigation of climate change: a review. *Environmental Chemistry Letters*, *18*(6), 2069-2094. https://doi.org/10.1007/s10311-020-01059-w
Ferraro, F., Etzion, D., & Gehman, J. (2015). Tackling Grand Challenges Pragmatically: Robust Action Revisited. *Organization Studies*, *36*(3), 363-390. https://doi.org/10.1177/0170840614563742
Fey, C., F. , Morgulis-Yakushev, S., Park, H. J., & Björkman, I. (2009). Opening the Black Box of the Relationship between HRM Practices and Firm Performance: A Comparison of MNE Subsidiaries in the USA, Finland, and Russia. *Journal of International Business Studies*, *40*(4), 690-712. https://doi.org/10.1057/jibs.2008.83
Flammer, C. (2015). Does Corporate Social Responsibility Lead to Superior Financial Performance? A Regression Discontinuity Approach. *Management Science*, *61*(11), 2549-2568. https://doi.org/10.1287/mnsc.2014.2038
Flammer, C., Toffel, M. W., & Viswanathan, K. (2021). Shareholder activism and firms' voluntary disclosure of climate change risks. *Strategic Management Journal*, *42*(10), 1850-1879-1879. https://doi.org/10.1002/smj.3313
Friedlingstein, P., Sullivan, M. O., Jones, M. W., Andrew, R. M., Hauck, J., Olsen, A., Peters, G. P., Peters, W., Pongratz, J., Sitch, S., Quéré, C. L., Canadell, J. G., Ciais, P., Jackson, R. B., Alin, S., Aragão, L. E. O. C., Arneth, A., Arora, V., Bates, N. R., … & Zaehle, S. (2020). Global Carbon Budget 2020. *Earth System Science Data*, *12*, 3269-3340. https://doi.org/10.5194/essd-12-3269-2020.
Fu, L. (2023). Why Bad News Can Be Good News: The Signaling Feedback Effect of Negative Media Coverage of Corporate Irresponsibility. *Organization and Environment*, *36*(1), 98-125-125. https://doi.org/10.1177/10860266221108704
Fu, Y., He, C., & Luo, L. (2021). Does the low-carbon city policy make a difference? Empirical evidence of the pilot scheme in China with DEA and PSM-DID. *Ecological Indicators*, *122*. https://doi.org/10.1016/j.ecolind.2020.107238
Fuinhas, J. A., & Marques, A. C. (2012). Energy consumption and economic growth nexus in Portugal, Italy, Greece, Spain and Turkey: An ARDL bounds test approach (1965–2009). *Energy Economics*, *34*(2), 511-517. https://doi.org/10.1016/j.eneco.2011.10.003

Gaba, V., & Bhattacharya, S. (2012). Aspirations, innovation, and corporate venture capital: A behavioral perspective. *Strategic Entrepreneurship Journal*, *6*(2), 178-199. https://doi.org/10.1002/sej.1133
Geng, Y., Chen, J., Liu, T., & Tao, D. (2023). Public environmental attention, media coverage, and corporate green innovation: evidence from heavily polluting industries in China. *Environmental Science and Pollution Research*, *30*(37), 86911-86926. https://doi.org/10.1007/s11356-023-28369-0
George, G. (2005). Slack resources and the performance of privately held firms. *Academy of Management Journal*, *48*(4), 661-676. https://doi.org/10.5465/AMJ.2005.17843944
Getz, D., & Page, S. J. (2016). *Event studies : theory, research and policy for planned events* (Third edition ed.). Routledge.
Gill, B. S. (2022). Natural Disaster, Public Attention, and External Sources of Corporate Finance. *Public Attention, and External Sources of Corporate Finance (May 13, 2022).*
Gimenez-Fernandez, E. M., Sandulli, F. D., & Bogers, M. (2020). Unpacking liabilities of newness and smallness in innovative start-ups: Investigating the differences in innovation performance between new and older small firms. *Research Policy*, *49*(10). https://doi.org/10.1016/j.respol.2020.104049
Ginglinger, E. (2020). Climate risk and finance. *Bankers Markets & Investors: an academic & professional review*, (160).
Graf-Vlachy, L., Banfield, R., König, A., Oliver, A. G., & Bundy, J. (2020). Media Coverage of Firms: Background, Integration, and Directions for Future Research. *Journal of Management*, *46*(1), 36-69. https://doi.org/10.1177/0149206319864155
Graves, C., & Shan, Y. G. (2014). An Empirical Analysis of the Effect of Internationalization on the Performance of Unlisted Family and Nonfamily Firms in Australia. *Family Business Review*, *27*(2), 142-160-160. https://doi.org/10.1177/0894486513491588
Green, J., & Newman, P. (2017). Disruptive innovation, stranded assets and forecasting: the rise and rise of renewable energy. *Journal of Sustainable Finance and Investment*, *7*(2), 169-187. https://doi.org/10.1080/20430795.2016.1265410
Greer, C. R., Bruton, G. D., & Zachary, M. A. (2023). Patent productivity: Strategic human resources and the attention-based view. *International Journal of Human Resource Management*. https://doi.org/10.1080/09585192.2022.2055970
Greve, H. R. (2003). A behavioral theory of R&D expenditures and innovations: Evidence from shipbuilding. *Academy of Management Journal*, *46*(6), 685-702. https://doi.org/10.5465/30040661
Griffin, P. A., Jaffe, A. M., Lont, D. H., & Dominguez-Faus, R. (2015). Science and the stock market: Invest'rs' recognition of unburnable carbon. *Energy Economics*, *52*(Part A), 1-12. https://doi.org/10.1016/j.eneco.2015.08.028
Gujarati, D. N. (2003). *Basic Econometrics*, McGraw-Hill, NY.
Gupta, A., Owusu, A., & Wang, J. (2023). Assessing US insurance firms' climate change impact and response. *The Geneva Papers on Risk and Insurance-Issues and Practice*, 1-34.
Habib, A., & Hasan, M. M. (2017). Firm life cycle, corporate risk-taking and investor sentiment. *Accounting & Finance*, *57*(2), 465-497. https://doi.org/10.1111/acfi.12141
Habibi, H., & Feld, J. (2020). The effects of earthquake exposure on preparedness in the short and long term: a difference-in-differences estimation. *Natural Hazards*, *104*(2), 1443-1463. https://doi.org/10.1007/s11069-020-04227-x
Hakimi, A., & Inglesi-Lotz, R. (2020). Examining the differences in the impact of climate change on innovation between developed and developing countries: evidence from a panel system GMM analysis. *Applied Economics*, *52*(22), 2353-2365. https://doi.org/10.1080/00036846.2019.1690126
Han, S. (2022). The effect of performance feedback on strategic alliance formation and R&D intensity. *European Management Journal*. https://doi.org/10.1016/j.emj.2022.03.010

Hardy, C., & Maguire, S. (2020). Organizations, Risk Translation, and the Ecology of Risks: The Discursive Construction of a Novel Risk. *Academy of Management Journal*, *63*(3), 685-716. https://doi.org/10.5465/amj.2017.0987
Harrison, J. S., Freeman, R. E., & Abreu, M. C. S. D. (2015). Stakeholder theory as an ethical approach to effective management: Applying the theory to multiple contexts. *Revista brasileira de gestão de negócios*, *17*(55), 858-869.
He, A., Zhao, R., Xue, Q., & Wang, D. (2021). Renewable energy technological innovation, market forces, and carbon emission efficiency. *Science of the Total Environment*, *796*. https://doi.org/10.1016/j.scitotenv.2021.148908
He, Z. (2022). Asymmetric impacts of individual investor sentiment on the time-varying risk-return relation in stock market. *International Review of Economics & Finance*, *78*, 177-194. https://doi.org/10.1016/j.iref.2021.11.018
Helmi Alharahsheh, H., & Oius, A. (2020). A review of key paradigms: positivsim vs interpretivism. *Global Academic Journal of Humanities and Social Sciences*, *2(3)*, 39-43.
Hemphill, T. A., Kelley, K. E., & Cullari, F. (2021). The ascendancy of stakeholder capitalism: What is its meaning for corporate governance?. *Journal of General Management*, *46*(4), 262-273.
Hille, E., Althammer, W., & Diederich, H. (2020). Environmental regulation and innovation in renewable energy technologies: Does the policy instrument matter? *Technological Forecasting & Social Change*, *153*. https://doi.org/10.1016/j.techfore.2020.119921
Hoskisson, R. E., Zyung, J., Gambeta, E., & Chirico, F. (2017). Managerial Risk Taking: A Multitheoretical Review and Future Research Agenda. *Journal of Management*, *43*(1), 137-169. https://doi.org/10.1177/0149206316671583
Howard-Grenville, J., Buckle, S. J., Hoskins, B. J., & George, G. (2014). Climate change and management. *Academy of Management Journal*, *57*(3), 615-623.
Hu, G., Luo, J.-h., Han, L., & Liu, T. (2024). Does media spotlight really burn innovation? Evidence from China. *Pacific-Basin Finance Journal*, *83*. https://doi.org/10.1016/j.pacfin.2023.102240
Hu, J., Pan, X., & Huang, Q. (2020). Quantity or quality? The impacts of environmental regulation on firms' innovation–Quasi-natural experiment based on China's carbon emissions trading pilot. *Technological Forecasting and Social Change*, *158*, 120122.
Hua-Hung, W., Ja-Shen, C., & Pei-Ching, C. (2015). Effects of Green Innovation on Environmental and Corporate Performance: A Stakeholder Perspective. *Sustainability*, *7*(5), 4997-5026. https://doi.org/10.3390/su7054997
Huang, D., Jiang, F., Tu, J., & Zhou, G. (2015). Investor Sentiment Aligned: A Powerful Predictor of Stock Returns. *Review of Financial Studies*, *28*(3), 791-837. https://doi.org/10.1093/rfs/hhu080
Huang, H., Mbanyele, W., Wang, F., Song, M., & Wang, Y. (2022). Climbing the quality ladder of green innovation: Does green finance matter? *Technological Forecasting & Social Change*, *184*. https://doi.org/10.1016/j.techfore.2022.122007
Huang, H. H., Kerstein, J., & Wang, C. (2018). The Impact of Climate Risk on Firm Performance and Financing Choices: An International Comparison. *Journal of International Business Studies*, *49*(5), 633-656.
Huang, H. H., Kerstein, J., Wang, C., & Wu, F. (2022). Firm climate risk, risk management, and bank loan financing. *Strategic Management Journal*, *43*(12), 2849-2880. https://doi.org/10.1002/smj.3437
Huang, J.-W., & Li, Y.-H. (2017). Green Innovation and Performance: The View of Organizational Capability and Social Reciprocity. *Journal of Business Ethics*, *145*(2), 309-324. https://doi.org/10.1007/s10551-015-2903-y
Huang, J., Liu, Q., Cai, X., Hao, Y., & Lei, H. (2018). The effect of technological factors on China's carbon intensity: New evidence from a panel threshold model. *Energy Policy*, *115*, 32-42. https://doi.org/10.1016/j.enpol.2017.12.008

Huang, L., Wang, J., Zhu, Y., & Zhang, K. (2023). Examining the interplay of green bonds and fossil fuel markets: The influence of investor sentiments. *Resources Policy*, *86*. https://doi.org/10.1016/j.resourpol.2023.104171

Huang, Q., Li, Y., Lin, M., & McBrayer, G. A. (2022). Natural disasters, risk salience, and corporate ESG disclosure. *Journal of Corporate Finance*, *72*. https://doi.org/10.1016/j.jcorpfin.2021.102152

Hudson, Y., & Green, C. J. (2015). Is investor sentiment contagious? International sentiment and UK equity returns. *Journal of Behavioral and Experimental Finance*, *5*, 46-59. https://doi.org/10.1016/j.jbef.2015.02.004

Hussain, S., Nguyen, V. C., Nguyen, H. T., Nguyen, Q. M., & Nguyen, T. T. (2021). Macroeconomic factors, working capital management, and firm performance—A static and dynamic panel analysis. *Humanities and Social Sciences Communications*, *8*(1). https://doi.org/10.1057/s41599-021-00778-x

Husted, B. W., Montiel, I., & Christmann, P. (2016). Effects of local legitimacy on certification decisions to global and national CSR standards by multinational subsidiaries and domestic firms. *Journal of International Business Studies*, *47*(3), 382-397.

Ibikunle, G., & Steffen, T. (2017). European Green Mutual Fund Performance: A Comparative Analysis with their Conventional and Black Peers. *Journal of Business Ethics*, *145*(2), 337-355. https://doi.org/10.1007/s10551-015-2850-7

Imas, A. (2016). The Realization Effect: Risk-Taking after Realized versus Paper Losses. *The American Economic Review*, *106*(8), 2086-2109.

IPCC. (2014). *Climate change 2014: Mitigation of climate change. Contribution of working group III to the fifth assessment report of the intergovernmental Panel on Climate Change*.

IPCC. (n.d.). IPCC DDC Glossary. Retrieved April 25, 2024, from https://www.ipcc-data.org/guidelines/pages/glossary/glossary_c.html

IRENA and CPI. (2023). *Global landscape of renewable energy finance 2023*. International Renewable Energy Agency, Abu Dhabi.

Işık, E. (2024). The firm-level anatomy of innovation in climate change mitigation technologies. *Journal of Cleaner Production*, 141090.

Jakobsen, S., & Clausen, T. H. (2016). Innovating for a greener future: the direct and indirect effects of firms' environmental objectives on the innovation process. *Journal of Cleaner Production*, *128*, 131-141. https://doi.org/10.1016/j.jclepro.2015.06.023

Jena, S. K., Tiwari, A. K., & Mitra, A. (2019). Put–call ratio volume vs. open interest in predicting market return: A frequency domain rolling causality analysis. *Economies*, *7*(1). https://doi.org/10.3390/economies7010024

Jiang, T., He, X., Su, B., Havea, P. H., Wei, K., Kundzewicz, Z. W., & Liu, D. (2024). COP 28: Challenge of coping with climate crisis. *The Innovation*, *5*(1). https://doi.org/10.1016/j.xinn.2023.100559

Jin, C., Monfort, A., Chen, F., Xia, N., & Wu, B. (2024). Institutional investor ESG activism and corporate green innovation against climate change: Exploring differences between digital and non-digital firms. *Technological Forecasting & Social Change*, *200*. https://doi.org/10.1016/j.techfore.2023.123129

Johnstone, N., Haščič, I., & Popp, D. (2010). Renewable Energy Policies and Technological Innovation: Evidence Based on Patent Counts. *Environmental and Resource Economics: The Official Journal of the European Association of Environmental and Resource Economists*, *45*(1), 133-155. https://doi.org/10.1007/s10640-009-9309-1

Kacperczyk, A. (2009). With greater power comes greater responsibility? takeover protection and corporate attention to stakeholders. *Strategic Management Journal*, *30*(3), 261-285. https://doi.org/10.1002/smj.733

Kesidou, E., & Demirel, P. (2012). On the drivers of eco-innovations: Empirical evidence from the UK. *Research Policy*, *41*(5), 862-870. https://doi.org/10.1016/j.respol.2012.01.005

Kim, J., & Park, K. (2016). Financial development and deployment of renewable energy technologies. *Energy Economics*, *59*, 238-250. https://doi.org/10.1016/j.eneco.2016.08.012
Kittner, N., Kammen, D. M., & Lill, F. (2017). Energy storage deployment and innovation for the clean energy transition. *Nature Energy*, *2*(9). https://doi.org/10.1038/nenergy.2017.125
Kölbel, J. F., Busch, T., & Jancso, L. M. (2017). How Media Coverage of Corporate Social Irresponsibility Increases Financial Risk. *Strategic Management Journal*, *38*(11), 2266-2284.
Kolk, A., & Pinkse, J. (2005). Business Responses to Climate Change: Identifying emergent strategies. *California Management Review*, *47*(3), 6-20. https://doi.org/10.2307/41166304
Kolk, A., & Pinkse, J. (2007). Towards strategic stakeholder management? Integrating perspectives on sustainability challenges such as corporate responses to climate change. *Corporate Governance: The international journal of business in society*, *7*(4), 370-378. https://doi.org/10.1108/14720700710820452
Kolk, A., & Pinkse, J. (2008). A Perspective on Multinational Enterprises and Climate Change: Learning from "An Inconvenient Truth"?. *Journal of International Business Studies*, *39*(8), 1359-1378. https://doi.org/10.1057/jibs.2008.61
Kong, G., Kong, D., & Wang, M. (2020). Does media attention affect firms' environmental protection efforts? Evidence from China. *Singapore Economic Review*, *65*(3), 577-600. https://doi.org/10.1142/S021759081741003X
Kouloukoui, D., Gomes, S. M. d. S., Marinho, M. M. d. O., Torres, E. A., Kiperstok, A., & de Jong, P. (2018). Disclosure of climate risk information by the world’s largest companies. *Mitigation and Adaptation Strategies for Global Change: An International Journal Devoted to Scientific, Engineering, Socio-Economic and Policy Responses to Environmental Change*, *23*(8), 1251-1279. https://doi.org/10.1007/s11027-018-9783-2
Kouloukoui, D., Marinho, M. M. d. O., Gomes, S. M. d. S., Kiperstok, A., & Torres, E. A. (2019). Corporate climate risk management and the implementation of climate projects by the world's largest emitters. *Journal of Cleaner Production*, *238*. https://doi.org/10.1016/j.jclepro.2019.117935
Krueger, P., Sautner, Z., & Starks, L. T. (2020). The Importance of Climate Risks for Institutional Investors. *Review of Financial Studies*, *33*(3), 1067-1111. https://doi.org/10.1093/rfs/hhz137
Kunapatarawong, R., & Martínez-Ros, E. (2016). Towards green growth: How does green innovation affect employment?. *Research Policy*, *45*(6), 1218-1232. https://doi.org/10.1016/j.respol.2016.03.013
Kuyper, J., Schroeder, H., & Linnér, B. O. (2018). The Evolution of the UNFCCC. *Annual Review of Environment and Resources*, *43*, 343-368.
Lant, T., & Shapira, Z. (2008). Managerial reasoning about aspirations and expectations. *Journal of Economic Behavior and Organization*, *66*(1), 60-73. https://doi.org/10.1016/j.jebo.2007.03.006
Lee, C. C., Wang, C. W., Ho, S. J., & Wu, T. P. (2021). The impact of natural disaster on energy consumption: International evidence. *Energy Economics*, *97*, 105021.
Leiter, A. M., Oberhofer, H., & Raschky, P. A. (2009). Creative Disasters? Flooding Effects on Capital, Labour and Productivity Within European Firms. *Environmental and Resource Economics: The Official Journal of the European Association of Environmental and Resource Economists*, *43*(3), 333-350. https://doi.org/10.1007/s10640-009-9273-9
Levinson, A., & Taylor, M. S. (2008). Unmasking the Pollution Haven Effect. *International Economic Review*, *49*(1), 223-254.
Leyva-de la Hiz, D. I., Ferron-Vilchez, V., & Aragon-Correa, J. A. (2019). Do Firms' Slack Resources Influence the Relationship Between Focused Environmental Innovations and Financial Performance? More is Not Always Better. *Journal of Business Ethics*, *159*(4), 1215-1227. https://doi.org/10.1007/s10551-017-3772-3

Li, D., Huang, M., Ren, S., Chen, X., & Ning, L. (2018). Environmental Legitimacy, Green Innovation, and Corporate Carbon Disclosure: Evidence from CDP China 100. *Journal of Business Ethics*, *150*(4), 1089-1104. https://doi.org/10.1007/s10551-016-3187-6

Li, J., & Wu, D. (2020). Do Corporate Social Responsibility Engagements Lead to Real Environmental, Social, and Governance Impact?. *Management Science*, *66*(6), 2564-2588. https://doi.org/10.1287/mnsc.2019.3324

Li, S., Daud Ishola, B., Abbas, S., Subhan, M., & Abduvaxitovna Shamansurova, Z. (2023). Building resilience in the face of natural disasters: ICT, fossil fuel use, and sustainable development in an emerging economy. *Gondwana Research*, *124*, 273-289-289. https://doi.org/10.1016/j.gr.2023.06.018

Li, X., & Zhou, Y. M. (2017). Offshoring Pollution while Offshoring Production?. *Strategic Management Journal*, *38*(11), 2310-2329. https://doi.org/10.1002/smj.2656

Liang, J., & Fiorino, D. J. (2013). The Implications of Policy Stability for Renewable Energy Innovation in the United States, 1974-2009. *Policy Studies Journal*, *41*(1), 97-118. https://doi.org/10.1111/psj.12004

Lin, B., & Zhu, J. (2019). Determinants of renewable energy technological innovation in China under CO2 emissions constraint. *Journal of Environmental Management*, *247*, 662-671. https://doi.org/10.1016/j.jenvman.2019.06.121

Lin, B., & Zhu, J. (2019). The role of renewable energy technological innovation on climate change: Empirical evidence from China. *Science of the Total Environment*, *659*, 1505-1512-1512. https://doi.org/10.1016/j.scitotenv.2018.12.449

Lin, Z. (2023). Impact of investor sentiment on firm innovation: Evidence from textual analysis. *Borsa Istanbul Review*, *23*(5), 1141-1151. https://doi.org/10.1016/j.bir.2023.07.002

Lindman, Å., & Söderholm, P. (2016). Wind energy and green economy in Europe: Measuring policy-induced innovation using patent data. *Applied Energy*, *179*, 1351-1359. https://doi.org/10.1016/j.apenergy.2015.10.128

Liu, L., Chen, M., Wang, H., & Liu, B. (2023). How does the Chinese pilot policy on information consumption affect carbon emissions?. *Sustainable Production and Consumption*, *41*, 88-106-106. https://doi.org/10.1016/j.spc.2023.07.030

Löfgren, Å., Wråke, M., Hagberg, T., & Roth, S. (2014). Why the EU ETS needs reforming: an empirical analysis of the impact on company investments. *Climate Policy*, *14*(5), 537-558. https://doi.org/10.1080/14693062.2014.864800

Lu, X., & White, H. (2014). Robustness checks and robustness tests in applied economics. *Journal of Econometrics*, *178*(Part 1), 194-206. https://doi.org/10.1016/j.jeconom.2013.08.016

Ma, L., Wang, Q., Shi, D., & Shao, Q. (2023). Spatiotemporal patterns and determinants of renewable energy innovation: Evidence from a province-level analysis in China. *Humanities and Social Sciences Communications*, *10*(1). https://doi.org/10.1057/s41599-023-01848-y

Ma, Y., Feng, G. F., & Chang, C. P. (2023). From traditional innovation to green innovation: How an occurrence of natural disasters influences sustainable development?. *Sustainable Development*. https://doi.org/10.1002/sd.2802

Majeed, M. T., & Ozturk, I. (2020). Environmental degradation and population health outcomes: a global panel data analysis. *Environmental Science and Pollution Research*, *27*(13), 15901-15911. https://doi.org/10.1007/s11356-020-08167-8

Majid, S., Abbas, F., & Malik, M. N. (2023). Nexus between corporate innovation and investor sentiment: empirical evidence from the US. *Kybernetes*. https://doi.org/10.1108/K-12-2022-1688

Marshall, B. R., Nguyen, H. T., Nguyen, N. H., Visaltanachoti, N., & Young, M. (2021). Do climate risks matter for green investment?. *Journal of International Financial Markets, Institutions & Money*, *75*. https://doi.org/10.1016/j.intfin.2021.101438

Mbanyele, W., Huang, H., & Muchenje, L. T. (2023). Peer performance and short-termism: evidence from green patenting activities. *Applied Economics Letters*. https://doi.org/10.1080/13504851.2023.2205088
McDowall, D., McCleary, R., & Bartos, B. J. (2021). *Interrupted time series analysis,* Oxford University Press.
Meyer, B. D. (1995). Natural and Quasi-Experiments in Economics. *Journal of Business & Economic Statistics*, *13*(2), 151-161. https://doi.org/10.2307/1392369
Miller, K. D. (1993). Industry and country effects on managers' perceptions of environmental uncertainties. *Journal of International Business Studies*, *24*(4), 693-714. https://doi.org/10.1057/palgrave.jibs.8490251
Mithani, M. A. (2017). Liability of foreignness, natural disasters, and corporate philanthropy. *Journal of International Business Studies*, *48*(8), 941-963.
Mithani, M. A. (2020). Adaptation in the Face of the New Normal. *Academy of Management Perspectives*, *.34*(4), 508-530. https://doi.org/10.5465/amp.2019.0054
Mithani, M. A., Gopalakrishnan, S., & Santoro, M. D. (2021). Does exposure to a traumatic event make organizations resilient?. *Long Range Planning*, *54*(3). https://doi.org/10.1016/j.lrp.2020.102031
Monasterolo, I. (2020). Climate Change and the Financial System. *Annual Review of Resource Economics*, *12*, 299-320. https://doi.org/10.1146/annurev-resource-110119-031134
Muttaqee, M., Furqan, M., & Boudet, H. (2023). Community response to microgrid development: Case studies from the U.S. *Energy Policy*, *181*. https://doi.org/10.1016/j.enpol.2023.113690
Najah, A., Narjess, B., Sadok El, G., Omrane, G., Najah, A., Narjess, B., Sadok El, G., & Omrane, G. (2016). Firm Internationalization and Corporate Social Responsibility. *Journal of Business Ethics*, *134*(2), 171-197.
Naughton, J. P., Wang, C., & Yeung, I. (2019). Investor Sentiment for Corporate Social Performance. *Accounting Review*, *94*(4), 401-420. https://doi.org/10.2308/accr-52303
Nesta, L., Vona, F., & Nicolli, F. (2014). Environmental policies, competition and innovation in renewable energy. *Journal of Environmental Economics and Management*, *67*(3), 396-411. https://doi.org/10.1016/j.jeem.2014.01.001
Neuman, W. L. (2014). *Social Research Methods: Pearson New International Edition : Qualitative and Quantitative Approaches* (Vol. Seventh edition, Pearson new international edition). Pearson.
Nippa, M., Patnaik, S., & Taussig, M. (2021a). MNE responses to carbon pricing regulations: Theory and evidence. *Journal of International Business Studies*, *52*(5), 904-929. https://doi.org/10.1057/s41267-021-00403-8
Nippa, M., Patnaik, S., & Taussig, M. (2021b). MNE responses to carbon pricing regulations: Theory and evidence. *Journal of International Business Studies*, *52*(5), 904. https://doi.org/10.1057/s41267-021-00403-8
Noailly, J., & Smeets, R. (2015). Directing technical change from fossil-fuel to renewable energy innovation: An application using firm-level patent data. *Journal of Environmental Economics and Management*, *72*, 15-37. https://doi.org/10.1016/j.jeem.2015.03.004
Oetzel, J., & Oh, C. H. (2014). Learning to Carry the Cat by the Tail: Firm Experience, Disasters, and Multinational Subsidiary Entry and Expansion. *Organization Science*, *25*(3), 732-756.
Oetzel, J., & Oh, C. H. (2021). A storm is brewing: Antecedents of disaster preparation in risk prone locations. *Strategic Management Journal*, *42*(8), 1545-1570. https://doi.org/10.1002/smj.3272
Pan, A., Zhang, W., Shi, X., & Dai, L. (2022). Climate policy and low-carbon innovation: Evidence from low-carbon city pilots in China. *Energy Economics*, *112*. https://doi.org/10.1016/j.eneco.2022.106129
Park, Y. S., Konge, L., & Artino, A. R. (2020). The Positivism Paradigm of Research. *Academic Medicine*, *95*(5), 690-694. https://doi.org/10.1097/ACM.0000000000003093

Perruchas, F., Consoli, D., & Barbieri, N. (2020). Specialisation, diversification and the ladder of green technology development. *Research Policy*, *49*(3). https://doi.org/10.1016/j.respol.2020.103922
Pinkse, J., & Kolk, A. (2012). Multinational enterprises and climate change: Exploring institutional failures and embeddedness. *Journal of International Business Studies*, *43*(3), 332-341.
Piperopoulos, P., Jimenez-Moro, E., & Dindial, M. (2023). Can hurricanes drive green innovations?. *Journal of Environmental Management*, *327*. https://doi.org/10.1016/j.jenvman.2022.116893
Porter, M. E., & Kramer, M. R. (2006). Strategy & Society: The Link Between Competitive Advantage and Corporate Social Responsibility. *Harvard Business Review*, *84*(12), 78-92.
Porter, M. E., & Kramer, M. R. (2011). The Big Idea: Creating Shared Value. *CFA Digest*, *41*(1), 12-13.
Porter, M. E., & Reinhardt, F. L. (2007). A Strategic Approach to Climate. *Harvard Business Review*, *85*(10), 22-26.
Porter, M. E., & van der Linde, C. (1995). Toward a New Conception of the Environment-Competitiveness Relationship. *The Journal of Economic Perspectives*, *9*(4), 97-118.
Prest, B. C. (2018). Explanations for the 2014 oil price decline: Supply or demand?. *Energy Economics*, *74*, 63-75.
Qiu, S., Jiang, J., Liu, X., Chen, M.-H., & Yuan, X. (2021). Can corporate social responsibility protect firm value during the COVID-19 pandemic?. *International Journal of Hospitality Management*, *93*. https://doi.org/10.1016/j.ijhm.2020.102759
Raynard, M., Lu, F., & Jing, R. (2020). Reinventing the State-Owned Enterprise? Negotiating Change during Profound Environmental Upheaval. *Academy of Management Journal*, *63*(4), 1300-1335. https://doi.org/10.5465/amj.2017.1162
Regnér, P., & Edman, J. (2014). MNE institutional advantage: How subunits shape, transpose and evade host country institutions. *Journal of International Business Studies*, *45*(3), 275-302.
Reis, P. M. N., & Pinho, C. (2021). A Reappraisal of the Causal Relationship between Sentiment Proxies and Stock Returns. *Journal of Behavioral Finance*, *22*(4), 420-442.
Ren, X., Li, Y., Shahbaz, M., Dong, K., & Lu, Z. (2022). Climate risk and corporate environmental performance: Empirical evidence from China. *Sustainable Production and Consumption*, *30*, 467-477. https://doi.org/10.1016/j.spc.2021.12.023
Robertson, D., C. . (2009). Corporate Social Responsibility and Different Stages of Economic Development: Singapore, Turkey, and Ethiopia. *Journal of Business Ethics*, *88*, 617-633. https://doi.org/10.1007/s10551-009-0311-x
Roper, S., & Tapinos, E. (2016). Taking risks in the face of uncertainty: An exploratory analysis of green innovation. *Technological Forecasting & Social Change*, *112*, 357-363. https://doi.org/10.1016/j.techfore.2016.07.037
Ryan, A. M., Burgess, J. F., & Dimick, J. B. (2015). Why we should not be indifferent to specification choices for difference-in-differences. *Health Services Research*, *50*(4), 1211-1235-1235. https://doi.org/10.1111/1475-6773.12270
Sadovnikova, A., & Pujari, A. (2017). The effect of green partnerships on firm value. *Journal of the Academy of Marketing Science*, *45*(2), 251-267. https://doi.org/10.1007/s11747-016-0490-9
Sakhel, A. (2017). Corporate climate risk management: Are European companies prepared?. *Journal of Cleaner Production*, *165*, 103-118. https://doi.org/10.1016/j.jclepro.2017.07.056
Saunders, M., Lewis, P., & Thornhill, A. (2011). *Research methods for business students (7th ed.)*. Essex, UK: Pearson Education.
Scotland, J. (2012). Exploring the Philosophical Underpinnings of Research: Relating Ontology and Epistemology to the Methodology and Methods of the Scientific, Interpretive, and Critical Research Paradigms. *English Language Teaching*, *5*(9), 9-16.
Shan, Y. G., & Troshani, I. (2014). Does XBRL benefit financial statement auditing?. *Journal of Computer Information Systems*, *54*(4), 11-21-21. https://doi.org/10.1080/08874417.2014.11645718

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*(4), 1121-1138. https://doi.org/10.2307/45022718

Shinkle, G. A. (2012). Organizational Aspirations, Reference Points, and Goals: Building on the Past and Aiming for the Future. *Journal of Management*, *38*(1), 415-455. https://doi.org/10.1177/0149206311419856

Simon, D. P., & Wiggins Iii, R. A. (2001). S&P futures returns and contrary sentiment indicators. *Journal of Futures Markets*, *21*(5), 447-462. https://doi.org/10.1002/fut.4

Sinha, A., Tiwari, S., & Saha, T. (2024). Modeling the behavior of renewable energy market: Understanding the moderation of climate risk factors. *Energy Economics*, *130*. https://doi.org/10.1016/j.eneco.2023.107290

Smirnova, O., Strumsky, D., & Qualls, A. C. (2021). Do federal regulations beget innovation? Legislative policy and the role of executive orders. *Energy Policy*, *158*. https://doi.org/10.1016/j.enpol.2021.112570

Smulowitz, S. J., Rousseau, H. E., & Bromiley, P. (2020). The behavioral theory of the (community-oriented) firm: The differing response of community-oriented firms to performance relative to aspirations. *Strategic Management Journal*, *41*(6), 1023-1053. https://doi.org/10.1002/smj.3123

Sodhi, M. S. (2016). Natural disasters, the economy and population vulnerability as a vicious cycle with exogenous hazards. *Journal of Operations Management*, *45*, 101-113. https://doi.org/10.1016/j.jom.2016.05.010

Sofka, W., Grimpe, C., Hasanov, F., & Cherif, R. (2022). Additionality or opportunism: Do host-country R&D subsidies impact innovation in foreign MNC subsidiaries?. *Journal of International Business Policy*, *5*(3), 296-327. https://doi.org/10.1057/s42214-021-00106-9

Song, Y., Ji, Q., Du, Y.-J., & Geng, J.-B. (2019). The dynamic dependence of fossil energy, investor sentiment and renewable energy stock markets. *Energy Economics*, *84*. https://doi.org/10.1016/j.eneco.2019.104564

Sprengel, D. C., & Busch, T. (2011). Stakeholder engagement and environmental strategy - the case of climate change. *Business Strategy & the Environment*, *20*(6), 351-364. https://doi.org/10.1002/bse.684

Staw, B. M., Sandelands, L. E., & Dutton, J. E. (1981). Threat-Rigidity Effects in Organizational Behavior: A Multilevel Analysis. *Administrative Science Quarterly*, *26*(4), 501-524. https://doi.org/10.2307/2392337

Steffen, B. (2020). Estimating the cost of capital for renewable energy projects. *Energy Economics*, *88*. https://doi.org/10.1016/j.eneco.2020.104783

Stuart, E. A., Huskamp, H. A., Duckworth, K., Simmons, J., Song, Z., Chernew, M. E., & Barry, C. L. (2014). Using propensity scores in difference-in-differences models to estimate the effects of a policy change. *Health Services and Outcomes Research Methodology: An International Journal Devoted to Methods for the Study of the Utilization, Quality, Cost and Outcomes of Health Care*, *14*(4), 166-182. https://doi.org/10.1007/s10742-014-0123-z

Stucki, T. (2019). Which firms benefit from investments in green energy technologies? – The effect of energy costs. *Research Policy*, *48*(3), 546-555. https://doi.org/10.1016/j.respol.2018.09.010

Sun, Y., Li, H., Bao, Q., & Lu, Z. (2022). Environmental Regulation, Sentiment, and Eco-Innovation: Evidence From China. *Frontiers in Environmental Science*, *9*. https://doi.org/10.3389/fenvs.2021.809452

Symeou, P. C., Zyglidopoulos, S., & Gardberg, N. A. (2019). Corporate environmental performance: Revisiting the role of organizational slack. *Journal of Business Research*, *96*, 169-182. https://doi.org/10.1016/j.jbusres.2018.11.019

Tariq, A., Badir, Y. F., Tariq, W., & Bhutta, U. S. (2017). Drivers and consequences of green product and process innovation: A systematic review, conceptual framework, and future outlook. *Technology in Society*, *51*, 8-23.

Tavakolifar, M., Omar, A., Lemma, T. T., & Samkin, G. (2021). Media attention and its impact on corporate commitment to climate change action. *Journal of Cleaner Production*, *313*. https://doi.org/10.1016/j.jclepro.2021.127833

Tilcsik, A., & Marquis, C. (2013). Punctuated Generosity: How Mega-events and Natural Disasters Affect Corporate Philanthropy in U.S. Communities. *Administrative Science Quarterly*, *58*(1), 111-148. https://doi.org/10.1177/0001839213475800

Truong, C., Trück, S., & Mathew, S. (2018). Managing risks from climate impacted hazards – The value of investment flexibility under uncertainty. *European Journal of Operational Research*, *269*(1), 132-145. https://doi.org/10.1016/j.ejor.2017.07.012

Tsalis, T. A., & Nikolaou, I. E. (2017). Assessing the Effects of Climate Change Regulations on the Business Community: A System Dynamic Approach. *Business Strategy & the Environment*, *26*(6), 826-843. https://doi.org/10.1002/bse.1953

Tu, Y., & Wu, W. (2021). How does green innovation improve enterprises' competitive advantage? The role of organizational learning. *Sustainable Production and Consumption*, *26*, 504-516.

Twidell, J., & Weir, A. D. (2015). *Renewable energy resources* (Third edition ed.). Routledge.

Umar, Z., Adekoya, O. B., Oliyide, J. A., & Gubareva, M. (2021). Media sentiment and short stocks performance during a systemic crisis. *International Review of Financial Analysis*, *78*, 101896.

Un, C. A. (2011). The advantage of foreignness in innovation. *Strategic Management Journal*, *32*(11), 1232-1242. https://doi.org/10.2307/41261788

Un, C. A. (2016). The liability of localness in innovation. *Journal of International Business Studies*, *47*(1), 44-67.

Wagner, M. (2011). Corporate performance implications of extended stakeholder management: New insights on mediation and moderation effects. *Ecological Economics*, *70*(5), 942-950. https://doi.org/10.1016/j.ecolecon.2010.12.010

Wang, C., Wei, Y., & Wu, L. (2023). Global eco-innovation and its local impact in emerging economies: Boundary conditions of environmental regulations and pollution intensity. *Journal of Product Innovation Management*, *40*(6), 761-793-793. https://doi.org/10.1111/jpim.12675

Wang, G., Yu, G., & Shen, X. (2021). The effect of online environmental news on green industry stocks: The mediating role of investor sentiment. *Physica A: Statistical Mechanics and its Applications*, *573*. https://doi.org/10.1016/j.physa.2021.125979

Wang, K., & Zhang, X. (2021). The effect of media coverage on disciplining firms' pollution behaviors: Evidence from Chinese heavy polluting listed companies. *Journal of Cleaner Production*, *280*(Part 1). https://doi.org/10.1016/j.jclepro.2020.123035

Wang, W., Sun, Z., Wang, W., Hua, Q., & Wu, F. (2023). The impact of environmental uncertainty on ESG performance: Emotional vs. rational. *Journal of Cleaner Production*, *397*. https://doi.org/10.1016/j.jclepro.2023.136528

Wang, Y.-H., Keswani, A., & Taylor, S. J. (2006). The relationships between sentiment, returns and volatility. *International Journal of Forecasting*, *22*(1), 109-123. https://doi.org/10.1016/j.ijforecast.2005.04.019

Wang, Z., & Li, Z. (2023). Does minority shareholder activism enhance corporate innovation? Evidence from China. *Finance Research Letters*, *54*. https://doi.org/10.1016/j.frl.2023.103755

Weigelt, C., & Shittu, E. (2016). Competition, regulatory policy, and firms' resource investments: The case of renewable energy technologies. *Academy of Management Journal*, *59*(2), 678-704. https://doi.org/10.5465/amj.2013.0661

Wiese, P. (2020). *Trends in Normalized Weather-Related Property Losses in the United States: 1960–2018* S. o. Actuaries.

Wiklund, J., Baker, T., & Shepherd, D. (2010). The age-effect of financial indicators as buffers against the liability of newness. *Journal of Business Venturing*, *25*(4), 423-437. https://doi.org/10.1016/j.jbusvent.2008.10.011

Winn, M., Kirchgeorg, M., Griffiths, A., Linnenluecke, M. K., & Günther, E. (2011). Impacts from climate change on organizations: a conceptual foundation. *Business strategy and the environment*, *20*(3), 157-173.

WIPO. (2023). *Global Innovation Index 2023 Innovation in the face of uncertainty*. https://www.wipo.int/global_innovation_index/en/2023

Wooldridge, J. M. (1999). Distribution-Free Estimation of Some Nonlinear Panel Data Models. *Journal of Econometrics*, *90*(1), 77-97.

Xiongfeng, P., Xianyou, P., Changyu, L., Jinbo, S., & Jing, Z. (2018). Effects of China's environmental policy on carbon emission efficiency. *International Journal of Climate Change Strategies and Management*, *11*(3), 326-340. https://doi.org/10.1108/IJCCSM-12-2017-0206

Xu, B., & Lin, B. (2018). Assessing the development of China's new energy industry. *Energy Economics*, *70*, 116-131. https://doi.org/10.1016/j.eneco.2018.01.001

Xu, D., Zhou, K. Z., & Du, F. (2019). Deviant versus Aspirational Risk Taking: The Effects of Performance Feedback on Bribery Expenditure and R&D Intensity. *Academy of Management Journal*, *62*(4), 1226-1251. https://doi.org/10.5465/amj.2016.0749

Xu, Y., Chin, W., Liu, Y., & He, K. (2023). Do institutional pressures promote green innovation? The effects of cross-functional coopetition in green supply chain management. *International Journal of Physical Distribution & Logistics Management*, *53*(7/8), 743-761. https://doi.org/10.1108/IJPDLM-03-2022-0104

Yalabik, B., & Fairchild, R. J. (2011). Customer, regulatory, and competitive pressure as drivers of environmental innovation. *International Journal of Production Economics*, *131*(2), 519-527. https://doi.org/10.1016/j.ijpe.2011.01.020

Yang, A., Uysal, N., & Taylor, M. (2018). Unleashing the Power of Networks: Shareholder Activism, Sustainable Development and Corporate Environmental Policy. *Business Strategy & the Environment*, *27*(6), 712-727. https://doi.org/10.1002/bse.2026

Yang, A., & Wu, M.-L. (2011). Exploring the relationship between investor sentiment and price volatility. *Quantitative Finance*, *11*(6), 955-965. https://doi.org/10.1080/14697688.2010.507214

Yang, J., & Chen, X. (2024). Financial performance feedback, institutional ownership and green innovation: evidence from China. *Chinese Management Studies*, *18*(2), 526-549.

Yang, N., Zhang, Y., Yu, L., Wang, J., & Liu, X. (2022). Cross-Border Mergers and Acquisitions, Regional Cultural Diversity and Acquirers' Corporate Social Responsibility: Evidence from China Listed Companies. *International Review of Economics and Finance*, *79*, 565-578. https://doi.org/10.1016/j.iref.2022.02.041

Yang, Q.-C., Zheng, M., & Chang, C.-P. (2022). Energy policy and green innovation: A quantile investigation into renewable energy. *Renewable Energy*, *189*, 1166-1175. https://doi.org/10.1016/j.renene.2022.03.046

Yeo, J., & Knox, C. C. (2019). Public attention to a local disaster versus competing focusing events: Google trends analysis following the 2016 Louisiana flood. *Social Science Quarterly*, *100*(7), 2542-2554.

Yue, X.-L., & Gao, Q.-X. (2018). Contributions of natural systems and human activity to greenhouse gas emissions. *Advances in Climate Change Research*, *9*(4), 243-252. https://doi.org/10.1016/j.accre.2018.12.003

Zaheer, S. (1995). Overcoming the liability of foreignness. *Academy of Management Journal*, *38*(2), 341-363. https://doi.org/10.2307/256683

Zaheer, S., & Mosakowski, E. (1997). The Dynamics of the Liability of Foreignness: A Global Study of Survival in Financial Services. *Strategic Management Journal*, *18*(6), 439-463.

Zhang, D., Zheng, M., Feng, G.-F., & Chang, C.-P. (2022). Does an environmental policy bring to green innovation in renewable energy? *Renewable Energy*, *195*, 1113-1124. https://doi.org/10.1016/j.renene.2022.06.074

Zhang, Y., Zhang, R., & Zhang, C. (2022). Insight into the driving force of environmental performance improvement: Environmental regulation or media coverage. *Journal of Cleaner Production*, *358*. https://doi.org/10.1016/j.jclepro.2022.132024

Zhao, W., Feng, T., Xin, X., & Hao, G. (2021). How to respond to competitors' green success for improving performance: The moderating role of organizational ambidexterity. *Business Strategy & the Environment*, *30*(1), 489-506. https://doi.org/10.1002/bse.2633

Zhao, X.-X., Zheng, M., & Fu, Q. (2022). How natural disasters affect energy innovation? The perspective of environmental sustainability. *Energy Economics*, *109*. https://doi.org/10.1016/j.eneco.2022.105992

Zhou, N., Li, J., Bai, C., & Zhang, D. (2023). From Learner to Innovator: Knowledge Transfer from a Parent MNE and Foreign Subsidiaries' Local Innovation. *Management International Review: Journal of International Business*, 1-40. https://doi.org/10.1007/s11575-023-00512-6

Zhou, P., & Wen, W. (2020). Carbon-constrained firm decisions: From business strategies to operations modeling. *European Journal of Operational Research*, *281*(1), 1-15. https://doi.org/10.1016/j.ejor.2019.02.050

Zobeidi, T., Komendantova, N., & Yazdanpanah, M. (2022). Social media as a driver of the use of renewable energy: The perceptions of Instagram users in Iran. *Energy Policy*, *161*. https://doi.org/10.1016/j.enpol.2021.112721

Zyglidopoulos, S. C., Georgiadis, A. P., Carroll, C. E., & Siegel, D. S. (2012). Does media attention drive corporate social responsibility?. *Journal of Business Research*, *65*(11), 1622-1627. https://doi.org/10.1016/j.jbusres.2011.10.021

Appendices

Appendix 1 Ethics Notification Email

Gmail

Hiva Rastegar <hivarmm@gmail.com>

[HE007] - Human Ethics Notification - 4000025239
1 message

humanethics@massey.ac.nz <humanethics@massey.ac.nz> Wed, Nov 17, 2021 at 12:06 AM
To: Hiva.RastegarMoghadamMoadab.1@uni.massey.ac.nz, H.Chung@massey.ac.nz, Y.D.Liu@massey.ac.nz
Cc: humanethics@massey.ac.nz

Kia ora,

Link to the application
HoU Review Group

Ethics Notification Number: 4000025239
Title: Climate change and corporate strategy

Thank you for your notification which you have assessed as low risk.

Your project has been recorded in our database for inclusion in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

Please notify me if situations subsequently occur which cause you to reconsider your initial ethical analysis that it is safe to proceed without approval by one of the University's Human Ethics Committees.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanethics@massey.ac.nz."

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish require evidence of committee approval (with an approval number), you will have to complete the application form again answering yes to the publication question to provide more information to go before one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

You are reminded that staff researchers and supervisors are fully responsible for ensuring that the information in the low risk notification has met the requirements and guidelines for submission of a low risk notification.

If you wish to print an official copy of this letter:

1. Please login to the RIMS system (https://rme.massey.ac.nz).
2. In the Ethics menu, select Ethics Applications.
3. Using the Advanced search with appropriate criteria to find only this application.
4. With the application on the Results tab, select Reports from the toolbar.
5. Select the "Human Ethics - Low Risk Notification Letter" link, this will open the report viewer.
6. Select the application code from the Report Parameters dropdown and submit. You can then select an export option from the top toolbar (Print, Save).

Yours sincerely
Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and
Director (Research Ethics)

Appendix 2 IPC codes for RE technologies

Wind	
Wind motors with rotation axis substantially in wind direction	F03D 1
Wind motors with rotation axis substantially at right angle to wind direction	F03D 3
Other wind motors	F03D 5
Controlling wind motors	F03D 7
Adaptations of wind motors for special use;	F03D 9
Details, component parts, or accessories not provided for in, or of interest apart from, the other groups of this subclass	F03D 11
Solar	
Devices for producing mechanical power from solar energy	F03G 6
Use of solar heat, e.g. solar heat collectors	F24J 2
Devices consisting of a plurality of semiconductor components sensitive to infra-red radiation, light-specially adapted for the conversion of the energy of such radiation into electrical energy	H01L 27/142
Semiconductor devices sensitive to infra-red radiation, light-adapted as conversion devices	H01L 31/04-078
Generators in which light radiation is directly converted into electrical energy	H02N 6
Aspects of roofing for energy collecting devices-e.g. incl. solar panels	E04D 13/18
Geothermal	
Production or use of heat, not derived from combustion-using natural or geothermal heat	F24J 3
Devices for producing mechanical power from geothermal energy	F03G 4
Mechanical-power-producing mechanisms-using pressure differences or thermal differences occurring in nature	F03G 7/04
Ocean	
Tide or wave power plants	E02B 9/08
Submerged units incorporating electric generators or motors characterised by using wave or tide energy	F03B 13/10-26
Mechanical-power producing mechanisms-ocean thermal energy conversion	F03G 7/05
Biomass and waste	
Solid fuels essentially based on materials of non-mineral origin-animal or vegetable substances; sewage, town, or house refuse; industrial residues or waste materials	C10L 5/40-48
Engines or plants operating on gaseous fuel generated from solid fuel, e.g. wood	F02B 43/08
Liquid carbonaceous fuels; Gaseous fuels; Solid fuels	C10L 1
AND	C10L 3
Dumping solid waste;	C10L 5
Destroying solid waste or transforming solid waste into something useful or harmless;	AND B09B 1
Incineration of waste; Incinerator constructions;	B09B
Incinerators or other apparatus specially adapted for consuming specific waste or low grade fuels, e.g. chemicals	F23G5
Plants for converting heat or fluid energy into mechanical energy; use of waste heat;	F23G 7
Profiting from waste heat of combustion engines;	F01K 27
Machines, plant, or systems, using particular sources of energy-using waste heat, e.g. from internal-combustion engines;	F02G 5 F25B 27/02
AND	AND
Incineration of waste; incinerator constructions;	F23G 5
Incinerators or other apparatus specially adapted for consuming specific waste or low grade fuels, e.g. chemicals.	F23G 7
Plants or engines characterised by use of industrial or other waste gases	F01K 25/14
Incineration of waste-recuperation of heat	F23G 5/46

Source: Johnstone et al. (2010)