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**THE INFLUENCE OF CORPORATE CLIMATE RISK
DISCLOSURE ON ESG PERFORMANCE: THE MODERATING
ROLE OF STAKEHOLDER ENGAGEMENT**



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**DOCTOR OF PHILOSOPHY
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**THE INFLUENCE OF CORPORATE CLIMATE RISK DISCLOSURE ON
ESG PERFORMANCE: THE MODERATING ROLE OF STAKEHOLDER
ENGAGEMENT**



**BY
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Kolej Perniagaan
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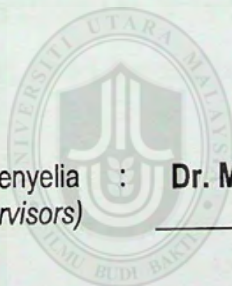
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ABSTRAK

Kesan perubahan iklim semakin meningkat secara global, terutamanya di negara membangun seperti China. China menghadapi masalah serius seperti mekanisme kawal selia yang tidak sempurna dan cabaran alam sekitar yang kritikal. Justeru, pendedahan korporat tentang risiko iklim dan prestasi alam sekitar, sosial dan tadbir urus telah menjadi isu penting. Kajian ini meneroka hubungan antara pendedahan risiko iklim dan prestasi alam sekitar, sosial dan tadbir urus (prestasi ESG) syarikat China. Kajian ini menggunakan kaedah kajian kuantitatif untuk membina model regresi istilah kuadratik. Ia menggunakan data empirikal daripada syarikat China untuk menganalisis hubungan antara pendedahan risiko iklim dan prestasi ESG. Kemudian, ia meneroka lebih lanjut kesan penglibatan pihak berkepentingan, seperti media, pelabur dan kerajaan terhadap hubungan ini. Hasil penyelidikan menunjukkan hubungan berbentuk U yang signifikan antara pendedahan risiko iklim dan prestasi ESG; iaitu pada peringkat awal pendedahan, apabila pendedahan risiko iklim meningkat, prestasi ESG akan terjejas. Walau bagaimanapun, apabila pendedahan semakin meningkat dan mencapai titik infleksi hubungan berbentuk U (titik X), lebih banyak pendedahan boleh meningkatkan prestasi ESG. Ini bermakna pendedahan risiko iklim akhirnya akan menggalakkan prestasi ESG korporat. Perhatian media dan kebimbangan pelabur menyederhanakan hubungan antara pendedahan risiko iklim dan prestasi ESG, tetapi campur tangan kerajaan tidak menunjukkan kesan penyederhanaan yang ketara. Kajian ini mendedahkan kesan kompleks pendedahan risiko iklim terhadap prestasi ESG korporat dan menekankan kepentingan penglibatan pihak berkepentingan dalam pengantaraan hubungan ini. Hal ini seterusnya, memperkayakan aplikasi teori legitimasi, dengan menyediakan perspektif baharu untuk syarikat China dalam meningkatkan prestasi ESG. Selain itu, ia juga menjadi rujukan untuk penggubal dasar dan tadbir urus korporat.

Kata kunci: Prestasi ESG, Pendedahan risiko iklim, Teori legitimasi, Penglibatan pihak berkepentingan, China

ABSTRACT

The impact of climate change is increasing globally, especially in developing countries like China. China faces serious problems such as imperfect regulatory mechanisms and severe environmental challenges. As a result, corporate disclosures on climate risks and environmental, social and governance performance have become a vital issue. This study explores the relationship between climate risk disclosure and Chinese companies' environmental, social and governance performance (ESG performance). This study employed quantitative research methods to construct a quadratic term regression model. It used empirical data from Chinese companies to analyse the relationship between climate risk disclosure and ESG performance. Then, it further explored the impacts of stakeholder engagements, such as the media, investors and government on this relationship. The research results show a significant U-shaped relationship between climate risk disclosure and ESG performance; that is, in the early stage of disclosure, as climate risk disclosure increases, ESG performance will be harmed. However, as disclosure increases and reaches the U-shaped relationship's inflection point (X-point), more disclosure can improve ESG performance, which also means climate risk disclosure will ultimately promote corporate ESG performance. Media attention and investor concern moderate the relationship between climate risk disclosure and ESG performance, but government intervention does not show a significant moderating effect. This study reveals the complex impact of climate risk disclosure on corporate ESG performance and emphasizes the importance of stakeholder engagement in mediating this relationship. Consequently, it enriches the application of legitimacy theory by providing a new perspective for Chinese companies to enhance their ESG performance. Additionally, it serves as a reference for policymakers and corporate governance.

Keywords: ESG performance; Climate risk disclosure; Legitimacy theory; Stakeholder Engagement; China

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List of Abbreviations

ESG	Environmental, Social and Governance
TCFD	Task Force on Climate-Related Financial Disclosure
GRP	Global Reporting Initiative
CEO	Chief Executive Officer
IFRS	International Financial Reporting Standards
PRI	Principles for Responsible Investment
SASAC	State-owned Assets Supervision and Administration Commission of the State Council
PBOC	People's Bank of China
SFC	Securities and Futures Commission
SZSE	Shenzhen Stock Exchange
CPC	Communist Party of China
VIF	Variance Inflation Factor
FPL	Florida Power & Light Company
MD&A	Management's Discussion and Analysis
CSRC	China Securities Regulatory Commission
MSCI	Morgan Stanley Capital International
CNRDS	Chinese Research Data Services Platform

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Global warming has accelerated in the 21st century (Schuur et al., 2022), and climate change and sustainable development contract a great concern to the international community. According to the report of the International Climate Organization, the global average temperature has increased by about 0.9°C since the end of the 19th century (Harris et al., 2020), while the rate of sea level rise has accelerated significantly over the past few decades (Dangendorf et al., 2019). These climatic changes have brought about not only disasters at the environmental level but also threats to human sustainable development and economic stability. According to the Germanwatch organization report, from 2000 to 2019, there were more than 11,000 extreme weather events globally, with more than 475,000 deaths and 2.56 trillion dollars in economic losses due to extreme weather events (Eckstein et al., 2021). Figure 1.1 below shows the Global Climate Risk Index rankings from Germanwatch, with darker colors indicating more serious climate risk problems in the region, and it can be seen that the Asian region faces more severe climate risks.

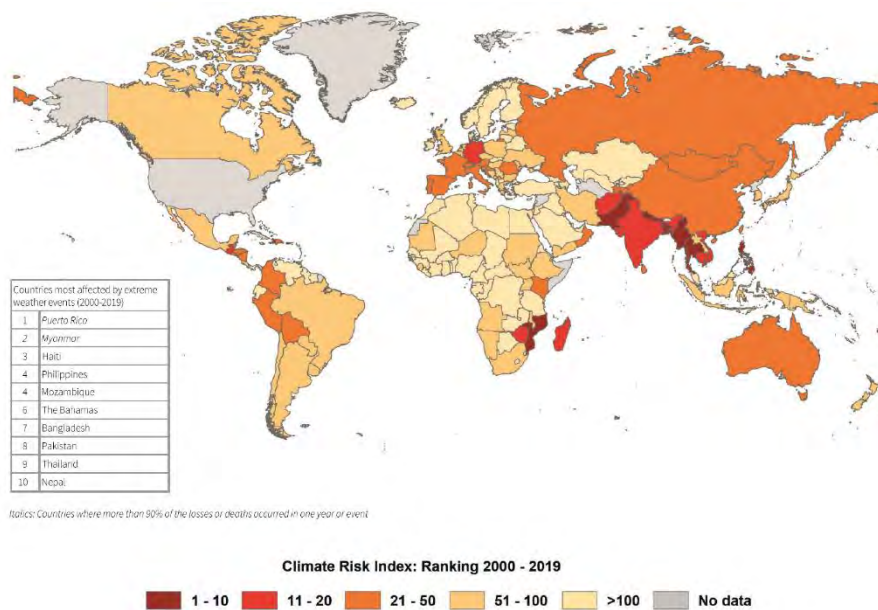


Figure 1.1
Climate risk index: Ranking 2000-2019

Based on the severe consequences of climate risk mentioned above, climate risk disclosure has become crucial. Climate risk disclosure refers to the disclosure of climate-related risks and information affecting a business entity by a company in its published reports (Deloitte, 2021). The initiative proposed by the Taskforce on Climate-Related Financial Disclosures (TCFD) plays a vital role in the context of climate risk disclosures. TCFD constructs a framework for corporate disclosures related to climate risk, guiding companies to disclose climate-related risks and opportunities in public reports (TCFD, 2017). TCFD reports cover four elements of climate risk governance, strategy, risk management, and indicators and targets to disclose climate-related information. However, businesses in only 19 countries worldwide must adopt the TCFD framework for climate risk disclosure (Ngo et al., 2023).

Companies play a crucial role in dealing with climate change; they must change their thinking mode of pursuing maximization of their interests and creating value for ESG (Adams & Abhayawansa, 2022). Especially for companies, climate risk not only affects the stability of their operation and supply chain (Pankratz & Schiller, 2021) , but also poses a threat to their long-term financial performance and reputation (Sun et al., 2020) , and even legal and regulatory risks arising from environmental problems (Krueger et al., 2020). In addition, with the enhancement of public awareness of environmental protection, firms' behavior in environmental protection is increasingly affecting consumers' purchase decisions and investors' investment choices (Chuang & Huang, 2018; Yenipazarli, 2019). Therefore, it has become an essential part of their sustainable development strategy for companies to actively deal with climate risks and reduce the negative environmental impact.

If companies adopt unsustainable practices, it will lead to extreme environmental and diversified injustice (Slawinski et al., 2017). However, some multinational companies still resist international regulations on greenhouse gas emissions and question these environmental protection regulations (Haque & Deegan, 2010). Although there will be different voices, it is clear that extreme climate results from human activities (Mahmoud & Gan, 2018). Therefore, companies should reduce the environmental damage caused by their business activities. In this process, the ESG performance of companies has become an important indicator to measure their ability to respond to these global challenges (Sciarelli et al., 2021). ESG performance not only reflects the performance of companies in environmental protection, social responsibility, and governance transparency but also reflects their long-term sustainable development ability and comprehensive competitiveness.

According to the Global Sustainable Investment Alliance report, the assets under global sustainable investment management were \$35.2 trillion at the beginning of 2020, an increase of 55% over 2016 (GSIA, 2021). This shows that investors are paying more and more attention to the ESG performance. Sustainable investment by companies with good ESG performance has increased significantly, highlighting the importance investors attach to ESG performance when environmental issues are becoming more and more critical (Albuquerque et al., 2020). ESG performance is no longer just a response to climate and social challenges. Disclosure of climate risk and ESG performance has become a market-based competitive advantage for long-term growth and success (Ngo et al., 2023). Therefore, the issues of climate risk disclosure and ESG performance are very urgent for companies. Climate-related risks must be disclosed fully and on time to improve company management, level the field of market information, and help people make intelligent long-term investment choices (Gholami et al., 2022). The ESG performance activities carried out by companies also reflect the social responsibility of companies in environmental protection.

From an international perspective, only a few developed countries require mandatory disclosure of climate risks, but most developing countries do not make mandatory disclosure of climate risk information (Ngo et al., 2023). Moreover, the level and standards of ESG performance in developed countries are better than those in developing countries (Naeem et al., 2022; Singhania & Saini, 2023). Most developed countries have recognized the close relationship between climate-related content and ESG and made efforts to achieve sustainable development (Kouloukoui et al., 2018). In addition to significant countries such as the United States and European economies, other countries such as New Zealand have established regulatory frameworks and

formulated the world's first climate reporting legislation (Ngo et al., 2023). However, climate-related actions significantly differ among companies, industries, and countries (Graafland & Noorderhaven, 2020). However, most developing countries do not attach importance to climate risk and ESG (Matemane & Graca, 2023).

As the world's largest developing country and the second-largest economy, China's situation presents some uniqueness and complexity. China is currently in an essential stage of economic transformation; however, the problems of high total consumption and low environmental efficiency pose a threat to the high-quality development of the economy (Wang et al., 2005). Although companies in China have achieved remarkable economic growth, for a long time, the rapid economic growth in China has primarily depended on output expansion and resource consumption (Fan & Hao, 2020; Li & Lin, 2017); this is undoubtedly facing the challenge of enormous climate and environmental pressure. At the same time, due to China's weak supervision and market management, China has no clear regulations and disclosure norms for climate risk disclosure (Yang & Farley, 2016). Regarding companies' performance of ESG, the Chinese government only initiated the performance but did not enforce it. Some companies even took ESG as a symbolic reporting tool, and what was more serious was the "Greenwashing" behavior (Gallagher & Qi, 2021; Lund-Thomsen et al., 2016). Against this background, ESG performance practices and climate risk disclosure of listed companies in China shows unique research value.

Concerns have been raised worldwide about the link between companies' ESG success and how well they disclose climate risk in a world where climate change is worsening. However, this relationship has its unique characteristics and connotations in China.

Understanding and exploring this particularity is of great theoretical and practical significance not only for China but also for other countries and regions around the world. Considering the critical position of listed companies in China in the global economy, this study aims to provide in-depth insights for academic circles and strategic suggestions for practical fields on promoting the harmonious integration of sustainable development.



Figure 1.2
CRI rank in China

1.2 Problem Statement

As Hao et al. (2020) emphasized, the fulfillment of ESG performance still needs to be improved globally, and the fulfillment of ESG performance by Chinese companies is especially weak. First, China has severe environmental pollution, accounting for 28.8% of global carbon dioxide emissions in 2019 (Zhang et al., 2022). Some cities in China are among the most air-polluted cities in the world (Luo et al., 2023; Zhao et al., 2013). Second, China has a severe social responsibility problem. Most companies in China have realized the "996" work culture, i.e., working hours from 9 a.m. to 9 p.m. every day from Monday to Saturday (BBC, 2021), which seriously exceeds the legal working

hours of eight hours, and the protection of labor rights and interests in China is still not standardized. Finally, Chinese firms' internal governance structures are flawed, lacking transparency and relying on management's subjective discretion (Qian et al., 2017). This hinders adequate information disclosure and strategic decision-making, leading to governance challenges. Chinese firms face serious ESG performance fulfillment issues, undermining their market competitiveness and sustainability. Therefore, Chinese firms are eager to adapt to social expectations and environmental requirements and have tried various ways to improve ESG performance (Shen et al., 2023).

For example, internal and external factors of ESG performance have been extensively studied in past research, such as corporate governance, R&D investment, corporate culture, human resource management, internal control, market environment, policies and regulations, industry standards, and public opinion (Bai et al., 2024; Garcia et al., 2017; Harasheh & Provasi, 2023; He et al., 2024; Lewellyn & Muller-Kahle, 2023; Mooneepen et al., 2022; Noja et al., 2019; Xu et al., 2021; Zheng et al., 2022). However, the growing environmental risks and social challenges posed by climate change in an increasingly challenging climate environment have forced companies to realize that transparent and effective climate risk disclosure can address the challenges posed by climate change (Oreshkova, 2023). However, no study has yet focused on climate risk disclosure as an influencing factor, and there is still a significant gap in understanding the impact of climate risk disclosure on ESG performance.

Legitimacy theory proposes that firms can meet the credibility and legitimacy requirements of the public when making climate risk disclosures (Kouloukoui et al., 2018). This can positively impact the firm's overall ESG performance when legitimacy

requirements are met (Kouloukoui et al., 2023; Truant et al., 2017). However, companies do not pay enough attention to climate issues (Benz-Saliasi, 2020), and management is not sufficiently equipped to deal with climate risks (Kouloukoui et al., 2019). In addition, the lack of a harmonized governance framework for climate risk disclosure poses a challenge, with many companies viewing disclosure as a symbolic gesture rather than a substantive commitment (Griffin & Jaffe, 2022; Mahoney et al., 2013). However, both ESG performance and climate risk disclosure are areas of scrutiny by investors. A sufficient understanding of whether climate risk disclosure can influence corporate ESG performance must still be made. This gap hinders firms' strategic decisions and practical improvements in these critical areas. Although previous research has explored the potential of climate risk disclosure to improve environmental performance (Kim et al., 2023), exploring the relationship between climate risk disclosure and ESG performance remains a 'Gray Area' (Greenwood & Warren, 2022). This is also due to gaps in climate-related disclosures across companies. At the same time, most companies do not adequately consider the long-term outlook (Guthrie et al., 2020), and implementing climate risk disclosure and ESG performance is a long-term sustainable practice. However, companies continue to overemphasize financial materiality in their public disclosures (Adams et al., 2021), ignoring climate risk disclosure as an important influencing factor. However, making climate risk disclosures and performing ESG performance require firms to invest significant resources and funds. As both activities involve costs, exploring the link between climate risk disclosure and ESG performance not only helps to understand the impact of climate risk management on corporate sustainability but also encourages firms to find ways to realize a "Win-Win" strategy with limited resources, which not only manages climate risks effectively but also improves ESG performance.

In addition, climate risk disclosure and ESG performance are public disclosures and practical activities of firms, but different stakeholders have different information needs and responses (Weiss et al., 2008). According to signaling theory and stakeholder theory, stakeholder engagement plays an essential role in studies related to ESG performance. For example, the media can release signals to monitor and guide corporate behavior (Basoglu & Hess, 2014); investors are increasingly focusing on corporate sustainability performance, especially in terms of climate risk (Aliano et al., 2023); and governments are continually pushing for environmental governance and social responsibility, among others (Lihua et al., 2020). However, existing research lacks in-depth analysis and an integrated stakeholder engagement framework perspective on the specific impacts between stakeholder engagement in climate risk disclosure and ESG performance, such as media, investors, and governments. Past studies need to pay more attention to the impacts of different stakeholder engagements, limiting the comprehensive insights into the dynamics of ESG performance of Chinese companies.

Given the existing problems and research gap gaps in the existing literature, this study aims to explore the relationship between climate risk disclosure and ESG performance of Chinese firms and how this relationship is moderated in different stakeholder engagements. This study also addresses the weaker ESG performance fulfillment of Chinese firms under the intensification of global climate change and the firms' lack of attention to climate risk disclosure. It proposes climate risk disclosure as an important factor based on the legitimacy theory perspective. Also, previous studies have yet to integrate the moderating role of stakeholder involvement in this perspective. This study integrates the moderating role of significant stakeholder engagement, including the three major stakeholder engagements: media, investors, and government.

1.3 Research Questions

- (1) What is the ESG performance level of companies in China?
- (2) What is the relationship between climate risk disclosure and ESG performance of companies in China?
- (3) How do stakeholder engagements moderate the relationship between climate risk disclosure and ESG performance?

1.4 Research Objectives

- (1) To investigate the ESG performance level of companies in China.
- (2) To test the impact of China companies' climate risk disclosure on ESG performance.
- (3) To test the moderating effect of climate risk disclosure on ESG from the perspective of stakeholder engagement.

1.5 Significance of the Study

1.5.1 Theoretical Significance

This research employs legitimacy theory as its theoretical foundation to explore the relationship between climate risk disclosure and ESG performance. Subsequently, it delves deeper into the potential impacts of three primary stakeholder engagements—public media, investors, and the government—on this relationship, drawing on signaling theory and stakeholder theory for further analysis. This makes the study

innovative in extending a new theoretical outlook in applying the legitimacy theory, particularly in how companies tend to create and maintain their legitimacy through climate risk disclosure. Most importantly, this theoretical approach not only strengthens the application of legitimacy theory in environmental management but also helps us learn why companies behave the way they do and what strategies are being adopted to respond to the emerging problems due to climate change. Finally, exploring the link between climate risk disclosure and ESG performance provides a solid theoretical basis for climate risk management, helping to understand how a firm can improve its environmental protection, social responsibility, and governance transparency through adequate risk disclosure.

Furthermore, it will extend the theoretical domain of this study to include legitimacy theory, signaling theory, and stakeholder theory to examine how different stakeholder engagements interact with the relationship between climate risk disclosure and ESG performance. Based on signaling theory, this dimension illustrates how information in ESG disclosure sends a positive signal from a company to third parties, depicting that the company has concerns for the environment and is, therefore, operating in a manner that poses less harm. In contrast, stakeholder theory delineates the response of various parties, such as investors, media, and government, to that information and how it influences corporate ESG performance. Such multidimensional theoretical integrations stand to spur the growth of a more comprehensive framework for understanding corporate ESG practices.

1.5.2 Practical Significance

This study's importance is to make concrete and practical contributions to advancing and implementing the relevant policies. Thus, the conclusions drawn from the study will allow the firms to evaluate the effectiveness of the climate risk management strategies more reasonably and, in this case, to implement targeted measures for enhancing ESG performance. This will not only enhance market competitiveness and risk resilience but also arouse motives to adjust strategies proactively to comply with the government's climate change policies and realize their goal for sustainable development.

Hence, the realization from this research can grant the government the basis for formulating and adjusting policies that can help governments consider the actual situation and the needs of companies, hence coming up with more effective measures. The study has outlined how important it is for businesses to be honest about climate risk. This will help the government get companies to do something about climate change, supporting society's green development transformation. Investors can identify potential investment risks and opportunities more effectively through the new perspectives offered by this study, optimizing investment decisions. This research reinforces the importance of climate risk disclosure, aiding investors in promoting responsible business practices among companies and fostering long-term sustainable development. As a bridge for information dissemination, the findings can help the media enhance public awareness of climate change risks and ESG performance. By improving disclosure quality, media can promote information transparency, providing the public and investors with more accurate information and enhancing public support for and expectations of corporate climate actions.

According to this study, governments should also establish clear rules for disclosing climate risk and promote the creation of an ESG evaluation system to help businesses improve their ESG performance. Through these practical contributions, this study helps all parties better understand and address climate risks and promotes a more sustainable economic development path.

1.5.3 Methodological Significance

The past literature analyzing the link between corporate social responsibility and the disclosure of climate risk usually employs carbon emissions as an individual indicator for accounting for climate-related information disclosure (Cronin & Doyle-Kent, 2022; Zitti & Guttormsen, 2023). While there has been a great contribution from the incorporation of climate risk information disclosure as a means to add value to companies' performance in terms of social responsibility beyond governance, it has its flaws. Only the use of carbon emissions as an indicator for climate risk disclosure fails to capture the overall performance of firms in terms of climate risk management and adaptation strategies. Thus, the sole use of carbon emission data might not depict the real scenario of the firms in terms of climate risk disclosure.

This study innovates methodologically by using machine learning algorithms to construct a word frequency indicator for climate risk disclosure. This method allows for a more comprehensive capture of companies' disclosures on climate risks in annual reports and other public documents, including various aspects of physical and transition risks. Machine learning algorithms can effectively process and analyze large volumes of text data, identifying key information and trends related to climate risks. This

approach not only enhances the precision of disclosure quality assessment but also makes the evaluation of companies' climate risk management capabilities more comprehensive and in-depth.

It will, therefore, provide a more precise and comprehensive tool in assessing the climate risk disclosure of companies. It could contribute not only to understanding the relationship of climate risk disclosure with corporate ESG performance but also open new perspectives and methodologies for further research. Such innovative methodological application will make it possible for the study to capture and analyze, in a much more accurate way, the firms' efforts and achievements in addressing the problem of climate change, providing a much richer and insightful perspective to business managers, policymakers, and researchers.

1.6 Scope of the Study

The sample research scope of this study is Chinese listed companies. There are three main reasons: first, China is the most powerful developing country in the world, with the second largest economy in the world. Therefore, China plays an important role in the process of global climate governance and sustainable development. Climate risk disclosure by Chinese companies is not only of great practical significance for China's own environment and society, but also provides significant guidance for the promotion of global strategies to address climate change. Second, according to the two main variables of this study, climate risk disclosure and ESG performance, this study selects China as a research sample considering the complexity of China's climate and the diverse climate risks that China faces.

China is a country with diverse geographic and climatic conditions, with arid and semi-arid regions in the north, humid regions in the south, and high mountains and plateaus in the west. These regions are subject to different types of climate risks, including floods, droughts, heavy rains, high temperatures and typhoons. The diversity of climates and the frequency of extreme weather events provide many lessons on how companies can disclose climate risks. On the other hand, as global warming and extreme environments intensify, the impact of climate risk in China will become more significant, with a greater impact on the operational and financial status of companies as well as their long-term development strategies. Therefore, it is of great practical and theoretical significance to analyze how Chinese companies identify, assess and report climate risks, as well as the impact of these risk disclosure methods on corporate ESG performance.

Finally, compared with developed countries, in terms of ESG performance, China's regulatory system is weaker and a standardized enforcement system has not yet been formed, which also affects climate risk disclosure and ESG performance. Due to weak regulatory requirements and enforcement, but growing public and investor demand for ESG, there are significant differences in the ability of Chinese companies to identify, assess, and report climate risks, as well as the level of fulfillment of ESG performance. Therefore, an in-depth study of the Chinese case can provide valuable insights and recommendations for improving relevant regulatory policies, enhancing corporate ESG performance, and incentivizing firms to address climate change more effectively.

This study examines the relationship between climate risk disclosure and ESG performance of Chinese firms. When climate risks arise, two main types of risks are generally disclosed: physical risks and transformational risks. Physical risks refer to the immediate tangible impacts of climate change, such as extreme weather conditions, as well as the long-term potential impacts on businesses. Whenever extreme weather conditions occur, they can cause damage to a company's assets, thereby reducing their value and hindering normal operations. This negatively affects the potential economic benefits of the business (Huang et al., 2018). Indeed, a cascade of economic and policy changes may occur in response to climate change. These changes include the development of new legislation and policies, changes in consumer tastes and preferences, and the emergence of new technologies. Transformational risks also relate to the potential impacts that the above changes may have on business operations and value chains (Benz-Saliassi, 2020). Considering the perspectives of previous studies, the main scope of this study is the collection of information on climate risk disclosure and ESG performance scores in the public disclosure reports of Chinese main board listed companies. Chinese main board listed companies are relatively stable and able to operate continuously, which enables better data analysis and research at the company level.

This study focuses on the collection of relevant data on the published ESG performance and public disclosure reports of Chinese main board listed companies. In addition, considering the stability and continuity of the operating conditions of main board listed companies, this study excludes companies with significant data issues. The scope of the research sample selected for this study

excludes companies with significant data issues, companies listed in the financial industry, or companies scheduled to be delisted at the end of the year, as such companies have unstable and highly volatile operations, which affects the generalizability of the research data in this study.

In terms of time horizon, the research data collected in this study focuses on the period between 2011 and 2022. This is a decisive decade for the Chinese economy and its relationship with the rest of the world. Chinese companies are faced with an increasingly serious situation of climate and environmental issues as well as an increasing public attention to environmental issues, which has led to an increased focus on climate risk disclosure and ESG performance. In addition, with the growing global focus on climate change, global environmental policies - like the Paris Agreement - have placed more responsibility on Chinese companies, prompting them to accelerate the pace of adaptation to changes in the global marketplace in order to remain competitive in global supply chains.

At the same time, as an emerging concept, ESG has been developed in China for a relatively short period of time. Although starting later than Western countries, from 2011 to 2022, Chinese listed companies have made great strides in ESG and data collection has become increasingly sophisticated. This is a critical period for China's economic restructuring and industrial upgrading, and with the great importance attached to sustainable development and the green economy, Chinese companies' investment and performance in ESG has become an important indicator of long-term corporate value and social responsibility. Green credit and green bonds, as well as other government policies and assistance, give companies

more reasons to improve their ESG construction. Therefore, studying the climate risk disclosure and ESG performance of Chinese companies during this period can not only reflect their ability and attitude to address climate change, but also reveal China's changing role in global environmental governance and its contribution to global climate action.

1.7 Definition of Key Terms

1.7.1 ESG Performance

ESG performance here refers to the three dimensions of a company's environmental, social and governance performance. The environmental dimension covers the extent to which a company uses natural resources and protects the environment (Yan et al., 2022); the social dimension reflects the extent to which a company cares about its relationships and responsibilities with employees, suppliers, customers and the community (Becchetti et al., 2022); and the governance dimension has to do with the company's governance model, governance structure, and safeguarding shareholders' rights (Li et al., 2021). A business's good ESG performance shows how well it does in the three areas of environment, society, and governance. It also shows how socially responsible the company is (Chen et al., 2021), but also increases investor confidence and attracts investors (Fulton et al., 2012), as well as being regarded as a key factor that reduces the investment risk (Giese et al., 2019) and can increase the value of the company (Aydoğmuş et al., 2022).

However, this study is about ESG performance, which represents a niche direction of ESG research, rather than the related concepts about ESG studied. There are past studies

about ESG concepts (Li et al., 2021), ESG greenwashing behavior (Lokuwaduge & De Silva, 2022), and qualitative ESG research (Meiden & Silaban, 2023). But this study only looks at one way of ESG performance. It builds on previous research that looked at what factors affect ESG performance from the point of view of climate risk disclosure. There are also a lot of studies from the past that have looked into ESG issues that affect businesses.

In academic research, having a clear definition of the idea of ESG performance helps to build theoretical models, do empirical research, and eventually encourage the growth and new ideas in theory. This is important to know in order to understand the factors that affect ESG success and how they affect business and society in the real world. Not only that, the accurate definition of the concept of ESG performance in this study helps to ensure precision and consistency in research and practice, so that different researchers and practitioners can have a common understanding base when discussing ESG performance, thus improving the efficiency and quality of communication.

1.7.2 Climate Risk Disclosure

Regarding climate risk disclosure, there is a research misconception that climate risk is confused with climate risk disclosure in past studies, for example, in Wu et al. (2022)'s study that used the variable of climate risk and examined the relationship between climate risk and stock market reaction, although it was talked about in the title and the abstract that the higher the climate risk, the more negative the stock market's reaction is in a short period of time. However, the variable of climate risk disclosure constructed by word frequency was used in the literature review study and measurement of the variable. And in the Khalifa et al. (2023)'s research also used the variable of climate

risk to study the relationship between climate risk and accounting robustness, and concluded that the higher the climate risk, the lower the accounting robustness, this article actually used the real climate risk, using the Germanwatch published on the CRI indicator about the damage to the assets and the destruction of human and financial resources caused by the extreme weather to measure the climate risk. Based on this, in order to avoid any confusion in the definition of the variables, this study considers it necessary to explain the variables in detail for the disclosure of climate risk, which is one of the main variables in this study.

The climate risk disclosure variable in this study refers to a firm's disclosure of its exposure to climate change-related risks(Kouloukoui et al., 2018), such as physical risks (the impacts of natural disasters, such as hurricanes, floods and heat waves) and transition risks (i.e., the risks associated with relevant policy, legal, technological, and market changes that firms may encounter during the transition to a low-carbon economy) (Reboredo & Ugolini, 2022). This disclosure is meant to help investors, creditors, and other interested parties figure out how a company will do financially and risk-wise in the future by giving them important climate risk information. The company shows that its plan to manage climate risk and be environmentally friendly works with its climate risk disclosures.

1.7.3 Stakeholder Engagement: Media

The point is that, within the context of researching the relationship between disclosure of climate risks and ESG performance, the disclosure of climate risk refers to the type of disclosure by stakeholder engagement. The previous research also points out that the media is an important recipient of information. This is because the media, to some

extent, not only reports but also has the power to shape public awareness and opinion, according to Van Leuven and Slater (1991). Upon the receipt of a company's climate risk information disclosure, the media, in turn, carries out the media coverage and publicity (Li, 2024). One of the moderating factors used in this study to look at the link between climate risk disclosure and ESG performance is media attention.

1.7.4 Stakeholder Engagement: Government

In terms of stakeholder engagement, the government is also an important recipient of companies' climate risk disclosure information. The government holds a regulatory perspective on corporate climate risk disclosure as well as a policy making perspective. One study points out that governments refer to the four indicators (1. Governance; 2. Strategy; 3. Risk Management; and 4. Metrics and Targets.) of the TCFD's climate risk disclosure report to mandate corporate climate risk disclosure (Maji & Kalita, 2022), but most governments around the world do not adopt this mandatory measure. However, most governments around the world have not adopted this mandatory measure (Ngo et al., 2023). As the world focuses on sustainable development, government agencies will intervene to a certain extent in real time to scrutinize the environmental impacts of business activities and formulate relevant environmental policies and regulatory requirements accordingly. Because of this, the level of government involvement is used as a moderating variable in this study to look at the link between climate risk disclosure and ESG performance.

1.7.5 Stakeholder Engagement: Investor

Investors are concerned about corporate climate risk disclosure because climate-related issues are directly related to their investment decisions and risk management (Hons,

2018).By identifying the climate risk disclosures made by a company, investors assess the future profitability and risk exposure of the company, especially in the context of increasingly mainstream sustainable investment. Transparent and comprehensive climate risk disclosure enhances investor confidence and contributes to the efficient functioning of capital markets. Therefore, this study chooses investor concern as one of the moderating variables to test the relationship between climate risk disclosure and ESG performance.



1.8 The Organization of the Study

Then, in the second chapter, the paper reviews the past literature and explains the theories used in this study. The third chapter includes the development of research methodology and hypothesis, and puts forward the hypothesis of this research. In chapter Four, the empirical results and analysis of this study are described. In Chapter Five, discussion and policy recommendations are given.



CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this section of the literature review, the study first defines the concept of ESG and explains the ESG performance under the concept of sustainable development, including the contents of each ESG dimension. The purpose of this part is to provide a clear understanding framework for this study, clarifying the scope and meaning of ESG performance, and laying the foundation for subsequent discussions. Following this, the chapter reviews the motivations for companies to fulfill ESG performance from the internal and external perspectives of companies. Through this review, the study highlights the multidimensional exposition of ESG performance from theoretical perspectives. Additionally, it outlines the global and Chinese companies' performance in fulfilling ESG.

In the context of emphasizing sustainable development, the factors influencing ESG performance are summarized from multiple angles. In the subsequent parts of the literature review, this study will systematically organize the internal and external factors affecting ESG performance.

This chapter also notes that although previous related studies have explored the factors affecting ESG performance, climate risk disclosure often does not receive sufficient attention. This is closely related to the problem statement introduced in the first chapter of this study, emphasizing the importance of in-depth research into the relationship between climate risk disclosure and ESG performance. Taking into consideration the

inadequacy of the framework for the disclosure of climate risk and the problem of the quality of disclosure in the international context, studying this relationship can help define the standards and practices of high-quality disclosure and promote framework improvement. At the company level, this research can point out the deficiencies of companies in understanding and managing climate risks, revealing the value of effective climate risk disclosure in enhancing ESG performance. Especially in China, given the poor performance of companies in fulfilling ESG, exploring the connection between climate risk disclosure and ESG performance is crucial for encouraging companies to adopt more effective sustainable development strategies. Furthermore, given the existing lack of understanding of the relationship between climate risk disclosure and ESG performance, the findings of this study will fill this gap by providing organizations with both theoretical and practical assistance to improve their ESG performance.

In addition, this study also elaborates the theoretical logic of the relationship between climate risk disclosure and ESG performance under the legitimacy theory, and further explores the relationship between climate risk disclosure and ESG performance from three different perspectives of stakeholder engagements: media, government and investors under the legitimacy theory.

Lastly, since climate risk disclosure and ESG performance are probably viewed differently by the information users, it will be made an effort to analyze the impact between climate risk disclosure and ESG performance by different viewpoints of the three major types of information users. This research further elaborates the connection

between climate risk disclosure and ESG performance from the views of three major types of information users: media, investors, and government.

2.2 Definition of ESG Performance

2.2.1 Concept of Sustainable Development

The most common definition of sustainable development is the development that should meet the needs of people living in the present without compromising the need of future generations to meet theirs (Holden et al., 2017; Tomislav, 2018). The consideration of environmental and social development received the most important attention from the international community in the 1980s. It was especially noted in the Brundtland Report, published in 1987 and calling for the idea of "sustainable development". It noted all three significant aspects—economy, society, and environment (Mondini, 2019).

2.2.2 Concept of ESG

ESG is the acronym for "environment, society and governance". The three areas illustrate the nature of commitment and seriousness companies undertake in support of sustainable development. The three areas depict the three main areas in which companies need to focus their actions of business (Litvinenko et al., 2022). Meanwhile, ESG gives investors, partners, and the public a clear and measurable way to see how well companies are doing in terms of sustainability (Khaled et al., 2021). In this sense, ESG can be regarded as a practical application tool for sustainable development goals.

As early as June, 2004, the United Nations Global Compact first proposed the concept of ESG investment (UNGC, 2004), and the concept has been definitely put forward in

the Who Cares Wins report released by UNGC for the first time, which calls on the company to consider the performance of Environment, Social and Governance in the meantime of paying attention to the business. This study illustrates the dimensional connection between companies and ESG governance in the meantime that was recognized by many international financial institutions, for example, Eccles et al. (2020), which also demonstrates a new structure and way for companies to explore long-term development. After that, the concept of ESG investment has been carried out further by foreign groups and investment banks.

The United Nations Principles for Responsible Investment (UNPRI), which came out in 2006, was a big part of how the concept of ESG grew (Newland, 2023). Concurrently, Goldman Sachs also released a full ESG research report integrating the information released by UNPRI, integrating the three concepts of environment, society, and corporate governance in furthering the concept of ESG (Sachs, 2006). Since then, many foreign groups and investment banks have built on the idea of ESG by creating thorough and organized guidelines for sharing information and testing methods for three different aspects of ESG. Over time, these have come together to form a full ESG concept system. Companies have become more ESG-friendly thanks to support from everyone. This has helped make ESG information disclosure standards official and up-to-date, and it has made it easier for more buyers to use ESG factors when making investment decisions.

The concept of ESG and the concept of sustainable development that it represents have gradually become known to the general public, and the new field of ESG research and application has further expanded as a result of the combined efforts of relevant United Nations organizations, the International Financial Reporting Standards Foundation

(IFRS Foundation), and related investment institutions (Beerbaum, 2021). Research on ESG issues at the firm level has gradually emerged as a result of the idea of ESG, which has pointed out a new development route for both the macroeconomy and micro companies.

From the content, ESG is an index for comprehensive evaluation of corporate responsibility performance in three dimensions: Environmental (E), Social (S) and Governance (G). From the practical application level, ESG concept is further divided into "ESG practice" at the firm level and "ESG investment" at the investment level. "ESG practice" refers to the integration of ESG ideas into the operation and management of companies (Patil et al., 2021), and the specific ESG indicators are the standard system for evaluating the performance of companies from the perspective of non-financial indicators. Yet, despite much discussion over the connotation of ESG, a performance measurement method of ESG for companies is also worthy to be explored.

Table 2.1
ESG factor summary

Environment (E)	Social responsibility (S)	Corporate governance (G)
Carbon Dioxide Emission	Sex Composition	Executive Pay
Greenhouse Gas Emissions	Gender Balance Policy	Fair Labor Practice
Environmental Policy	Human Rights Policies And Violations	Bribery And Corruption
Waste Pollution And Management	Health And Safety Of Employees	Oppose Unfair Competition
Energy Use	Equal Employment	Risk Management
Biodiversity	Management Training Situation	Tax Transparency
Validity	Labor Norms	Code Of Moral Conduct
Employees' Awareness Of Environmental Protection	Product Liability	Compliance
Green Purchasing Policy	Community Construction	Independence Of Board Of Directors
Energy Saving And Emission Reduction Measures	Product Quality	Organization Structure
Environmental Protection Cost Accounting	Supply Chain Responsibility Relationship	Investor Relations
Green Technology	Targeted Poverty Alleviation	Community Construction
Natural Resource Management	Charity	Diversity And Structure Of Board Of Directors

Environment (E)	Social responsibility (S)	Corporate governance (G)
Climate Change	Modern Slavery	Government Lobbying and Donation
Resource Consumption	Child Laborer	Tax Policy
Waste Pollution	Working Conditions	/
Deforestation And Protection	Staff Relationship	/

(Source: Author based on literature)

2.3 Classification of ESG

ESG generally categorizes the performance of a business. This categorization helps in assessing the sustainable performance of companies from different aspects. It is found that ESG performance can be viewed as a whole; breaking it down into these dimensions can help to study the performance of that individual area (Auer & Schuhmacher, 2016; Hoang, 2018; Sahut & Pasquini-Descomps, 2015). In the environmental aspect, the evaluation might focus on how companies work to cut down on greenhouse gas pollution and make better use of resources (Xie et al., 2019); In the aspect of social dimensions, based on labor standards in companies, the emphasis will also be given to community participation (Piao et al., 2022); Further, the emphasis will be on the governance dimension to focus on the management structure and the transparency of decision making about the companies (Piao et al., 2022).

Below is a detailed description of each dimension of ESG: its content and the criteria for evaluating them. This study discusses social responsibility, the environment, governance, among others; how well companies do in this light and how these things impact a company's overall ESG. By doing this level of analysis on a case-by-case basis, this is a study that overall might get a much better idea as to how well businesses are doing and what issues they have whenever they attempt to reach one of these sustainable development goals.

2.3.1 Environmental Aspect

The performance of the environment is one of the major dimensions against which a company's sustainability is weighed during the evaluation system for ESG performance. Companies, basically, are measured for their impacts on the natural environment and their effectiveness in coming up with strategies for the protection of the environment (Escrig - Olmedo et al., 2017). There are numerous aspects to the evaluation of environmental performance that reflect the practice and achievement of a company in terms of environmental protection and resource management.

Among those, an important part of the environmental performance is the effort to reduce the emission of greenhouse gases (Delmas et al., 2015). This fact includes the management of the carbon footprint (Chang et al., 2015), the optimization of energy consumption and the use of renewable energy (Hou et al., 2019). Another aspect covered here is the management of water resources based on how a company can be efficient in the use and protection of water resources, reduce water pollution, and improve the reuse of water.

Another good example is in waste management, which involves the reducing of waste from companies and encouraging recovery and treatment while minimizing landfill dependency of companies (Wu et al., 2019). Biodiversity protection has also slowly made it into the list of corporate environmental performance evaluation indicators (Kleijn et al., 2020). Attention is drawn to the biodiversity affected by corporate activities and the measures taken to protect it (Slootweg et al., 2009).

It further considers the degree of companies complying with the rules and regulations related to environmental affairs issued by concerned authorities (Elmagrhi et al., 2019; Kagan et al., 2003), and the proactiveness regarding taking initiatives and innovating in addressing the risks and challenges related to the environment (Carrión-Flores & Innes, 2010). Performance in the environment part shapes the business not only toward sustainable development but also the overall reputation and sustainability in the long run. In so many indispensable areas, the measurement of a company's environmental performance involves looking at how they are doing: from the treatment of greenhouse gas emissions and resources to water and energy, trash management to biodiversity protection, and the observance of environmental laws and rules. All-encompassing measurements currently give a hint of the efforts and rewards made by the companies in protecting the environment and could be turned out to be of great use in further encouraging the companies toward the set of broad sustainable development goals.

2.3.2 Social Aspect

Social performance in the context of ESG performance describes how a company handles its relationship with employees, customers, suppliers, and the local community (Duque-Grisales & Aguilera-Caracuel, 2021; Eccles & Strohle, 2018). Evaluation of the social performance takes into account and measures a group of factors that test attempts and achievements that companies have been able to handle up to this moment in attaining social responsibility and ethical conduct.

First, it is directed at the labor standards and practices that incorporate working conditions, protection of labor rights, pay equity, and the opportunities for employee

training and development (Noja et al., 2019; Sychenko, 2023; Yang et al., 2019). as these factors directly affect the well-being and satisfaction of the employees, which in turn affects the overall performance and reputation of the companies. Social performance also reflects corporate commitment towards health and safety, especially the health and safety policy and measures at the workplace (Ortas et al., 2015). Effective management of health and safety can result in the reduction of accidents and injuries at work, thus improving the morale and productivity of staff (Shabani et al., 2023).

The social performance of an organization also encompasses the promotion of diversity and inclusiveness. This is done through the establishment of an inclusive and diverse working environment, promotion of gender equity and provision of equal opportunities for career development of the employees, as observed by Cho et al. (2021); Torres et al. (2023). Indicated as the key drivers for enhancing the capacity for innovation, diversity and inclusiveness also enhance engrossment of workers, according to Kirton (2020). Customer management relations is yet another important characteristic of social performance, as noted by Kulova and Nikolova-Alexieva (2023). It pertains to ways in which the organization manages to retain customer satisfaction and loyalty, especially with quality, customer service and ethical standards of the products and services.

Second, the contribution and participation of the companies in society are another key indicator in determining the social performance of a company. This pool includes investments by the company in local communities, involvement in charitable activities (Arpana, 2013), and social development projects as well as efforts by companies to deal with social challenges such as poverty and illiteracy.

Essentially, the social performance ratings investigate how social performance is rated based on health and safety, family and diversity, customer service, community involvement, and labor standards. Taken together, all these factor into the larger picture of corporate social performance. It is very important for knowing how companies meet their social obligations and for rating those same companies.

2.3.3 Governance Aspect

Governance performance looks at the structure of management and decisions with regard to the firm and how this then goes on to contribute to the general sustainability and accountability of the firm (Whitelock, 2015). Governance performance is generally judged based on many important areas. The target here is to see just how the well companies do in relation to being open, responsible, and ethical.

First among these is the make-up and job duties of the board of directors as a contributor to how well government works (Naciti, 2019). This entails how independent and varied the board of directors are, how well they check on management, make the plans of the company, and make sure all parties follow by the rules. When a company makes decisions, it's important to make sure that the needs of more people are taken into account, protect the owners, and make sure that management doesn't have too much power (Zald, 1969).

On the other hand, governance performance lies in internal control and the process of auditing companies (Cohen et al., 2002). hese processes must be of quality and transparent since they derive directly from the accuracy and credibility of corporate financial reports (Garrett et al., 2014). Effective internal control and independent

external audit help to identify and reduce financial and operational risks (Coetzee & Lubbe, 2014; Vijayakumar & Nagaraja, 2012), to enhance the confidence of shareholders and investors.

Corporate governance performance is also further determined by the anti-corruption and ethical standards of companies (Osifo, 2012). This involves the coming up with and enforcement of rules against bribery and corruption to ensure those business actions are taken at the right time to be lawful and ethical. As good moral leadership shows, companies are less likely to be sued by customers (Sullivan, 2009), and they improve their reputation in the market. An information disclosure and transparency of companies is also a key to evaluate the governance performance (Fung, 2014). Transparent information disclosure process helps to improve the transparency of firm decision making (Chiang & He, 2010), and lets the shareholders and stakeholders know the operation and strategy of firm. Shareholder's rights and participation are the other most significant part of governance performance evaluation (Barko et al., 2022). It involves how to make things sure that the shareholders are allowed to take proper part in any significant decision-making procedures of the business, for example, the annual meeting of shareholders, the vote system for shareholders, etc. In a broader sense, governance performance is normally looked at through the board structure, internal control and audit, anti-corruption and ethical standards, information disclosure, and shareholders' rights and participation. The structure makes the level of corporate governance, which is the togetherness of these things. Good corporate governance is of utmost importance for a company to remain stable and trustworthy over time and for its general sustainability.

2.4 Worldwide ESG

Globally, there is a clear uneven level of ESG performance. In particular, some countries perform excellently, and mostly in the fields of environmental protection, social responsibility, and transparency in governance, while others face myriad challenges that are connected with these indicators. This difference comes from the fact that each country is at a different stage of economic development, political system, cultural value, and the importance they attach to sustainable development. Therefore, ESG performance in different countries of the world varies enormously, from being stars to laggards. According to the research of Graafland and Noorderhaven (2020), different countries and business make very different steps towards coping with this variability in climate change. According to Adger et al. (2013) and Jenkins et al. (2018), this difference reflects the cultural values and strategies to adapt to the climate change. In general, countries with high are performance in ESG are developed since they set a high standard for, among others, social justice, environment, and doing business (Mooneeapen et al., 2022; Peiró-Signes & Segarra-Oña, 2013; Pinheiro et al., 2023).

For instance, European countries are in the lead of the chart in the list of countries that succeed in lowering emissions, using green energy, and in running circular economies. In addition, the US and Canada are great in running businesses and with corporate governance well. Companies in developed countries are usually bound by strict laws and regulations, and face the growing demand for sustainable development from consumers and investors. Therefore, companies in these countries tend to invest more resources in ESG to meet regulatory requirements and market expectations. Singhania and Saini (2023) pointed out that social and governance information disclosure in different countries is influenced by voluntary or mandatory standards, and these

standards are not the only factors to improve ESG level. Other practices such as sustainable development report and comprehensive report cannot be ignored. This shows that environmental commitment at the national level is very important for both developed and emerging markets to fix the lack of knowledge and make business operations and reporting more flexible.

The study also found that the ESG legal frameworks of developed and developing countries are very different from one another. For example, the research of Buallay (2020) shows that ESG performance in developed countries has a positive impact on bank market performance, which supports the theory of value creation, but has a negative impact on financial performance, which illustrates the theory of cost capital reduction. In developing countries, ESG has a good effect on how well banks do financially, but it doesn't have a big effect on how well markets do. This shows how ESG is used in different countries in different ways.

Naeem et al. (2022) studied how ESG performance had an impact on the financial performance of companies running their business in environmentally friendly industries. They also studied how these relationships differ, in the context of developed and emerging countries. The results showed that in developed countries the ESG performance of environment-friendly companies greatly impacts the financial performance of the firms while in the case of emerging countries, this relationship was not that strong.

In contrast, many developing countries still face challenges in fulfilling ESG performance. Economic development capacity and resource constraints are often the

main obstacles for these countries to improve ESG performance (Naomi & Akbar, 2021; Teplova et al., 2022). In some developing countries, the awareness of environmental protection and social responsibility is gradually improving, but limited by factors such as technology, capital and system, these countries are slow to improve ESG performance. In addition, corporate governance in many developing countries also faces the problems of lack of transparency and corruption. In addition, although developing countries and emerging countries have established an institutional framework for ESG practice and reporting, there are deficiencies in legislation, punishment and encouragement of ESG practice. For example, Yoon et al. (2018) pointed out that developed countries pay more attention to economic and environmental sustainability and social and cultural rights. Although companies in emerging markets have begun to voluntarily participate in ESG practice, there is still a significant gap.

Figure 2.1 shows the ranking of ESG scores by country by GRP (2022) (Global Risk Profile) with three sub-indices that measure ESG exposure based on 65 variables. From 0 to 100, where 0 represents the lowest danger and 100 represents the highest risk, country scores are stated on a scale that ranges from 0 to 100. In addition, the map categorizes countries according to five different danger levels, ranging from very low (the lightest shade) to very high (the deepest shade).

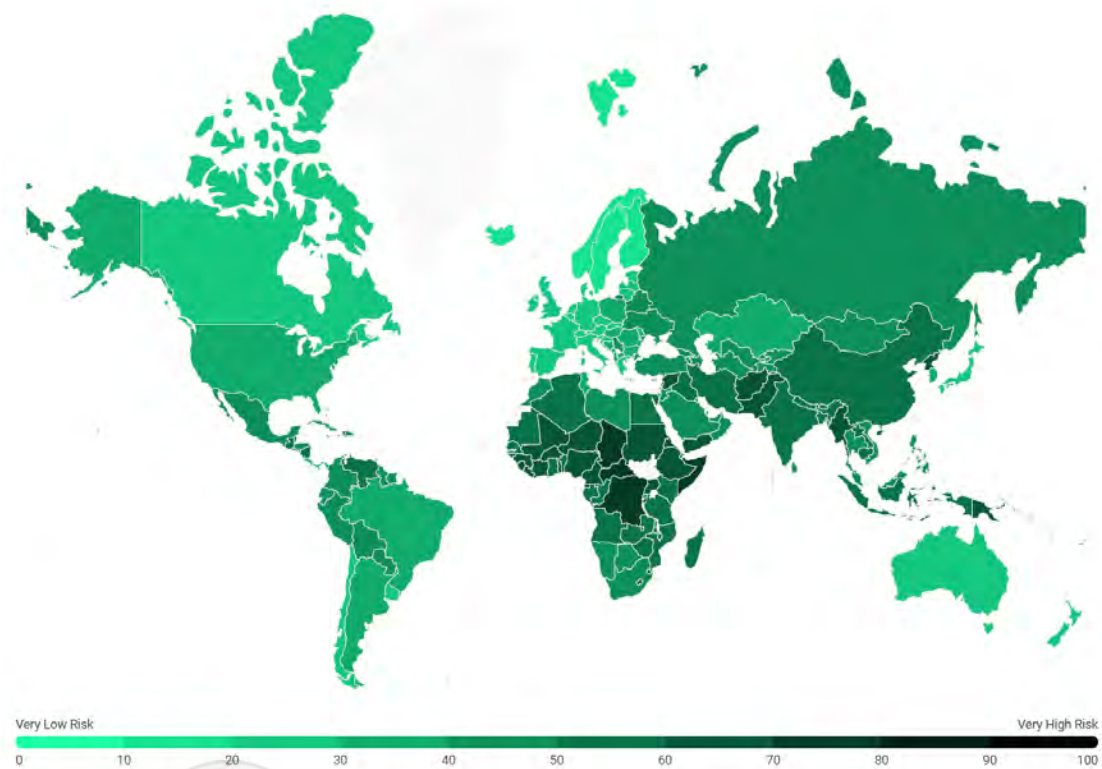


Figure 2.1
ESG risk by GRP
 Source: GRP (2022)

In general, there are considerable variations in the ESG performance of industrialized countries and developing countries. These differences stem from their respective economic structures, legal systems, social and cultural backgrounds and their understanding of environmental and social responsibilities. ESG practice strategies and performance evaluation methodologies in various countries each have their own unique characteristics, despite the fact that they are confronted with similar global concerns such as climate change and social injustice. Understanding these distinctions is therefore of utmost importance for the creation and improvement of ESG practices on a global scale.

2.5 ESG in China

In China, the fulfillment of ESG performance has shown significant progress in recent years. The concept of ESG aligns with traditional Chinese moral values, emphasizing harmonious coexistence with nature and society. In 2004, Kofi Annan, then-Secretary-General of the UN, came up with the idea of ESG. In 2006, the Principles for Responsible Investment (PRI) were released, which added ESG factors to investment choices (PRI, 2018). By the end of 2020, the global value of sustainable investments reached \$35.3 trillion (Alliance, 2022), with China emerging as one of the most active green finance markets in Asia and a significant participant in the global ESG market.

China's green finance development is particularly noteworthy. By the end of 2020, The market for green bonds in China currently ranks as the world's second-largest (Initiative, 2022), with the total green loans of its 21 major banks reaching \$1.69 trillion (Council, 2021). The significant progress that China has made in achieving the Sustainable Development Goals of the United Nations and in achieving sustainable economic development is reflected in this. The advancement of ESG in China is not only a contemporary manifestation of traditional morals but also an embodiment of the pursuit of high-quality economic development.

Academic interest in the ESG field has also been increasing. In the Web of Science, the number of articles published each year on ESG issues rose from 94 in 2015 to 1,410 in 2022. The number of articles published each year on "ESG and China" rose from 3 in 2015 to 117 in 2022. This growth reflects the rise of ESG research in China and its importance in the global perspective (Shen et al., 2023).

The ESG disclosures is different in Hong Kong and mainland China. ESG disclosure requirements in mainland China were issued in 2008, while those in Hong Kong, namely the Environmental, Social, and Governance Reporting Guide, was established in 2012, then revised in 2016 and then revised again in 2020 to become mandatory, while it was a voluntary matter in the past (Fang & Guo, 2018). ESG disclosures and confidence in China have gone a long way ahead, and updated, time and again, in the years since these requirements were issued the first time. The China Listed Companies Association said in a statement during 2021 that more and more ESG or environmental reports are being given by organizations expl. Figure 2.2 shows the ESG reports released by listed companies in the past nine years from 2012 to 2021 according to the statistics of China Securities and Exchange Administration. Chinese firms gradually attach importance to ESG.

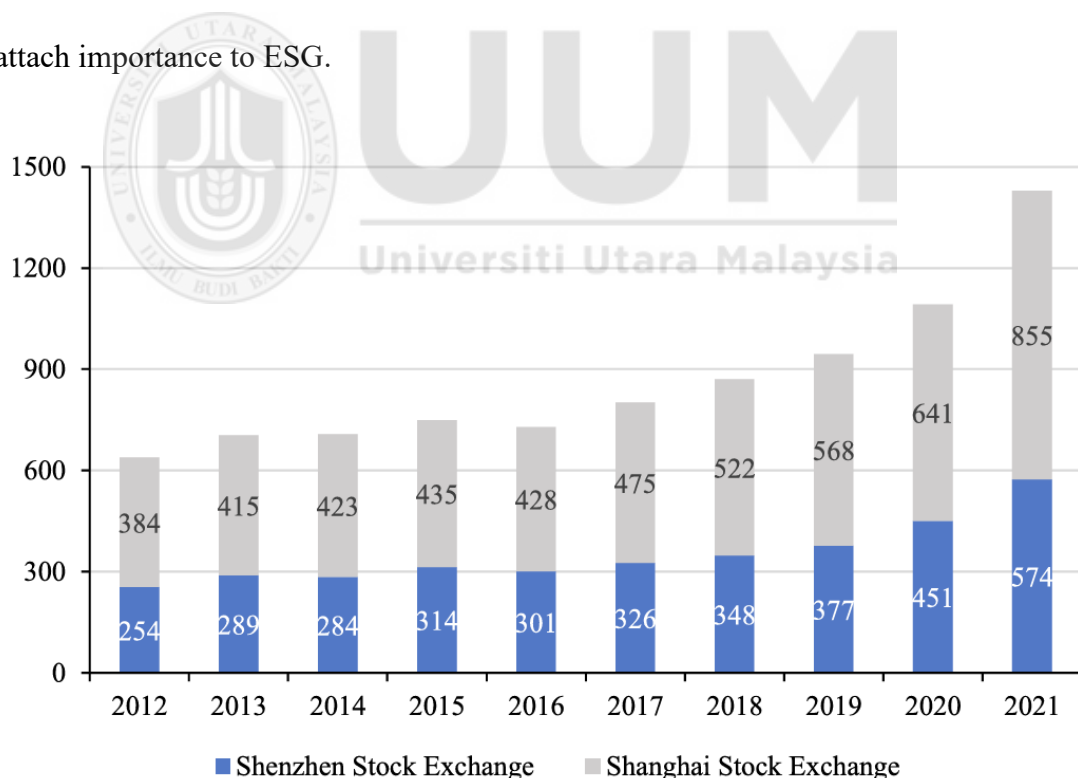


Figure 2.2
Number of ESG reports that Chinese public companies have released
Source: Companies (2022)

Outside and inside factors are the two types of things that affect ESG success in China. Rules about the environment, acts by the government, and market forces are all examples of external factors. On the other hand, ownership structure, company governance, and digitization are examples of internal factors. A low-carbon industry system has been made possible by projects like the National Development and Reform Commission's low-carbon city pilot project (Wang & Wang, 2022). Collusion between government and companies is also considered a hindrance to corporate ESG practices (Meng et al., 2023). But it's also important to think about how new players in the financial market, like non-governmental organizations, institutional investors, and big tech companies, affect ESG performance.

The development of ESG policies in China can be broadly categorized into three phases, which are:

- (1) Budding and starting phase (from 2002 to July 2016);
- (2) Exploratory development phase (from August 2016 to September 2020);
- (3) Deepening and enhancing phase (from October 2020 to the present).

The early stages of China's ESG policy system development took place from 2002 to July 2016. China's early and continued efforts in the areas of social responsibility, environmental protection, and organizational governance can be seen in how its policies have changed over this time. China's ESG policies have been built from scratch from 2002 to July 2016, when they were just getting started. At first, the Governance Code for Listed Companies issued by the Securities and Futures Commission (SFC) in 2002 set a clear scope for the disclosure of governance information of listed companies for

the first time (Katelouzou & Puchniak, 2021), which not only marked the beginning of China's ESG policy, but also signaled the beginning of an increased emphasis on corporate governance transparency. Subsequently, in 2006 and 2008, the Shenzhen and Shanghai Stock Exchanges launched guidelines and notices encouraging companies to publish social responsibility reports, indicating that social responsibility began to be formally included in the consideration of corporate development (Noronha et al., 2013). Also, in 2007, the State-owned Assets Supervision and Administration Commission of the State Council (SASAC) released the Guiding Opinions on the Fulfilment of Social Responsibility by Central Enterprises. These said that SOEs had to publish social responsibility or sustainable development reports on a regular basis (Zhang et al., 2023), showing the leading role of SOEs in promoting social responsibility. By 2014, with the revision of the Environmental Protection Law, China for the first time required companies to disclose environmental information in the form of legislation (Wang, 2018), a move that not only reinforced the legal requirements for environmental protection, but also demonstrated the growing importance of environmental information transparency to the public and investors. Immediately following this, in 2015, the former General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) issued the "Guidelines on Social Responsibility" and related guidance documents, which further clarified the connotation of social responsibility and how companies should fulfill their social responsibility (Roberts & Lin, 2016), and provided specific guidance on how to practice social responsibility.

China's ESG policies have been formed and are still being developed. These policies show that the government is actively researching and practicing environmental protection, social responsibility, and good company governance. Putting these policies

into action has not only made corporate governance more open and socially responsible, but it has also built a strong base for the future growth of China's ESG policy system, showing that China is dedicated to creating a sustainable society.

China's ESG policy started a new phase of fast exploration and growth in August 2016 and will end in September 2020. The main goals of this phase are to strengthen the green financial system and improve the disclosure of environmental information. The People's Bank of China (PBOC), in conjunction with seven other ministries and commissions, published the Guiding Opinions on Building a Green Financial System, which marked the beginning of this period (Zhang & Crooks, 2012), which not only marked a new milestone in the development of China's ESG policies, but also clarified the "three-step" strategy for establishing a mandatory environmental information disclosure system for listed companies. Subsequently, in September of 2018, the Securities and Futures Commission (SFC) issued the Revised Guidelines on the Governance of Listed Companies (Wu & Habek, 2021). These guidelines laid out the basic rules for ESG sharing even more. They required companies that were on the stock market to share information about the environment as well as information about how they were meeting their social obligations, like reducing poverty. This step has made a big difference in both the quality and quantity of knowledge that is shared.

Immediately following this, in November 2018, the Green Investment Guidelines (for Trial Implementation) issued by the China Securities Industry Funds Association (CSIFA) further clarified the connotations and objectives of green investment (Zhang & Zhao, 2024), listed businesses were directed to consider the quality of ESG information disclosure as a crucial reference point for investment choices. This not only

indicates China's desire to encourage green investment, but it also offers clear advice to publicly traded firms, urging them to increase the transparency and reliability of ESG information.

These were the Guiding Opinions on Building a Modern Environmental Governance System that the Central Committee of the Communist Party of China and the State Council put out in 2020 (Hou et al., 2021), which expanded the subject of information disclosure from listed companies to include debt issuers, a policy expansion that further increased the scope and depth of environmental information disclosure. Meanwhile, major stock exchanges have responded to the policy requirements by revising and improving the requirements for environmental information disclosure, among which the SZSE proposed for the first time to assess the active disclosure of ESG and fulfillment of social responsibility of listed companies in its assessment measures released in 2020, a measure that undoubtedly strengthened the enthusiasm of companies in environmental and social responsibility.

Overall, during this exploratory development phase, China has made significant progress in promoting green finance and strengthening corporate environmental responsibility. Setting up a set of rules and standards has not only helped companies be more open about their ESG activities, but it has also made it easier to create a green financial system. These steps show how determined the Chinese government is to protect the environment and be socially responsible. They also make a big difference in promoting sustainable growth in China and around the world.

Since October 2020, China's ESG policies have entered a phase of deepening and upgrading, which is centered on achieving the country's "dual-carbon" goals - i.e., to reach peak carbon dioxide emissions by 2030, and to achieve carbon dioxide emissions by 2060, and to achieve carbon dioxide emissions by 2060, as well as to achieve the "double-carbon" goal. emissions by 2030 and carbon neutrality by 2060 (Chen et al., 2022). During this period, the Chinese government's and the market's efforts in the ESG area have been particularly focused on the strategic deployment of the economy and society towards a comprehensive green transition.

During this period, a series of important policies and measures have been rolled out with the aim of strengthening the corporate ESG information disclosure system and promoting the development of ESG investments. These policy documents establish the subject, content and principles of environmental information disclosure from multiple dimensions, providing clear guidance and requirements for firms.

First, there are a number of policy documents that explain how to share environmental information about businesses. These include the Reform Program for the System of Environmental Information Disclosure in Line with the Law and the Format Guidelines for the Disclosure of Corporate Environmental Information in Line with the Law., and the Administrative Measures for the Disclosure of Corporate Environmental Information in accordance with the Law, have been issued one after another. These documents provide detailed regulations on the scope, format and management of environmental information disclosure, improving the quality and transparency of information disclosure.

In July 2023, SASAC issued the "Notice on the Transmission of the Study on the Preparation of Special Reports on ESG of Listed Companies Controlled by Central Enterprises" (Sun & Zhu, 2024), which put forward the goal of realizing the "full coverage" of ESG information of listed companies controlled by central firms by 2023, showing the importance attached to improving the level of compilation of ESG reports by state-owned enterprises and the scope of their coverage.

On the other hand, national financial regulators, such as the People's Bank of China, have issued documents such as the Catalogue of Projects Supported by Green Bonds (2021 Edition), the 14th Five-Year Development Plan for Financial Standardization, and the Guidelines on Investor Relationship Management for Listed Companies, which provide stable policy support for ESG investment by clarifying the standards for green bonds and incorporating ESG into the communication between listed companies and investors. These papers support ESG investment by making the requirements for green bonds clearer and adding ESG to the conversations between public companies and investors. The objective of this sequence of measures is to facilitate the sustainable development and green transformation of the financial market by means of transparent policy guidance and standardization.

Meanwhile, major stock exchanges have also revised and made special provisions for rules on environmental information disclosure based on industry characteristics. For example, the SSE issued special regulations on disclosure for insurance companies, commercial banks and highly polluting industries in 2022, and these measures further strengthened the refinement and emphasis on industry-specific ESG disclosure requirements.

Overall, this deepening and upgrading phase has seen China's ESG policy efforts focus on improving the standards and quality of environmental disclosure, fostering the growth of green finance and improving the systematic and standardized character of ESG communication in its relationship management with investors. Through the implementation of these policies and measures, China has not only made progress in advancing its own green transformation and sustainable development goals, but also contributed Chinese solutions and strength to the global ESG development trend, demonstrating China's responsibility and commitment in global environmental governance.



Table 2.2

ESG policies in China

Period	Release Time	Policy Content
Sprouting Period	2002: The Beginning of the Policy	Code of Governance for Listed Companies
	2006 & 2008: Promotion of Social Responsibility Reporting	Guidelines on Social Responsibility of Listed Companies and Circular on Strengthening the Assumption of Social Responsibility by Listed Companies
	Late 2007: Leadership of Social Responsibility of Central Enterprises	Guiding Opinions on the Fulfillment of Social Responsibility by Central Enterprises
Exploration Period	2014: Revision of the Environmental Protection Law	Law on Environmental Protection
	2015: Publication of Social Responsibility Guidelines	Guidelines on Social Responsibility
	August 2016: Construction of Green Financial System	Guiding Opinions on Building a Green Financial System
	September 2018: Establishment of ESG Disclosure Framework	Code of Governance for Listed Companies (Revised)
	November 2018: Green Investment Guidelines	Green Investment Guidelines (Trial Implementation)
	2020: Construction of Environmental Governance System	Guiding Opinions on Building a Modern Environmental Governance System
Deepening Period	September 2020: The proposal of dual-carbon target	At the 75th meeting of the UN General Assembly, Chinese President Xi Jinping says, "We will try to peak carbon dioxide emissions by 2030 and reach carbon neutrality by 2060."
	October 2020: Strategic Deployment of Comprehensive Green Transformation	When the 19th Central Committee of the Communist Party of China (CPC) met for the fifth time, they made a big plan to "promote a comprehensive green transformation of economic and social development," providing policy and strategic guidance for realizing the "dual-carbon" goal, and clarifying the path of China's development in a green transformation.
	July 2023: Special Report on ESG of Listed Companies Controlled by Central Enterprises	Notice on the Transmission of the Study on the Preparation of ESG Special Report for Listed Companies Controlled by Central Enterprises
	2021: Update of the Catalog of Projects Supported by Green Bonds	Catalog of Green Bond Supported Projects (2021 Edition)
	2022: Special Provisions on Industry Disclosure	Rules for the Compilation and Reporting of Information Disclosure by Companies Offering Securities to the Public

In the evolution of ESG policy in China, the interaction between policy orientation, regulatory framework and market practice has demonstrated its complexity and far-reaching impact. The government's increased emphasis on environmental protection and social responsibility has made policy a key external motivating force behind the enhancement of ESG performance. This process is also significantly influenced by market forces, especially in terms of technological innovation and resource allocation optimization, which provides a broad space and impetus for ESG practice. Nonetheless, policy and market forces face many challenges. Some of the internal management tools that have a big effect on putting ESG policies into action and making companies better at what they do are the business structure, corporate governance, and pushing for digitalization. The interaction between these internal elements and the external environment jointly influences the current state and future trend of ESG performance attained by Chinese companies.

China's ESG performance is influenced by both traditional ethics and modernization (Bao et al., 2023). The traditional Confucian concept of "unity of man and nature" aligns with ESG's environmental management and resource conservation philosophies (Zhao, 2014), under the rural regeneration approach, modernization has influenced the distinctive ESG practices of Chinese businesses (Chen et al., 2023). However, despite the increase in quantity, the quality and standardization of China's ESG disclosures still require further improvement.

ESG performance in China, as a whole, reveals that there is ongoing development in environmental protection, social responsibility, and corporate governance. However, it also reveals that there are problems and potential for improvement in the practices that

are now in place. China's development in ESG not only has a profound impact on its domestic economy and society but also provides an important case study for global ESG practices.

2.6 Factors Influencing ESG Performance

The internal and external environments in which businesses operate are the primary sources of past research on the factors that influence ESG performance. Among these, internal influencing factors have been widely explored, with studies focusing on aspects such as organizational culture and human resource management, resource allocation, innovation and application of new technologies, and management characteristics.

To begin with, the structure of the corporate governance has a considerable influence on the ESG performance of the organization. In order to develop and put into action successful ESG policies, it is essential that the board be of high quality, independent, and diverse (Jo & Harjoto, 2011). A strong governance structure encourages openness, raises responsibility, and makes sure that ESG goals are in line with the company's overall strategy. In the ESG areas, for instance, companies with more independent directors and a wider range of directors tend to do better (Chouaibi et al., 2022). Moreover, traditional factors such as ownership structure, board structure, and CEO compensation (Barros et al., 2022; McGuinness et al., 2017; Menicucci & Paolucci, 2022; Wang et al., 2023), while influential on ESG performance, are particularly critical in the context of digitalization.

Secondly, as an internal influencing factor, the importance of organizational culture for ESG performance is increasingly recognized and valued. Research by Bai et al. (2024),

based on data from A-share listed companies in China from 2009 to 2021, found through text analysis that corporate culture significantly enhances ESG performance. Corporate culture is important because it encourages green innovations, makes information more open, and has effects on resources and information. Additionally, Bao et al. (2023) noted a positive correlation between corporate integrity culture and ESG performance, a relationship stemming from indirect effects on green innovation and direct signaling to external stakeholders. Jin and Kim (2022) further confirmed the positive impact of ESG activity recognition on work performance, moderated by innovative organizational culture and support for change behaviors. Research by Gill et al. (2023) emphasized the role of trust and accountability cultures in achieving ESG goals. DasGupta and Roy (2023) showed that national cultural dimensions significantly modulate a company's ESG performance at the country level. All of these studies show that organisational culture is a key internal driver of ESG success, and that different aspects of culture have big effects on ESG outcomes.

Lastly, company resources are important for ESG performance because they are internal factors that can change things. Studies proved that business digital transformation had a great impact on ESG results. A study by Zhong et al. (2023) found that digital transformation not only promotes ESG performance, but works through curbing managerial myopia, enhancing information transparency, and fostering technological innovation. At the same time, certainly the impact of national power and industry characteristics on ESG performance cannot be ignored. The research by Abdi et al. (2022), Huang (2021), and Wong et al. (2021) showed an important way for the external factors, such as the institutional quality and education system, to directly

impact ESG performance. Thus, the effect of corporate resources on the ESG performance is a complex process of both internal and external influence.

On one hand, when a firm tries to improve the ESG performance, it has to face several internal barriers. Indeed, one of the most important ones is the outdated philosophy in management or an inflexible culture (Alvesson & Sveningsson, 2015), which might make the management and employees become without awareness of sustainability or resist new changes (Lee, 2015; Nicolaides, 2006). Besides that, it is also problematic for firms to implement effective ESG strategies because they simply lack resources like money, technology, or people. Mostly, it is found in environmental technologies and social projects, as these projects are highly capital-intensive. In addition, key challenges are insufficient internal governance and lack of transparency. Without the relevant governance structures in place, there is a possibility of mismanagement associated with ESG risks and opportunities.

Furthermore, businesses may lack sufficient ESG-related training and awareness-raising measures, resulting in inadequate understanding of ESG issues among employees and management, leading to a lack of proactive actions. Insufficient incentive mechanisms, such as not incorporating ESG performance into evaluation systems, may lead to a lack of motivation among employees and management in ESG matters. Limited innovation capabilities and an excessive focus on short-term profits may sideline investments and efforts in ESG. Additionally, poor supply chain management may lead to brand reputation damage and compliance risks, especially when ESG issues within the supply chain are not effectively managed. Therefore, to make progress on the path to sustainability, businesses need to identify and address

these internal challenges, overcoming obstacles through internal reforms and strategic adjustments.

It is just as important to understand the external factors that affect ESG outcomes as it is to understand the internal factors that affect ESG success. These external variables are highly essential in the business world and have a direct effect on how well the company does in ESG areas. About outside forces that affect ESG performance.

Firstly, a company's ESG performance is significantly influenced by the norms, culture, laws, and policies of the society in which it operates (Pinheiro et al., 2023). These external factors set the framework and boundaries for corporate behavior. For example, laws and regulations pose minimum requirements for environmental protection, social welfare, and corporate governance (Rahim, 2013), with businesses needing to at least meet these basic standards to maintain their operational legality. Cultural norms and business practices also have an effect on companies' ESG strategies and actions. In order to stay competitive and socially acceptable, companies often try to conform to these norms.

Secondly, a company's ESG performance is influenced by its broad stakeholder group (Huang, 2022). Corporate ESG strategies can be substantially influenced by the expectations and pressures of stakeholders, including consumers, investors, suppliers, communities, and governments (Ying et al., 2021). Businesses are increasingly recognizing the significance of environmental and social issues, as investors prioritize investments that are beneficial to society and the environment (Friedman & Miles, 2001). Similarly, consumer focus on ethical consumption also drives companies to

emphasize social and environmental factors in their products and services (Shaw & Newholm, 2002).

Finally, the dependence of companies on external resources drives them to follow the rules and expectations of the external environment (Teece, 2007). In terms of ESG performance, this means that businesses may follow certain social and environmental rules to make sure they always have access to important resources like money, talent, and market share. For example, companies may implement stricter environmental management systems to attract environmentally conscious consumers and investors (Earnhart et al., 2014).

At the same time, although the factors influencing ESG have been studied more extensively in past research, the reality is often more complex. Stakeholder expectations and pressures are important factors driving ESG performance (Daugaard & Ding, 2022). However, the obstacle for organizations is the necessity of maintaining equilibrium between the expectations and requirements of various stakeholders. In other words, organizations must not only meet the public's demand for ESG performance, but also optimize the advantages to guarantee that stakeholders, including investors and shareholders, are satisfied, obtain gains, given their limited resources (Daugaard & Ding, 2022). For example, while laws, regulations, and industry standards set a certain level of compliance standards for firms, firms' implementation of these standards and adherence to these norms can be influenced by the pursuit of profit-maximizing economic interests (Short, 2021). In addition, while trends such as serious environmental issues are driving public interest in ESG, this interest can be limited by media coverage and public perception. For example, investors expect a quick return on

capital invested, yet this expectation of a quick return on capital may conflict with long-term environmental and social responsibility goals (Brest et al., 2018), as firms not only need to maximize short-term profits, but also need to satisfy requirements for ESG aspects in their pursuit of profits. The complexity and dynamics of these external factors require companies to adopt flexible and diversified strategies to cope with the changing external environment.

In this context, climate risk disclosure becomes a key influencing factor. The identification, appraisal, and reporting of climate-related risks in an organization's operations and business paradigm are referred to as climate risk disclosure. This disclosure is crucial for enhancing the transparency of companies in the environmental dimension and can assist investors, shareholders, and other stakeholders in gaining a more comprehensive understanding of the efforts and performance of companies in addressing climate change (Sullivan & Gouldson, 2017; TCFD, 2017). Effective climate risk disclosure not only enhances stakeholder participants' trust in the firm, but also improves the ability of management within the firm to make decisions, which in turn helps the firm to manage its long-term environmental risks and opportunities more effectively (TCFD, 2017). Thus, it serves as a means for organizations to demonstrate transparency and accountability and to adapt to changes in the external environment, in addition to reflecting their internal management. Good climate risk disclosure can help companies build trust, enhance their image in the minds of investors and consumers, and can sustainably improve their market competitiveness. Climate risk disclosure is therefore not only a complement to a company's internal strategy, but also a key tool for facing external challenges and opportunities.

However, considering the current climate environment, which is becoming increasingly challenging, past research has often overlooked climate risk disclosure as a key factor when thinking critically about the internal and external influences on ESG performance. While past studies have explored that corporate governance, organizational culture, and resource allocation undoubtedly have a significant impact on ESG performance, the current climate change challenges that the world is confronting should not be neglected in the context of the contribution of climate risk disclosure to ESG performance. Past studies have mainly focused on which factors to focus on or change to improve ESG performance, and companies then work in this direction, such as by analyzing internal and external influences to improve ESG performance (T. T. Li et al., 2021), and more studies have used ESG ratings from the Bloomberg database to improve corporate value or market performance, etc (Alareeni & Hamdan, 2020; Junius et al., 2020). However, there are unanswered questions in these studies, i.e., whether it is possible to consider the enhancement of ESG performance in the context of the current severe climate challenges, in order to address the obstacles presented by climate change and to at least partially influence ESG performance.

Climate risk disclosure has often been marginalized in past research, possibly due to a lack of corporate awareness of its immediate impact and importance (Benz-Saliasi, 2020). In fact, with the growing global concern over the impacts of climate change, companies' climate risk disclosure has become a key component of their ESG performance assessment. Through the content of climate risk disclosure, companies can not only respond to the current severe climate challenges but also fulfill the demand for information transparency from other stakeholder participants. Therefore, climate risk disclosure needs to be considered as an important factor in the study of corporate ESG

performance, alongside traditional internal factors such as governance, culture and resources. In summary, while traditional ESG performance influencing factors remain important, the role of climate risk disclosure cannot be ignored in the current environmental context.

2.7 Climate Risk Disclosure

2.7.1 Concept of Climate Risk Disclosure

Past research has widely investigated the nature and effects of climate change, elaborating that there is a need to adapt to these changes (Berrang-Ford et al., 2011; Smith et al., 2009; Weinhofer & Hoffmann, 2010). The corporate world, in particular, is keenly attentive to these changes, given the inseparable nexus of corporate operations and climate change.

Indeed, has turned the risks associated with climate change as the most crucial challenge with which corporations need to be concerned. Deloitte (2021) and the United Nations Framework Convention on Climate Change highlight that corporations should disclose their climate-related risks to provide market participants with crucial information about such risks and the corporation's strategy to respond to such risks. (UNFCCC, 2012). This, in turn, would enable the market to make informed decisions and would also serve to motivate the market in its pursuit of sustainable development and the mitigation of climate change risks..

Moreover, climate risks can be broadly classified widely into three categories: physical climate risks (including rise in sea level, catastrophe weather patterns), regulatory climate risks (including changes in policies and regulations), and market climate risks

(including shifts in consumers' attitudes and behavior as well as risk related to reputation) (Demertzidis et al., 2015; Elijido-Ten, 2017). The nature and severity of these risks are so intricate and uncertain that it requires corporations to follow multi-dimensional approaches for the management of such risks.

However, leaving aside the manner how the economic impacts of the climate risk disclosure develop, it is also necessary to admit that the nature of the climate-risk disclosure is not just related to compliance and information sharing. At the back of the climate-risk disclosure remains a gigantic issue, one that goes to create wide and deep-reaching economic impacts not only on the financial and operational situation of a company but also on the behavior of investors, the confidence of the market, and the soundness and sustainable development of the whole economic system. This is because, to the extent that one does not understand the economic impact of the disclosure of climate risk, one cannot be in a position to tell if it is worth or not, even if and when it is needed in the management of climate risk. The following sections illustrate how the climate risk disclosure impacts corporations and, in effect, the general economy, thus compelling corporations to take even more proactive steps in managing the risk.

2.7.2 Disclosure of Economic Consequences of Climate Risks

With the rising emphasis on sustainable development in the universe, relevancy of the disclosure of climate risk has come to the top. The information from the disclosure of climate risk would empower companies to identify, assess, and manage risks and opportunities which are linked with climate change. The transparency not only empowers investors and other stakeholders to make decisions, but also the companies themselves to enhance their environmental performance and strategies for combating

climate change. By the companies disclosing the information, proper climate risk management may help in predicting and alleviating financial losses as well as increasing the market competitiveness and reputation (TCFD, 2017). Besides, companies' disclosure of this part of climate risk information builds trust with stakeholders (Matemane & Graca, 2023), improves the brand image as well as ensures company sustainability in the end (Kouloukoui et al., 2019).

In earlier studies, climate risk disclosure has not been able to show economic consequences of various types which are linked or directly connected to the financial stability of companies, market reaction, risk management, management behavior, environmental performance and social impacts, as well as the influence of market dynamics and investors. To begin with, research had been conducted to set right the link between the financial stability and performance show that the companies that disclose climate risk do better (Eleftheriadis et al., 2015; Maji & Kalita, 2022). Companies have the ability to improve their financial performance and strengthen their market competitiveness by using climate risk management and information disclosure practices which are transparent (Kouloukoui et al., 2019), reduce uncertainty (Düsterhöft et al., 2023), and improve the return rate of investment projects (Antoniuk, 2023).

Market response and the company's value are positively correlated with climate risk disclosure. However, a relation can very easily turn into negative if more attention is being extended to the issue of climate change in the market in future (Vestrelli et al., 2024). On the other hand, it gives a complex and changing relation of climate risk disclosure with the stock price and the traded volume of stock and security to the market

response to the climate-related information (Vestrelli et al., 2024). Secondly, it has been determined that the likelihood of stock price collapses is decreased by the disclosure of climate risk in risk management and control (Lin & Wu, 2023). In addition, the spread of credit default swaps is simultaneously increased, while information asymmetry persists (Kölbel et al., 2020; Schiemann & Sakhel, 2019). This proves the fact that companies, through the disclosure of climate risk, are able to manage their market and credit risks in a better way.

It has been found in studies that the disclosure of climate risks could push for management to be more involved in environmental activities and influence the decision-making process by regarding these risks with appropriate importance (Kim et al., 2023). This has also been found as one of the driving forces toward the development of companies in a more sustainable direction. Additionally, it has been disclosed that the disclosure of climate risk enhances the transparency and quality of financial reporting for companies (Zitti & Guttormsen, 2023).

Hence, in the improvement of the environmental performance, the disclosure of climate risk is considered as the main improvement in terms of the social impact and environmental performance (Kim et al., 2023). Transparent and comprehensive climate information helps business organizations to be able to identify and manage their environmental impacts, which enhances the performance in the environmental dimension. To the contrary, climate risk information enhances the precision of financial analysts' earnings forecasts and also mitigates the volatility of stock prices for investors and market dynamics (Ben-Amar et al.). In other terms, it means that the market, with

the climate information, effectively allows the pricing of the climate risks to be done more prudently.

In response to the consequences of disclosure of climate risk, businesses have responded in various ways. To begin with, it is according to the studies of Busch and Hoffmann (2011) and Busch et al. (2016) that the businesses have developed adaptation strategies to climate change based on their characteristics and the background of the industry and have constituted an effective system of climate risk assessment. Businesses invest in things like clean energy, optimization of the production process, Enhancing energy efficiency and decreasing carbon emissions, as indicated in the research conducted by Fujii et al. (2013) and Linnenluecke et al. (2011). In order to mitigate the risks of supply chain disruptions that are a result of climate risks, the businesses have modified their supply chain structures, as put forward by the research of Craighead et al. (2007) and Weinhofer and Busch (2013). Finally, businesses pay attention to the development trends of the climate policies and regulations to ensure that their actions are in compliance with the relevant requirements that reduce the transition risks optimally (Busch et al., 2016).

All the more important facts are that through the measures mentioned above, the companies have not only been able to gain considerable progress in managing the specific challenges related to climate change but also have taken major steps towards the improvement of their overall ESG performance. Performance improvements do not only connote positive environmental actions, such as emission reduction and resource optimization, but they tug along with them other values, like understanding social responsibilities and governance structures, for efficiency. It is for the same reason that

today, enhancement of ESG performance has risen to an important key performance indicator used in measuring how effectively a business responds to the risks associated with climate change.

In this process, a business's ESG performance not only reflects its response to climate change but also embodies its social responsibility and values (Ngo et al., 2023; Ozkan et al., 2023). However, despite this, in the following important literature regarding the factors that have led to ESG performance, the economic impact of climate risk disclosure to businesses has not been studied much. In enhancing ESG performance, the businesses not only enhance their adjustment capacity toward climate change but also maximize their social and economic value. From the viewpoint of the environment, good practices, such as the clean energy development and reduction of carbon emissions, reflect the proactive management of the climate risk by the businesses (Acheampong et al., 2019). Socially, by strengthening efforts toward environmental protection and sustainable development, businesses can enhance their contribution to society and increase public trust (Lu et al., 2021; Yeh et al., 2020). In governance, paying attention to the development trends of climate policies and regulations not only aids in corporate compliance (Cullenward & Victor, 2020; Kraft, 2021) but also promotes the internal attention to climate change issues and decision-making transparency within the business.

2.8 Climate Risk Disclosure and ESG Performance

Previous research has demonstrated that firms' environmental performance is positively correlated with transparent and comprehensive climate risk disclosure (Kim et al., 2023). However, the discussion on climate risk disclosure in the study by Ding et al.

(2023) tends to be limited to carbon disclosure and fails to adequately address the broader and deeper aspects of climate risk disclosure. One significant disadvantage of this method is that carbon disclosure, which serves as a proxy for climate risk, may not fully capture the diverse climate risks faced by firms and also ignores the multidimensional impacts of climate risk disclosure at a broader level. Climate risk is not limited to carbon emissions; however, it also incorporates the consequences of extreme weather events and the broader environmental hazards and impacts associated with climate change. climate sensitivity in the supply chain, and market and regulatory changes related to climate change (Adams & Abhayawansa, 2022). Therefore, singular reliance on carbon disclosure in conducting research related to climate risk disclosure may overlook the risks and opportunities in these key areas.

Climate risk disclosure has significant positive impacts on environmental performance. Initially, the disclosure of climate risk has encouraged companies to prioritize the environmental consequences of their operations. with some studies suggesting that climate risk disclosure can help reduce carbon emissions and improve resource management (Kim et al., 2023). By transparently disclosing this climate risk information, companies not only demonstrate their commitment to environmental responsibility, but also incentivize internal continuous improvement. It also motivates management to become more actively involved in environmental protection activities (Kim et al., 2023). This reflects the increasing environmental responsibility of corporations in addressing climate change. For example, in order to enhance their environmental performance indicators, organizations may implement strategies to decrease their energy consumption and carbon imprint. Furthermore, the disclosure of climate risk can contribute to the establishment and preservation of public trust (Yang,

2023), as transparent and responsible environmental disclosure can be used as an important indicator of CSR to enhance CSR performance. These activities not only help to improve a firm's ESG performance, but also enhance its competitiveness and reputation in the marketplace, thereby contributing to sustainable development in the long term.

Climate risk disclosure may also have some negative impacts on the environmental dimension of ESG. The cost and complexity faced in making climate risk disclosures may pose a financial burden for some firms, especially for smaller firms with limited resources (Achenbach, 2021). Management can also consume time costs to make disclosures due to unfamiliarity with this part of climate risk disclosure, which can affect performance in carrying out other business activities (Kouloukoui, de Oliveira Marinho, et al., 2019).

In a more serious case, firms may take superficial improvements to fulfill the disclosure requirements, yet not substantially reduce their environmental impacts (Meng et al., 2019), and firms make false disclosures. This "Greenwashing" behavior not only undermines the true sustainability of companies, but may also mislead investors and consumers, affecting the environmental performance level of the industry as a whole.

From the social perspective of ESG performance, corporate climate risk disclosure can enhance the fulfillment of social responsibility, especially in the fight against climate change (Huang & Lin, 2022). By disclosing their assessment of climate risks and response strategies, firms not only demonstrate their commitment to environmental protection, but also demonstrate their concern for social well-being (Khan et al., 2021),

which is part of the fulfillment of social responsibility. For instance, corporate disclosure in reports regarding initiatives to mitigate greenhouse gas emissions (Depoers et al., 2016), adopt sustainable raw materials and improve ecosystems can enhance their reputation among consumers and communities. In addition, climate risk disclosure can also help to improve communication and trust between firms and stakeholders (Peters & Romi, 2014), and stakeholders are able to recognize a firm's response to social responsibility through the content of the firm's climate risk disclosure, which can result in improved performance in terms of social responsibility. However, certain critical studies have also contended that there is a general negative correlation between climate risk disclosure and firm valuation as reflected in P/E and P/B ratios (Benz-Saliasi, 2020), which may indicate that investors and the capital market are becoming more and more attentive to firms' attitudes towards transparency and action on climate change issues. Corporate transparency on climate risk management can be an important indicator of their social responsibility.

From a governance perspective, climate risk disclosure has a profound impact on the governance structure of a company. First, information transparency plays an important role in corporate governance. Increased climate risk disclosure means that firms demonstrate greater transparency in management decision-making (Kim et al., 2023) and business governance (Pattberg, 2012). Through climate risk disclosure, firms not only enhance their internal management's ability to manage climate risk, but also communicate transparency about climate risk disclosure information to stakeholders. At the same time, financial investors have become increasingly concerned about corporate responses to climate change and have begun to demand that firms develop specific risk management strategies (Pattberg, 2012). This suggests that firms must

integrate climate risk management in their governance structures to respond to increasingly stringent market and regulatory requirements.

Furthermore, there is a substantial positive correlation between the financial performance of firms and their disclosure of climate risk (Kouloukoui et al., 2019), which also implies that good governance practices for climate risk management can enhance the overall performance of firms. However, the same study also shows that corporate climate risk disclosure is negatively associated with debt levels, which may reflect a complex relationship of influence between firms' governance decisions in two areas, capital structure and financial soundness, and their responses to climate change. In critically reflecting on these studies, this study also notes that climate risk disclosure may have far-reaching implications for corporate governance structures and strategies. Firms need to find a balance between maintaining financial stability and responding positively to climate change, which may require adjustments and innovations in governance strategies.

In terms of overall ESG performance, the financial viability of firms is significantly influenced by the disclosure of climate risk. (Farbotko, 2019) and can influence firms' financial performance (Wang, 2023). Furthermore, there is a positive correlation between climate risk disclosure and firm value; however, this relationship may evolve as concerns regarding climate change intensify (Wang, 2023). Firms' share price and credit risk are also affected by climate risk disclosure (Antoniuk, 2023; Kölbel et al., 2020). These results indicate that climate risk disclosure is not only a manifestation of environmental responsibility, but it is also strongly correlated with the financial health and market performance of firms.

Reflecting critically on these findings, this study finds that while climate risk disclosure positively affects corporate ESG performance in a number of ways, there is also the potential for negative impacts, such as a possible negative correlation between firm value and stock price (Bratten & Cheng, 2023; Wang, 2023). In addition, firms need to balance financial and non-financial factors when making climate risk disclosures to ensure that the disclosed information fully reflects their response strategies to climate change. Corporate responses to climate risk disclosure vary along different dimensions, and their impact on ESG performance needs to be considered comprehensively.

Past studies have presented both positive and negative perspectives in exploring the relationship between disclosure and corporate ESG performance. Some studies believe that good information disclosure can significantly improve the ESG performance of firms. For example, Dhaliwal et al. (2011) found that firms can attract more investment by improving information transparency, especially the voluntary disclosure of ESG, thus improving the market value and ESG performance of firms. This shows that information disclosure plays an active role in enhancing corporate transparency, enhancing investor confidence and improving ESG performance. Some studies have also found that companies that voluntarily disclose environmental information can show better ESG performance (Alsayegh et al., 2020). Moreover, some studies believe that companies that provide sustainability information disclosure in annual reports have higher ESG performance (Yang et al., 2021). However, this part of the research only pays attention to the disclosure of environmental information, but ignores the disclosure of climate risk information.

At the same time, another part of the research puts forward a negative view that information disclosure may also bring negative ESG performance. Cho et al. (2015) found through analysis that excessive information disclosure may lead to information overload, which makes it difficult for investors to identify the real ESG performance of firms, thus affecting the market evaluation and ESG performance of firms (Cho et al., 2015). This shows that the impact of information disclosure quality and its interaction with recipients on ESG performance is a complex process, which requires more detailed management and strategy. Moreover, some studies have found that companies exaggerate their ESG performance (Greenwash) and understate their actual achievements (Brownwash) in sustainability reports, which will confuse the decisions of investors and stakeholders (Kim & Lyon, 2015). At the same time, some studies have found that when firms adopt traditional sustainability reports instead of comprehensive reports, their ESG information disclosure often lacks the combination of financial and non-financial information, which may have a negative impact on the accurate evaluation of ESG performance (Jensen & Berg, 2012).

At the same time, some studies use developing countries as research samples to study the effect of climate risk disclosure on firm value, and it is determined that the impact of climate risk disclosure (carbon disclosure) on firm value is negative (Mahmudah et al., 2023). Indonesia continues to maintain an extremely low level of climate risk disclosure. It is found that developing countries only abide by government regulations when making companies are concerned that the disclosure of climate risk will result in an increase in costs, which will subsequently impact the value of the company. This study only uses carbon disclosure to summarize climate risk disclosure, which is obviously not comprehensive, because climate risk disclosure not only includes the

single content of carbon dioxide emissions. Another study examined the influence of climate risk disclosure on environmental performance based on climate risk disclosure in 10-K reports and found that companies with more climate risk disclosure tended to improve their environmental performance (Kim et al., 2023), but only focused on a portion of ESG performance and did not yet comprehensively encompass ESG performance.

These studies indicate that the correlation between ESG performance and disclosure is not always advantageous. Despite this controversy, this study focuses on one particularly important area of disclosure - climate risk disclosure. The existing literature has had relatively little in-depth exploration of this area, creating a gap in the research. The risks posed by climate change have a significant impact on the long-term development of companies, and climate risk disclosure, as an important indicator for assessing the ability of companies to cope with climate change, has a far-reaching impact on the ESG performance of companies. Sullivan and Gouldson (2017) pointed out that effective climate risk disclosure can not only enhance the adaptive capacity of firms to climate change, but also build a stronger sense of trust among investors, which indirectly enhances their ESG performance.

In summary, although there are different views on the relationship between disclosure and ESG performance, climate risk disclosure, as a specific and critical area, still has much room for exploration in existing research. This study aims to fill this gap and provide clearer guidance and recommendations for companies, investors, and policy makers by analyzing in depth the impact of climate risk disclosure on ESG performance.

However, when exploring the impact of climate risk disclosure on corporate ESG performance, past studies have often focused on a single factor, such as environment or governance, and failed to provide a comprehensive assessment of ESG performance. This research approach may lead to a neglect of the impact of climate risk disclosure on corporate social responsibility and overall governance structure. ESG performance is a multidimensional concept that encompasses corporate performance in terms of environmental protection, social responsibility and governance transparency. A one-dimensional analysis may not accurately reflect the impact of climate risk disclosure on overall corporate sustainability.

2.9 Applicability of legitimacy theory to this study

Legitimacy theory could be used as an appropriate theoretical perspective when measuring the association between business climate risk disclosure and ESG performance. According to Suchman (1995), legitimacy is how individuals or organizations feel their practices relate to an organization's social value system in regard to what is right, proper, or desirable. Legitimacy theory asserts that in the disclosure of climate risk, firms share information on climate change to acquire or preserve their legitimacy in the eyes of stakeholders.

The public, government, investors, and other stakeholders, as the world increasingly pays attention to climate change issues, are raising their expectations in terms of corporate environmental responsibility and transparency. In these regards, therefore, corporate climate risk disclosure addresses not only the expectations from the external environment but also the internal motive of the creation and maintenance of social legitimacy for the company as a vehicle to develop and sustain social legitimacy (Qian

& Schaltegger, 2017). This way, corporations could help in portraying themselves as entities that are socially responsible, thus increasing their social legitimacy through the proactive revelation of climate risk information, as they indicate their responsiveness to the environment and related issues.

Moreover, From the perspective of the ESG performance, climate risk disclosure is related to the legitimacy theory (de Silva Lokuwaduge & de Silva, 2020). The legitimacy acquisition perspective describes the fact that the firm may disclose information in response to the expectations of the external environment, and such a process represents the maturity of internal management and the performance effect of climate risk management (González et al., 2020; Kouloukoui et al., 2020). This can be positively associated with improvement of management capability, which in turn shall be promoted through the increase in ESG performance, making a loop whereby the enhancement of social legitimacy status of the corporation will be realized. Therefore, from the perspective of legitimacy theory, climate risk disclosure is not only one way for corporations to pursue social legitimacy but also the key factor in promoting the improvement of their ESG performance.

The theory of legitimacy asserts that for corporations to acquire resources and rights, corporations must meet the expectation, norm, and value that society prescribes for them (Akhter et al., 2023; Lokuwaduge & Heenetigala, 2017). In relation to the disclosure of climate risk, corporations, through revealing their knowledge, appraisals, and acts relating to—and plans to address—climate change risks in a transparent and honest way, are simply trying to acquire or enhance the social legitimacy they hold in the eyes of their stakeholders. In detail, the following are the aspects mainly related to

the legitimacy that the corporations can derive or enhance by disclosing the risks of climate change:

First, climate risk disclosure can increase acceptance from where the stakeholders are involved. Often, the disclosure of information regarding climate risk means the corporation concerned is committed to its environmental responsibility and to ensuring its sustainable development goal or goals are realized at whatever cost (Fuso Nerini et al., 2019; Gunawan et al., 2020). This might not only increase consumer trust and loyalty but also attract investors who share the values of the corporation. Moreover, it will generate a kind of disclosure that will bring a good relation with the government and regulatory bodies by setting an example of a serious attitude of a corporation toward compliance with the relevant rules of the environment.

What is more, for the legitimacy of the climate risk declaration and the resources/support a company can get, the declaration needs to meet the needs of different stakeholder groups. To be more specific, a company has already shown the way to different environmental stakeholders—environmental groups, the public, etc.—of how to successfully find and minimize the adverse environmental consequences of operations (Li et al., 2017). Informed and satisfied social stakeholders, including employees, consumers, and suppliers, would be the result of the organization's initiatives regarding social responsibility, such as the improvement of the safety of the working environment and support of community development (Alsayegh et al., 2020). For governance stakeholders—investors and board members, a company shows the transparency and effectiveness of the governance structure and how the climate risk management should be achieved through good governance.

But companies have taken concrete actions in climate risk disclosure to meet the legitimacy of stakeholders in these different dimensions. For example, it includes implementing and reporting sustainable development practices (Shad et al., 2019), such as the utilization of renewable energy, the enhancement of resource efficiency, and the reduction of greenhouse gas emissions (Eskander & Fankhauser, 2020). Open corporate social responsibility activities (Kaymak & Bektas, 2017), such as community investment, employee welfare improvement and supply chain responsibility; And strengthen corporate governance, such as enhancing the diversity and independence of the board of directors (Cucari et al., 2018; Poletti-Hughes & Briano-Turrent, 2019), improving the risk management system, etc. On the one hand, companies can not only meet the expectation of stakeholders and then gain legitimacy but can further improve from the resources and support obtained through specific practices towards better performance in ESG.

The legitimacy theory simply explains that companies disclose climate information to attribute legitimacy to the company's operation. Disclosure of climate risk by companies is a manner of maintaining the invisible social contract. If the invisible contract is violated, the company may face more severe scrutiny or the emergence of mandatory regulations (Hrasky, 2011). The theory of the legitimacy of the theory existed and changed its name because the larger firm tends to disclose more climate information if (Garcia-Meca & Sanchez-Ballesta, 2010; Luo et al., 2012), according to the legitimacy theory, the recognition of the larger company and social review will result in more severe control and that big companies try to avoid the negative social reaction because the less or no disclosure of climate information is also a reason that very big companies try to search the legitimacy through the climate information

disclosure. Studies also demonstrate that larger companies disclose more climate information.

In brief, climate risk disclosure will help to build and maintain social legitimation for a corporation. Companies have the chance to acquire the resources and assistance they require through meeting the standards they want, particularly in how they want the company to handle ESG issues. This will also position them to do better in terms of ESG issues. For instance, in gaining legitimacy, this process shows initiative and responsibility from the companies in coping with the challenges of climate change. Likewise, it is a sound foundation for the sustainable development path of a company.

Against the background of China, which has been increasingly centered on sustainable development and environmental protection in recent years, this theory presents strong theoretical reasons to understand how companies build and maintain their legitimacy state through climate risk disclosure and how such a process impacts their ESG performance. In general, the application of legitimacy theory helps in explaining the confusing mechanism of the relationship between climate risk disclosure and ESG performance.

2.10 Stakeholder Engagement

2.10.1 Signaling theory and Stakeholder Theory

Signaling theory suggests that the involvement of different stakeholders can release a signal that in turn affects the performance of the firm. Signaling theory was proposed by (Michael & Shaw, 1994) and this theory is widely used by companies to transfer value and influence their performance through disclosure (Bae et al., 2018; Liu et al.,

2024). In previous studies, signaling theory has also been used to explain how climate risk disclosures signal to stakeholder engagements about a firm's sustainability and climate risk management capabilities (Bae et al., 2018). Through climate risk disclosure, companies signal to external parties that they take environmental responsibility and sustainability seriously. The media, as an important stakeholder engagement, influences the behavioral decisions of the public and investors by reporting on a company's sustainable development behavior (Manetti & Bellucci, 2016), and companies can gain relative prestige and resources. Investors value companies' management of climate risk, so they adjust their investment decisions based on these signals, and climate risk disclosure by companies can lead to a greater tendency for investors to support such companies (Ilhan et al., 2023). Finally, government thieves can formulate relevant policies or make regulatory interventions based on the signals of climate risk disclosure, which can prompt firms to improve their ESG performance (Ronen, 2024). Therefore, signaling theory provides a theoretical basis for how corporate climate risk disclosure affects ESG performance through stakeholder participants in this study.

Meanwhile, according to the stakeholder theory proposed by Freedman (Stieb, 2009), firms have to consider the interests of other stakeholders while maximizing their benefits. Including suppliers, customers and government, etc. Companies also need to balance the interests of different multi-stakeholder participants and respond to their different expectations when conducting ESG performance. Media, investors and government are important stakeholder participants in past studies on ESG performance. The media, as an important channel of information dissemination, is able to report on the business activities and disclosures made by companies, thus influencing ESG performance to a certain extent. Investors, as stakeholder participants who provide the

main capital to the company, have a direct impact on the company's resources and ability to carry out ESG performance activities. The government, on the other hand, monitors and establishes ESG behaviors by implementing policies or providing government subsidies, and the government's interventions can either motivate or constrain the ESG performance of firms. Stakeholder theory provides the theoretical foundation for this study to consider different stakeholder engagement perspectives to examine the connection between climate risk disclosure and ESG performance.

This study delves into the connection between climate risk disclosure and ESG performance from three different stakeholder engagement perspectives: media, government, and investors, which were chosen for reasons deeply rooted in legitimacy theory and its application in past literature (Akhter et al., 2023; Baldini et al., 2018; Ching & Gerab, 2017; Deegan, 2019; Etter et al., 2018; Solikhah et al., 2020). Legitimacy theory emphasizes that in order to gain and maintain legitimacy, firms must meet the norms, values, and expectations of the social environment in which they operate. In this process, the dissemination and reception of information becomes crucial, and the media, government, and investors are key players in these information flows. Starting from legitimacy theory and incorporating signaling and stakeholder theories, each perspective represents different social forces and expectations that have a unique impact on corporate climate risk disclosure and ESG performance.

The media, as a purveyor of social information, has a significant impact on the formation of public awareness and opinion (Kapoor et al., 2018; Weeks et al., 2017). It can increase the visibility of corporate climate risk disclosure and influence the public and other stakeholders' perception and evaluation of corporate ESG performance.

Governments and regulators, on the other hand, represent legal and normative requirements (Kerwin & Furlong, 2018; Kulin & Johansson Sevä, 2019), and their attitudes towards climate risk and policymaking directly influence the operating environment and legitimacy needs of firms. Finally, investors, as providers of resources, and their demand for and response to climate risk information can reflect the market's evaluation of a firm's ESG performance and influence a firm's ability to access finance (Arvidsson & Dumay, 2022; Kordsachia et al., 2022).

From the perspectives of signaling theory and stakeholder theory, and by integrating the three stakeholder engagement perspectives of media, government, and investors, this study is able to provide a comprehensive understanding of the role of climate risk disclosure among different societal forces and its impact on corporate ESG performance. This multi-perspective approach not only helps to reveal the complex impacts of climate risk disclosure on the acquisition of corporate legitimacy, but also provides insights into how corporations can meet the expectations of different stakeholders through their disclosure strategies. In addition, it can reveal how companies can enhance their ESG performance through effective climate risk management and disclosure to gain wider recognition and support in society under the current global climate change challenges. By synthesizing these three perspectives, this study aims to provide richer and more concrete guidance for understanding and practicing CSR.

2.10.2 Media

From the media perspective, the impact of media attention on corporate ESG performance has been widely explored in academic research. As a major channel for public information dissemination, media attention can significantly affect the social

image of firms, public perception and investor decision-making, which in turn has a far-reaching impact on the ESG performance of firms. Media attention is usually used as a moderating variable in past studies, affecting the connection between independent variables (e.g., climate risk disclosure) and dependent variables (e.g., ESG performance).

On the one hand, media attention can increase the visibility of a firm's climate risk disclosure, prompting the firm to pay more attention to the development and implementation of its ESG strategy. For example, Ioannou and Serafeim (2015) found that firms that receive a high level of media attention tend to provide higher-quality climate risk disclosures because they realize that the media can shape public and investor perceptions of their ESG performance. This suggests that media attention can promote positive corporate behavior in the ESG area, which in turn may enhance their ESG performance.

On the other hand, media attention may also increase public opinion pressure on firms, forcing them to react in the ESG domain to maintain their social legitimacy. It has been suggested that firms with high media attention are more likely to respond to public and market expectations by enhancing their ESG activities (Kölbel et al., 2017; Li & Wu, 2020), in order to avoid negative public opinion impacts. This suggests that media attention indirectly motivates firms to improve their ESG performance by increasing external pressure.

In past studies, the role of media attention as a moderating variable is mainly characterized by how it strengthens or alters the connection between disclosure and ESG performance (Capelle-Blancard & Petit, 2019; Chai et al., 2023; Chen et al., 2023; Xu et al., 2022). Specifically, when media attention is high, firms' climate risk disclosures and other ESG activities are more likely to be noticed by the public and the market (Hammami & Hendijani Zadeh, 2020), which increases the positive impact of these activities on firms' ESG performance. In other words, media attention enhances the positive impact of climate risk disclosure on firms' ESG performance because it promotes public and investor attention and feedback on this information by increasing its visibility and importance (Chai et al., 2023). However, there are also studies that provide a critical perspective, with one suggesting that negative ESG performance fulfillment by the stock market through media coverage can harm firm value (Wong & Zhang, 2022).

In conclusion, media attention plays an important role in moderating the connection between corporate climate risk disclosure and ESG performance. By increasing the visibility of corporate behavior and the public attention it receives, media attention not only directly influences the strategies and actions taken by corporations to improve ESG performance, but also indirectly motivates corporations to respond positively on ESG through public opinion pressure.

2.10.3 Government

Under the government perspective, government intervention as a moderating variable occupies an important position in the study of the relationship between climate risk disclosure and corporate ESG performance. Government interventions usually refer to

policy formulation, implementation of laws and regulations, as well as regulation and incentives for corporate ESG behaviors (Ritger, 2020; Yan et al., 2022), and these interventions can significantly influence corporate strategies and actions in terms of ESG.

The impact of government interventions can be seen in two main ways: directly by requiring firms to disclose information through the enactment of relevant climate change and ESG disclosure regulations (de Silva Lokuwaduge & de Silva, 2020; Singhania & Saini, 2023), and through the provision of incentives (e.g., tax incentives, subsidies, etc.) (Jiang et al., 2023) or exerting pressure (e.g., fines, restrictions, etc.) (Mooneeapen et al., 2022) to induce firms to improve their ESG performance. These policies and measures not only directly affect firms' behavior, but also indirectly affect firms' ESG performance by changing the way firms interact with other stakeholders, including investors, consumers, and the public.

Past research has shown that government interventions can improve the quality and quantity of reporting disclosures made by firms (Lee et al., 2017). For example, Luo et al. (2018) show that in China, in conjunction with the government's growing emphasis on sustainable development and the rigorous enforcement of environmental regulations (Shen et al., 2017; Wang et al., 2018), firms are increasingly inclined to improve the transparency and meticulousness of their environmental disclosures. This suggests that government intervention promotes improved corporate climate risk disclosure by increasing disclosure requirements.

In addition, government intervention can promote positive corporate behavior in the ESG field through incentives. Government environmental policies and incentives can effectively encourage firms to adopt more environmentally friendly operations and production methods, thereby enhancing their overall ESG performance (He et al., 2023; Zhang, 2022). This suggests that government incentives and regulatory mechanisms not only enhance firms' emphasis on climate risk management, but also promote their overall performance in environmental and social responsibility.

However, there are some critical views on the impact of government intervention on ESG performance. By enhancing their own ESG performance, organizations can secure government subsidies (Zhang et al., 2023), however, government subsidies will attract firms to "greenwash" and firms will engage in false ESG performance in order to obtain subsidies, which in turn undermines true ESG performance (Zhang, 2023).

In past studies, government intervention is often used as a moderating variable to further explore studies related to ESG performance (Henisz et al., 2019; Yoon et al., 2018). When the intensity of government intervention is high, firms tend to increase climate risk disclosure and take more proactive measures on ESG in order to adapt to policy requirements and avoid potential negative consequences. This mechanism not only reinforces the positive impact of climate risk disclosure on ESG performance, but also suggests that government policies and regulatory frameworks play a crucial role in promoting corporate sustainability.

2.10.4 Investors

When exploring the relationship between climate risk disclosure and corporate ESG performance from an investor perspective, investor attention plays a crucial role as a moderating variable (Bazrafshan, 2023; Flammer et al., 2021; He et al., 2023). Investor attention not only affects how corporate climate risk disclosures are received and handled, but also has both direct and indirect impacts on the ESG performance of corporations. In this framework, investor behavior and preferences form an important influence on corporate ESG strategy and performance through their demand and response to corporate disclosure.

On the one hand, Investor attention can amplify the significance of corporate climate risk disclosure. When investors show higher concern for climate risk information, firms are more inclined to provide more comprehensive and transparent climate risk information in order to attract and retain these investors (Flammer et al., 2021). For example, (Ilhan et al., 2023) finds that investors' environmental concerns have a positive impact on firms' social responsibility activities, and that high levels of investor attention to these activities motivate firms to improve the quality and frequency of their ESG disclosures. This implies that the quality of climate risk disclosures can be enhanced by firms in response to investor attention and pressure, which may influence their ESG performance.

On the other hand, investor attention can also serve as a signaling mechanism to indicate the market's evaluation of firms' ESG performance. A study by (Dyck et al., 2019) shows that investors show stronger interest in firms that exhibit good ESG performance, and this interest is not only reflected in investment decisions, but also influences firms'

cost of capital and market capitalization through market signals (Dyck et al., 2019) . As a result, investor interest motivates firms to make positive adjustments and improvements in climate risk management and ESG practices through market feedback mechanisms. However, there are also some critical perspectives suggesting that investor attention can lead to the receipt of damage to ESG performance, as a high level of investor attention to firms' performance may undermine subsequent potential investments and affect firms' access to capital and resources (Xue et al., 2023).

In conclusion, research conducted in the past has demonstrated that investor concern, as a moderating or autonomous variable, can have a limited impact on ESG performance and climate risk disclosure. Not only does a high level of investor concern encourage firms to be more proactive in their disclosure of climate risk, but it also enhances the impact of this disclosure on the ESG performance of firms through market and capital market responses. This suggests that under the investor perspective, firms' climate risk disclosure strategies and ESG performance are not only influenced by internal management and external policies, but also driven to a large extent by investment market dynamics and investor expectations.

2.11 Chapter summary

The literature review in this chapter deeply investigates the intricate relationship between corporate ESG performance and climate risk disclosure, and how the three moderating variables of media attention, government intervention and investor attention affect this relationship from different perspectives. Initially, climate risk disclosure is a critical component of corporate information transparency that not only demonstrates companies' dedication to environmental responsibility, but also serves as

a bridge for companies to communicate with stakeholders. By proactively disclosing climate risk information, companies are able to build trust among stakeholders, which in turn may improve their ESG performance.

However, this relationship is not static. Media attention can significantly improve the visibility of corporate climate risk disclosure, and then affect the public and investors' perception of corporate ESG performance. At the same time, government intervention provides a framework and guidance for climate risk disclosure by formulating relevant policies and standards, and promotes firms to take more active measures in ESG aspects. In addition, investor attention reflects the market's evaluation of corporate ESG performance, driving companies to continuously improve their climate risk disclosure quality and ESG performance.

The role of these moderating variables reveals a more dynamic and multivariate perspective, indicating that the connection between climate risk disclosure and ESG performance is influenced and moderated by multiple external factors. In addition, by analyzing the three important perspectives of media, government and investors, This literature review not only establishes a comprehensive theoretical framework for comprehending the effects of climate risk disclosure, but also points out the directions that future research can further explore, such as filling the research gap and exploring new perspectives. With this review, the objective of this chapter is to establish a comprehensive and multidimensional theoretical framework for the examination of the relationship between climate risk disclosure and ESG performance. This framework will serve as a blueprint for future research and practice.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, the theoretical framework is summarized at first, and the research hypothesis of this study is put forward in combination with the literature review part in the second chapter. In order to verify the research hypothesis proposed in this study and answer the research questions of this study, this chapter expounds the research methodology in detail. This chapter also includes the following contents: (1) Research methods and design; (2) Explain sample selection and data source; (3) Explanations and definitions of variables in research methods; (4) Build a model.

3.2 Research Framework

This is shown in Figure 3.1 Theoretical Framework. The research framework of this study focuses on the relationship between climate risk disclosure (CRD) and ESG performance and further analyzes how stakeholder engagement plays a moderating role in this relationship. Combining the signaling theory and stakeholder theory in Chapter 2, this study chooses media attention, government intervention level and investor attention as proxy variables to reveal how these external factors affect companies' CRD and ultimately their ESG performance.

First, CRD is the process by which firms disclose to outsiders their strategies and actions to address climate change risks (Elijido-Ten & Clarkson, 2019). Through this disclosure, firms not only increase information transparency but also demonstrate their commitment to social responsibility (Amar et al., 2022). Therefore, firms that actively

engage in climate risk disclosure should theoretically be able to better manage climate-related risks and thus perform better in terms of ESG performance. However, there is also a critical view from some studies, which argue that climate risk disclosure consumes funds and resources (Harmes, 2011), undermines ESG performance, and undermines investor confidence in the climate risk content presented in climate risk disclosures (Solomon et al., 2011), which can lead to a reduction of investor investment and thus jeopardize the funds obtained by the firm itself, negatively affecting ESG performance.

Stakeholder engagement may play an important moderating role in the relationship between climate risk disclosure and ESG performance. In this study, media, government and investors are selected as key stakeholders and their roles are explored separately. As a major information disseminator, the media's attention to and coverage of climate risk disclosure can enhance a firm's social image and market recognition; therefore, high media attention may strengthen the positive impact of climate risk disclosure on ESG performance. The government guides and restrains corporate behavior through policies and regulations, and government intervention may significantly affect ESG performance through mandatory requirements or incentives that lead to better corporate climate risk disclosure behavior. As an important force in the capital market, investors' attention directly affects the decision-making process of firms. Investors value the sustainability performance of firms, so their attention to climate risk disclosure can further drive firms to improve their ESG performance.

Overall, the framework of this study integrates signaling theory and stakeholder theory, and by analyzing the relationship between climate risk disclosure and ESG performance

as well as the moderating role of stakeholders, it attempts to comprehensively reveal the behavioral patterns of firms in dealing with climate risk and the influence of external factors. The framework not only helps readers understand the impact of climate risk disclosure on ESG performance, but also reveals how the media, government, and investors influence this relationship through their involvement. With such a research framework, this study provides a better theoretical foundation and empirical evidence for business managers and policy makers to help companies better meet the expectations of all stakeholders while realizing sustainable development goals.

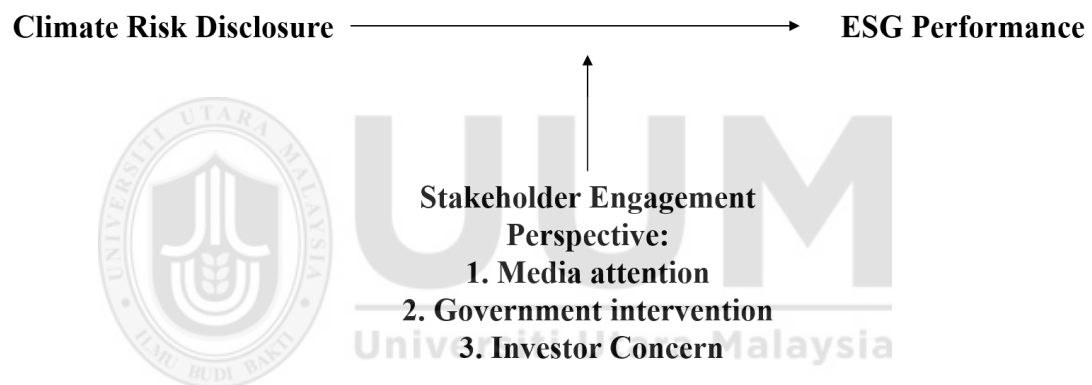


Figure 3.1
Theoretical framework
 Source: Draw by author

3.3 Hypotheses Development

3.3.1 Climate Risk Disclosure and ESGP

Through legitimacy theory, an organization can acquire and retain legitimacy for its operations through the need to uphold standards and principles that are already existing in the social surroundings where the organization operates (Luft Mobus, 2005). According to the definition of Suchman (1995), it is clear that validity is taken by the behavior of an entity under the background of norms, values, and beliefs in social

construction. This therefore implies that for the purpose of acquiring and retaining legitimacy, the behavior of companies must be done according to the expectations and values of society (Ieng Chu et al., 2012; Pellegrino & Lodhia, 2012). Legitimacy theory puts forward that companies operating under implicit or explicit social contracts must reflect social culture and values (Deegan, 2006; Dias Filho, 2012; O'donovan, 2002).

Climate change has become one of the most serious issues of global concern, and society has high expectations for the environmental behavior of companies, especially in the way they manage climate risks. Legitimacy theory underlines that for companies to live and develop in society, they need to gain legitimacy from their behavior, which means that most stakeholders and society are in support of these behaviors (Crossley et al., 2021). The information on climate risk that companies should publicize is a message that the business has captured the challenges under consideration from climate change and that it has developed solutions to tackle the risks. The solutions to be publicized could be through adaptation and mitigation methods or through emission reduction targets. Such disclosure behavior reveals the adaptation of the firm to the social expectations, in particular, about sustainable development and the environment, in order to receive or increase its legitimacy (Nasi et al., 1997; O'Donovan, 1999).

Transparency and trust between corporations and their stakeholders would also be built, given that information on climate risk disclosure provide the manner of how corporations identify, assess, and respond to climate change-related risks (Zitti & Guttormsen, 2023). It should be noted that such trust supported the building and sustaining of social legitimacy. Companies disclosing their climate risks proactively are more socially and environmentally responsible in the eyes of stakeholders, which

results in the formation of a favorable public image and hence increases social legitimacy of these companies (Li et al., 2023). Also, since there is a rising public, governmental, and market expectation for environmental protection as a global concern, at least the climate risk management of corporations can be tackled using climate risk disclosure means to respond to such external expectations and accordingly gain social acceptance and social support within the society at large (Lee et al., 2023). Companies revealing actively the risks related to climate changes demonstrate an environment-friendly attitude that is in line with the modern expectations of society in terms of the sustainable development and making efforts to protect the environment, thus increasing their legitimacy among the public (Galeone et al., 2023).

Climate risk disclosure directly incentivizes corporations to be attentive to and manage their environmental impact, such as reducing greenhouse gas emissions and enhancing energy efficiency, thereby directly challenging their environmental performance (Kim et al., 2023). On the social side, being transparent and proactive on climate change issues can encourage better employee engagement and community relations, leading to better performance on social responsibility (Li et al., 2023). Effective management of climate risk needs to be inducted with an infusion of climate-related decisions into the governance structure, such as the creation of a dedicated climate change committee or infusion into the risk management system, thereby enhancing the overall level of governance (Thistlethwaite, 2015). Enhanced legitimacy that promotes corporate performance on ESG reflects active management and response to ESG issues.

Companies not only demonstrate their commitment to environmental responsibility to stakeholders by exposing climate risks, but they also demonstrate their attention to ESG

duties because of this. This positive behavior, aligned with societal values, can promote improvements in corporate ESG performance. Corporations with high ESG performance are often more able to gain the trust and support of stakeholders and are more likely to access funding and market opportunities (Alsayegh et al., 2020; Henisz et al., 2019).

Therefore, it establishes the fact that a positive image and social acceptability is what ensures that a business thrives and exists in the long run, thus support under the legitimacy theory framework. The most drastic climate changes witnessed on the globe support the necessity and role of corporate reporting of climate risks in increasing their social legitimacy, considering also that they directly and indirectly improve their ESG performances by being open about their operations, ecological sensitivity, and governance structure enhancement. The effectiveness, in this case, is not just in positive influences on the environment but in their performances in the social and governance fronts, which means that the weight and thus influence of the 'disclosure of the climate risk' referred to under the given condition, is immense. Such an effectiveness is measured by positive influences on the environment.

However, within the framework of legitimacy theory, although climate risk disclosure is widely regarded as an important means to enhance corporate ESG performance, in certain circumstances, it might also negatively affect corporate ESG performance. This negative impact is primarily manifested in two aspects: the pressure brought by disclosure and the inauthenticity of information, including the existence of greenwashing.

Firstly, while CRD can help corporations establish legitimacy among their stakeholders, this process might also bring significant pressure to the corporations (Qing, 2022). To meet external demands for transparency and accountability, corporations may need to invest considerable resources in monitoring, reporting, and improving their environmental impact (Hess, 2019; Lyon et al., 2018). Moreover, climate risk disclosure will occupy resources and costs of firms, which will damage firm value to some extent (Mahmudah et al., 2023). This increased burden could distract corporations from their core business, especially in situations of limited resources, potentially diminishing their overall performance in ESG aspects.

CRD will also cause negative feedback on stock prices. Some studies have found that the more climate risk disclosure, the greater the abnormal trading volume of stocks (Britten & Cheng, 2023), which also indicates that climate risk disclosure will reduce investors' interest and thus narrow the channels for firms to obtain capital. It is not conducive to the company to obtain resources and costs to carry out ESG performance.

Secondly, the inauthenticity of information, especially greenwashing, is another reason why climate risk disclosure might have a negative impact. Greenwashing, the act of corporations exaggerating their environmentally friendly behaviors, could mislead stakeholders, particularly investors seeking to invest in corporations with good social responsibility performance (In & Schumacher, 2021). When such untruthful information is unveiled, a corporation's reputation might suffer, thereby affecting its ESG performance (Xue et al., 2023). Moreover, an excessive focus on shaping an external image while neglecting the implementation of actual environmental protection

and social responsibility measures could further reduce a corporation's ESG performance.

Based on the above discussion, although climate risk disclosure is theoretically considered an effective means to enhance corporate ESG performance, in practice, due to the pressure from disclosure and issues of information inauthenticity, particularly greenwashing, climate risk disclosure might also negatively impact corporate ESG performance.

It can be seen that, combined with the theoretical derivation and logical chain analysis in this section, the relationship between climate risk disclosure and ESG performance may not be a simple linear relationship such as positive or negative impact, but may have further non-linear relationships. relation. Based on this uncertainty, this study first deduced the hypothesis that climate risk disclosure has a positive impact on ESG performance, that is, when companies disclose climate risk information, they can improve their ESG performance by enhancing transparency and trust. However, some studies have shown that climate risk disclosure may have a negative impact on ESG performance because companies may increase disclosure costs or face higher regulatory pressure, resulting in a decline in their ESG performance.

In view of the above two completely different directions of influence, it is further speculated that there may be a non-linear relationship between climate risk disclosure and ESG performance. Specifically, this nonlinear relationship may appear as a U-shape or an inverted U-shape. In a U-shaped relationship, as performance levels

increase, ESG performance may first decrease and then increase; in an inverted U-shaped relationship, ESG performance may first increase and then decrease.

Based on this, this study proposes the following hypotheses:

H_{1a}: *There is a U-shaped relationship between climate risk disclosure and ESG performance.*

H_{1b}: *There is a inverted U-shaped relationship between climate risk disclosure and ESG performance.*

3.3.2 Perspectives of Stakeholder engagement

Climate risk disclosure and ESG performance originate from the disclosure actions made by corporations. Thus, the extent to which corporate climate risk disclosure impacts ESG performance may be related to the different stakeholder engagement a corporation faces. The reactions of stakeholder engagement not only determine the effectiveness of the disclosure but also influence corporate strategic decisions and behaviors (Allon & Bassamboo, 2011; Granados et al., 2010). This study looks through the perspectives of stakeholder engagement in the integrated framework of legitimacy, signaling, and stakeholder theories that are associated with the relevance of climate risk disclosure to the ESG performance of a firm. This is where the discussion of the three main types of stakeholder engagement—media, government, and investors—comes under an integrated theoretical framework.

This integrated theoretical framework emphasizes the perspectives of stakeholder engagements, such as media, government, and investors. It provides a more comprehensive theoretical basis for the analysis of the impact of corporate climate risk disclosure on corporate ESG performance. For the three main receivers of the news, which include media, government, and investors, respectively, here is the discussion under the aegis of this holistic theoretical framework.

Signaling theory postulates that the sender of information (corporations) communicates information about attributes or actions not directly observable to external recipients through signals (Barker et al., 2019). These signals allow the recipients to make better-informed decisions. As a signal, climate risk disclosure demonstrates the corporation's commitment and transparency in climate change mitigation measures to the market and society (Ismail & Obiedallah, 2023). Corporations inform the public about their positive stance on ESG performance improvement by disclosing carbon emissions information, especially high carbon-emitting companies that fulfill their social responsibility by raising the level of climate-related information disclosure to legitimize potential unethical behaviors and meet social pressure from stakeholder demands (Ding et al., 2023).

The concept of stakeholders underlines that a corporation may survive if the control of its most important relationships is provided and the expectations of these groups are fulfilled (Freeman & Phillips, 2002). According to the theory, corporate climate risk disclosure is viewed as one of the tools to meet the specific stakeholders' information needs, fostering relationships based on trust and legitimacy, raising ESG performance.

Climate risk disclosure by corporations is strategic action to gain legitimacy by showing commitment to environmental responsibility to stakeholders. On this basis, it could be further discussed how corporations communicate to different kinds of stakeholder engagement through climate risk disclosure and how such information would further support corporations to gain more or enhanced legitimacy by combining signaling theory with stakeholder theory.

3.3.2.1 Media: Transmission and Amplification of Signals

The media does not only act as a disseminator of information but also as a stimulus of signals of legitimacy (Tsfati et al., 2020). Since signaling theory proposes corporate climate risk disclosure as a signal activity in the conveying process of the realization of the firm towards climate change challenges and responses to the media and the public (Farbotko, 2019), Stakeholder theory further emphasizes that the media, as a key stakeholder, can influence the relationship between corporations and other stakeholders through reporting and commentary (Manetti & Bellucci, 2016; Wang & Huang, 2018), thereby affecting corporate legitimacy. Therefore, when engaging in climate risk disclosure, corporations need to pay attention to the role and influence of the media to ensure their information is positively transmitted and amplified, enhancing their social legitimacy.

The level of attention of the media to climate risk disclosure is beneficial to corporations for building an environmental profile and legitimating the corporation in question. In point, such disclosure boosts the environmental image and legitimation of the corporation in point by demonstrating its responsiveness to challenges associated with environmental protection and climate change (Kim et al., 2023). When media pay

more attention to corporate climate risk disclosure, such information will reach a larger population; hence, the effectiveness of the original signal will, therefore, be greatly increased. Media attention will raise public knowledge on corporate climate actions, hence raising the social visibility and legitimacy of the corporation (Li, 2023).

High media attention turns the disclosure of climate risk by corporates from an information transmission act into an effective social interaction process (Wu et al., 2022). The interaction can help create positive relationships of corporations with the public, and this, in turn, may impact corporate ESG performance. Under these conditions, high attention can bring about further positive action by corporations in the area of environmental management and sustainable development in order to gain approval from society and legitimize corporations.

As corporations effectively interact with the public and media using climate risk disclosure that increases their environmental responsibility actions under media scrutiny, ESG performance through Du et al. (2016) improves further, which in turn boosts the corporate market competence and social image in a cycle.

In this regard, media attention changes the dynamics of climate risk disclosure to people and their ESG performance. This chain of events shows the central role of media attention to increase the potential of companies disclosing climate risk to call for better ESG performance. Corporations should realize the importance of media attention in order to use the media platforms in the interest of raising quality and greater impact of climate risk disclosure that ultimately leads to better ESG performance, therefore reinforcing their legitimacy.

Based on this, the study proposes hypothesis:

H₂: Media attention can moderate the relationship between climate risk disclosure and ESG performance.

3.3.2.2 Government: Policy Makers and Norm Setters

As policy makers and norm setters, governments have a special interest in corporate climate risk disclosure. From the perspective of signaling theory, corporations demonstrate their environmental governance and efforts to adapt to climate change through climate risk disclosure, a process of sending legitimacy signals to the government (Elliott et al., 2023). According to stakeholder theory, the government, as a major external stakeholder, plays a crucial role in a corporation's acquisition of social legitimacy through its evaluation and response to corporate actions (Dart, 2004). In other words, to gain government approval and support, a corporation has to prove the behaviors shown through climate risk disclosure are in line with or above current environmental regulations, which will be conducive to its legitimacy.

Further, making public this climate risk information would be a way for corporations to communicate positive signals of their recognition and reaction towards climate change; they are responsible to the environment and are sustainable in the provision of goods and services to the government and the general public (Lemma et al., 2019). Governments reduce these measures in moving toward more proactive climate risk and sustainable development through providing the corporations with subsidies or other financial incentives in implementing climate risk management and sustainable development measures (Park et al., 2021). These subsidies target reducing the economic costs in implementing such measures and increasing the willingness and ability of the

corporations in taking on more positive acts toward the environment (Dean & McMullen, 2007).

The involvement of governance will, in turn, lead to higher climate risk disclosure by corporations, since these could become some sort of conditions or bonus points in securing subsidy eligibility. Furthermore, subsidies increase resources available for corporations in which to invest in furthering their ESG performance and, therefore, also enhance their implementation of climate change strategies by being more effective in greenhouse gas emission reduction, use of renewable energy, and attaining resource efficiency. Corporations will not only be more active in disclosing information on climate risk but also raise substantially their ESG performance indicators due to intervention by the government that may moderate the stance of more resources and better motivation to take action to ensure sustainable development (Zhang et al., 2023). Climate risk disclosure allows effective corporate legitimacy enhancement under government stimulation and public inspection. The further enhanced legitimacy contributes more to social support and market opportunities, thus making companies able to survive and develop in a persistent way.

The very involvement of the government is one external factor that significantly moderates the possibilities of disclosures between climate risks and corporate ESG performance. The government does not only offer economic incentives but also provides it with resources and support, material, and intellectual, so the development of higher ESG performance is possible. It is this process that not only assists a corporation in performing well on environmental and social fronts, but an activity-based way of ensuring legitimacy and potential performance in the societal environment.

Based on this, the study proposes hypothesis:

H₃: Government intervention can moderate the relationship between climate risk disclosure and ESG performance.

3.3.2.3 Investors: Participants in the Capital Market

Investor attention plays a critical role in moderating the relationship between corporate information disclosure behavior and ESG performance. This attention influences the efficiency and scope of corporate information dissemination, as well as exerts a supervisory and motivational effect on corporate behavior. Continuous investor scrutiny can drive corporations towards greater transparency and accessibility of information, thus acting as a bridge and catalyst between corporate information disclosure behaviors and ESG performance.

Climate risk disclosure provides essential information for investors to assess a corporation's environmental risk management and sustainable development capabilities. Signaling theory explains how corporations send positive signals to investors through climate risk disclosure, indicating their proactive response to climate change and proficient ESG management (Farbotko, 2019). According to stakeholder theory, investors, as significant stakeholders of the corporation (Wang & Cheng, 2023), , , directly influence corporate capital acquisition and costs with their evaluations and investment decisions. Through effective climate risk disclosure, corporations can meet investors' demands for transparency and accountability (Wong et al., 2021), enhancing their attractiveness to investors and thereby improving their legitimacy in the capital market.

For example, investor interest can enhance both the quality and quantity of information disclosed by corporations (Abramova et al., 2020). When businesses recognize that investors are particularly interested in ESG and climate concerns, they are more inclined to proactively disclose more relevant information to fulfill investors' requirements and expectations. This approach encourages the dissemination of information and transparency, enabling investors to make more informed decisions about their investments.

Investor concern also serves a supervisory role regarding corporate ESG performance (Arvidsson & Dumay, 2022). Investors not only focus on corporate financial performance but are increasingly concerned with corporate social responsibility and environmental performance. This attention encourages corporations to pay more attention to their performance in environmental protection, social responsibility, and good governance, as these factors are directly related to their ability to attract and retain investor interest and capital.

Furthermore, investor concern can moderate the relationship between information disclosure and ESG performance by enhancing or altering the dynamics between the two. For instance, high investor concern about specific ESG issues may compel corporations to provide more information in these areas (Hazen, 2020) and take concrete actions to improve their performance, thereby moderating the impact of information disclosure on ESG performance to some extent.

In summary, as a moderating variable, investor concern plays a significant role between corporate climate risk disclosure behavior and ESG performance. Investor concern

significantly impacts the long-term development and sustainability performance of organizations through the promotion of information transparency, the enhancement of corporate social responsibility, and the modification of interaction patterns between corporations and investors. Although the specific impact of investor concern may vary depending on the circumstances, it generally moderates the relationship between information disclosure and ESG performance.

Based on this, the study proposes hypothesis:

H4: Investor concern can moderate the relationship between climate risk disclosure and ESG performance.

Table 3.1
Sample Processing Process

Hyphothesis No.	Type	Content
H _{1a}	Main effect	There is a U-shaped relationship between Climate Risk Disclosure and ESG performance.
H _{1b}	Main effect	There is a inverted U-shaped relationship between Climate Risk Disclosure and ESG performance.
H ₂	Moderating effect	Media Attention can moderate the relationship between Climate Risk Disclosure and ESG performance.
H ₃	Moderating effect	Government Intervention can moderate the relationship between Climate Risk Disclosure and ESG performance.
H ₄	Moderating effect	Investor Concern can moderate the relationship between Climate Risk Disclosure and ESG performance.

3.4 Research Design

The purpose of this study is to explore the impact of climate risk disclosure on ESG performance of companies, and further analyze how factors enhance or weaken this impact. To accomplish this objective, the hypothesis is put to the test through the utilization of a multiple linear regression model in this study. And uses machine learning word frequency algorithm in variable construction. The core hypothesis of this study is based on the theory that climate risk disclosure has an impact on firm ESG performance. At the same time, studying different perspectives of stakeholder engagement plays a moderating role in this influence. Multiple linear regression model is selected as the main statistical tool to quantify the impact of climate risk disclosure on ESG performance of companies and the role of internal and external factors. The next part will focus on sample selection and data sources, the definition of each variable, and the model construction of this study.

3.5 Sample Selection and Data Source

The sample companies in this study are selected from the companies listed on China A-share main board from 2011 to 2022. These A-share listed companies are a good research group in this study for the following reasons. First of all, these companies are large in scale and mature in operation, because they can be listed on the A-share main board, which can study China companies in a unified environment. Secondly, the companies selected in this study are all listed and disclosed in China, and these listed companies are using the accounting standards for business companies of listed companies in China for data disclosure according to the requirements of CSRC. Third, companies listed on the domestic A-share main board have stronger strength, more

stable operation, more disclosure data and more disclosure reports, which can clearly divide the types of companies and collect more data.

Finally, the time span of this study is 2011-2022, and the time span is 12 years, which can ensure the aging stability of the study and have stable data during these 12 years. At the same time, choosing a ten-year time span is due to the consideration of long-term data stability and analysis depth. A ten-year time span can fully capture the dynamic changes of the long-term trend between climate risk disclosure and ESG performance, which is very important to reveal the true relationship between them. Long-term data helps to smooth the influence of short-term fluctuations or outliers, thus enhancing the stability and reliability of research results. In addition, this period is enough to cover multiple economic cycles and changes in the policy environment, so that the research can reflect the correlation under different macro backgrounds. At the same time, the strategy and response of companies to climate change is usually a gradual evolution process, and a longer time span can more effectively reveal the strategy adjustment and behavior evolution of companies in climate risk disclosure and ESG practice. Finally, a longer time span provides more data points, which provides stronger support for statistical analysis and increases the statistical significance and credibility of the research conclusions. The goal of this study is to correctly evaluate and understand the long-term effects of climate risk disclosure on ESG performance of companies. To do this, a ten-year time frame was chosen. To sum up, the research data used in this study came from companies that were traded on the China A-share main board between 2011 and 2022.

At the same time, in order to ensure the reliability and credibility of the data, this study adopts the following sample selection procedures: (1) Exclude financial listed companies because they have industry particularity; (2) Exclude companies with Special treatment (that is, listed companies with ST and *ST marks in the company logo), because these companies may have certain abnormal financial conditions, resulting in the risk of delisting, so the CSRC issued delisting risk warning (*ST) and other risk warnings (ST) for such companies (Jiang et al., 2021); (3) Excluding the data of IPO of listed companies in the current year, because there may be some artificial data manipulation problems such as earnings manipulation; (4) Excluding listed companies with incomplete financial data. According to the above standards, 11,165 annual observations of 1,403 listed companies are finally obtained in this study. The specific sample processing process is shown in Table 1.

As shown in Table 3.2 below, 24,729 companies were excluded from the sample, mainly because these companies lacked ESG rating data in the Bloomberg database. The ESG score in the Bloomberg database is a key indicator for measuring corporate ESG performance in this study. Therefore, only companies with complete ESG rating data can be included in the final research sample. This screening is to ensure the integrity and consistency of the research data. If some companies lack this part of the data, including these companies may lead to bias or distortion in the analysis results, so they are chosen to be excluded.

In addition, in order to make the research more comparable, the companies in the sample need to have the same data standards. Ensuring that all companies have complete ESG scores will help to make fair horizontal comparisons between different

companies, thereby improving the reliability of the research conclusions. By excluding these companies that lack ESG rating data, the research can maintain the consistency of the analysis standards and ensure the robustness and credibility of the results. Therefore, excluding these companies is an important step to ensure the scientific nature of the research.

At the same time, in the sample link where CRD is missing, this study excluded 3,965 samples. This is because the sample companies did not provide complete management discussion and analysis (MD&A) documents during the data period. The climate risk disclosure measurement in this article comes from the MD&A report. Therefore, the inability of companies to provide complete MD&A reports means that the reliability of climate risk disclosure measurement cannot be constructed. However, the number of these 3,965 companies is relatively small compared to the entire sample, indicating that most companies recognize the importance of climate risk disclosure and disclose it in MD&A. Therefore, the exclusion of these companies will not significantly affect the overall results of the study, but it will help ensure that all companies in the sample provide sufficient information, thereby improving the accuracy and reliability of the analysis.

Table 3.2
Sample Processing Process

Sample Processing Process	Deletes the sample size	Remaining sample size.
Original sample	-	43813
Excluding the samples of delisting, ST and ST* in that year	2486	41327
Excluding the observed values of financial and insurance companies	956	40371
Eliminate the missing samples of climate risk disclosure	3965	36406
Eliminate the missing samples of ESG rating data	24729	11677
Reject samples with missing control variables	445	11232

Sample Processing Process	Deletes the sample size	Remaining sample size.
Samples with missing data on stakeholder participants were eliminated	67	11165

3.6 Variable Measurement

In the third chapter, the variable measurement part, this study carefully designed a set of methods to accurately measure climate risk disclosure, corporate environment, social and governance (ESG) performance, and the internal and external regulatory factors that affect the relationship between them. The accuracy of such measures is of great purpose in understanding and explaining how the disclosure of climate risk has its impacts on ESG performance of companies. This part details the explanation of those variables that might moderates the relation between the independent and dependent variables; it is not only focused on the precise definition and measurement of the independent and dependent variables.

Based on this background, the paper will seek to demonstrate how current techniques for data analysis, and in particular machine learning methods, are used for the synthesis and analysis of a big array of quantitative information. This section also discusses the ways of effective identification and measurement of such regulatory variables, since today climate risk management is greatly influenced by internal and external factors. This guarantees, on the whole, coherence and efficiency of the research methods and provides a strong base for the in-depth understanding of mechanisms relating to climate risk disclosure and affecting performance in firm emissions.

3.6.1 Dependent Variable -ESG Performance (ESGP)

In this study, firms' ESG performance (ESGP) is selected as the main dependent variable. The data for ESGP is derived from the ESG rating report of Bloomberg Reuters, a third-party rating agency, and the Bloomberg ESG Disclosure Performance Ranking, a rating created by Bloomberg Terminal based on the level of ESG disclosure of listed businesses; this rating carries the importance of being a significant capital market weathervane. More studies have used this rating to quantify companies' ESG performance (Egginton & McBrayer, 2019; Fahad & Rahman, 2020; Gutsche, Schulz, & Gratwohl, 2017; Z. Wang, Hsieh, & Sarkis, 2018). The Bloomberg database is internationally recognized as an authoritative source of comprehensive and detailed company ESG data and scores. The database's ESG scores reflect corporate performance in environmental protection, social responsibility, and good governance, and are important indicators for assessing corporate sustainability and social responsibility practices.

Past literature has different choices in the selection of metrics for ESG performance. Some studies have adopted the ESG scores provided by MSCI (Morgan Stanley Capital International) for their ESG performance metrics (Giese et al., 2019; Haijun et al., 2023), and MSCI's ESG scores have been widely used in studies of world samples, but since MSCI scores rely more on reports and published data provided by the companies themselves, it may lead to biased and inaccurate information (Berg et al., 2022). In addition, the MSCI scoring system has not yet been able to provide transparent and complete evaluation criteria, thus making the data opaque and difficult for external researchers to verify the authenticity of this data.

In addition, some studies have used Refinitiv's ESG scores in measuring ESG performance (Apergis et al., 2022; Dobrick et al., 2023). Refinitiv is a global rating system that provides more than 400 ESG metrics to measure firms' ESG performance; however, Refinitiv's scoring data contains different weighting settings (Sahin et al., 2023), which affect the final ESG scores and lead to a deviation.

Considering the nature of Chinese firms, China has its own rating agency metrics, and Hexun.com, as one of the largest ESG rating agencies in China, has also been used by more researchers who have studied China in the past (He et al., 2023; Steurer et al., 2024). However, the ESG rating system of Hexun.com is relatively closed, without public scoring standards and lack of transparent timely and instructions, external researchers can not understand the specific calculation process and weight allocation based on Hexun.com's ratings, not only that, Hexun.com's ESG ratings are relatively backward in updating, and in the changing environment of the international market, the data is more backward not able to respond to the real ESG performance of firms.

There are also some studies that have used questionnaires to interview corporate executives to obtain ESG data (Khamisu et al., 2024; Syed, 2017). However, this type of questionnaire interview has a large degree of subjectivity, and the level of ESG performance depends more on the subjective judgment of those interviewed/participating in the questionnaire, which makes it more difficult to truly reflect the ESG performance of the company.

ESG ratings focus on environmental (E), social (S), and corporate governance (G), which are invisible indicators that traditional evaluation systems do not pay attention to, and can comprehensively assess the sustainability of a company's operations with a high degree of objectivity, and ESG databases are considered to be the most comprehensive databases for evaluating a company's ESG activities and results (Marquis et al., 2011). The Bloomberg database quantifies a company's ESG performance based on the E aspects, S aspects, and G aspects of fulfilling social responsibility, respectively. Not only that, it also subdivided the quantitative indicators according to each aspect, with a total of 122 points of quantitative indicators, which can make a more objective and detailed evaluation of the ESG performance of firms. Therefore, based on the above mentioned in the past studies related to ESG performance, the

Bloomberg ESG scores are chosen for this study, this is because the Bloomberg database is meticulously analyzed every year and the 122-point two-family indicators are meticulously analyzed. Not only that, the ESG rating data of Bloomberg database does not single out the reports provided by the companies themselves but covers a variety of public information, company data and third-party data, which avoids subjectivity and bias and makes Bloomberg's ESG database able to provide comprehensive and authoritative ESG data indicators. Second, Bloomberg's database provides long-term historical data, which enables detailed analysis of historical data spanning many years to analyze the long-term impact of a particular behavior on corporate behavior. In summary, this study chooses the ESG scores from the Bloomberg database as a measure of ESG performance, which ensures the reliability of the data selection and the generalizability of the findings in this study. By utilizing the

ESG scores from the Bloomberg database, the analysis in this study will be based on a solid data foundation, providing reliable support for an in-depth understanding of the impact of climate risk disclosure on corporate ESG performance.

This article provides a detailed analysis of industry averages in ESG performance. From the data in Table 3.4, it can be seen that there are significant differences in the performance of various industries in the dimensions of ESGP, environment (E), society (S) and governance (G). These differences reflect the varying focus and degree of implementation of the SDGs across industries.

First, in terms of ESGP, the scientific research and technical services industry (32.484) performs most prominently, indicating that this industry has high standards and requirements in terms of sustainable development. Compared with other industries, the scientific research and technical service industries have advantages in innovation due to their own industry advantages (Yang et al., 2009), so they may pay more attention to the application of innovation and technology to improve their environmental and social responsibility performance. This industry's high score may also be influenced by its high governance standards (mean value=69.723), as good corporate governance structures tend to help companies perform well in other dimensions.

The total ESG score of the electricity, heat, gas and water production and supply industry (D) is also high (30.383), especially in the governance dimension (mean value =66.353). Due to its extensive impact on the environment and society, this industry usually faces high regulatory pressure and social expectations, so it needs to maintain high standards in all aspects, especially in governance, which is why the industry has a

strong reputation in the environment (mean value =9.976) and social (mean value =14.819) dimensions.

The transportation, warehousing and postal industry (G) performs relatively well in the environmental dimension (mean value=11.129) and governance dimension (mean value=69.629). The transportation industry requires more efforts in environmental management due to its greater impact on the environment, and a high governance score indicates that the industry has stricter standards in management and supervision.

On the other hand, the education industry (P) has a relatively low overall ESG score (19.470), especially in the lack of data or poor performance in the E and G dimensions. This may reflect the industry's relatively low focus on environmental protection and governance structures, or the lack of external pressures it faces. Therefore, the industry may need to further strengthen its management of these dimensions.

The health and social work industry (Q) performs most prominently in the social dimension (mean value=27.877). This is to be expected because the industry is directly involved with public health and social welfare, and social responsibility is one of its core tasks. However, relatively weak performance in environment (mean value=5.713) and governance (mean value=52.574) suggests that the industry may need to strengthen management in these areas.

To sum up, the differences in ESG performance between different industries reflect the different priorities of each industry in responding to sustainable development challenges. Some industries perform well on ESG dimensions due to the nature of their

business and external pressures, while others may require more improvements in specific dimensions. By further analyzing these differences, companies and policymakers can better understand the needs and challenges of various industries and develop more targeted sustainable development strategies.



Table 3.3
ESG Performance Industry Comparison Table

Industry Code	Industry Name	Mean Value			
		ESGP	E	S	G
P	P-Education	38.107	27.877	16.513	69.807
Q	Q-Health and Social Work	33.067	12.742	17.927	68.401
M	M-Scientific Research and Technical Services	32.484	11.947	16.732	69.723
G	G-Transportation, Warehousing, and Postal Services	32.017	11.129	15.48	69.629
N	N-Water Conservancy, Environment and Public Facilities Management	30.633	11.335	14.855	65.721
D	D-Electricity, Heat, Gas and Water Production and Supply	30.383	9.976	14.819	66.353
B	B-Mining Industry	30.368	12.568	14.182	64.445
C	C-Manufacturing Industry	30.05	11.216	14.446	65.121
E	E-Construction Industry	29.407	8.192	15.407	65.431
L	L-Leasing and Business Services	28.939	6.255	13.267	67.424
I	I-Information Transmission, Software and IT Services	27.868	5.105	13.023	65.95
H	H-Accommodation and Catering Industry	27.811	5.374	12.526	65.395
F	F-Wholesale and Retail Trade	27.785	5.973	13.926	63.849
K	K-Real Estate Industry	27.701	5.319	12.086	65.578
R	R-Culture, Sports, and Entertainment	26.88	4.909	11.011	64.736
A	A-Agriculture, Forestry, Animal Husbandry, and Fishery	26.809	5.896	11.943	62.637
S	S-Comprehensive Industry	25.098	4.634	9.908	60.766
O	O-Resident Services, Repairs, and Other Services	19.47	-	5.713	52.574

3.6.2 Independent Variable-Climate risk disclosure

In this study, climate risk disclosure (CRD) was selected as a key independent variable. Although the Working Group on Climate-related Financial Information Disclosure (TCFD) of the Financial Stability Board put forward the framework of climate information disclosure as early as 2017, China has not implemented it as a mandatory standard at present (Ngo et al., 2023). Therefore, companies in China generally lack information in climate risk disclosure.

In the past research, the word frequency of earnings conference call records of listed companies was used to measure the disclosure of climate risk at the firm level (Li et al., 2020; Sautner et al., 2023; Vestrelli et al., 2024), however, the differences in expression and composition between English and Chinese can't express the accuracy of climate risk disclosure of China companies, and the existing capital market environment in China can't be applied to telephone earnings conference for text analysis. There are also a large number of studies that use carbon disclosure information as a measure of climate risk disclosure (Kouloukoui et al., 2023; Trinh, 2023), however, only using carbon to disclose information has certain singularity and incompleteness. Therefore, based on a series of problems of climate risk disclosure measurement, this study adopts a word frequency analysis method based on machine learning (Du et al., 2023), and uses Python to measure climate risk disclosure variables.

MD&A documents are chosen to be subjected to word frequency text analysis in this study because they are considered comprehensive and standardized in features of corporate information disclosure. The MD&A, as part of the corporate financial report, provides background data to understand the financing conditions, operating results, and

future development of a corporation. The basic reason this study chose to analyze the disclosure of the climate risk through word frequency text analysis of the MD&A documents is several cardinal points. First, the MD&A documents offer a means through which management makes a direct exposition about the risks and opportunities faced by the corporation, including the potential impacts of climate change on corporate operations and financial performance, and hence are suitable for analyzing how the corporations identify, assess, and respond to climate risk. As pointed out by Li (2019), making MD&A an ideal resource for analyzing how corporations identify, assess, and respond to climate risks. Secondly, the information in MD&A is prepared and reviewed by corporate management (Cho & Muslu, 2021), thus providing a more reliable and authoritative source of information compared to other informal corporate communications. In addition, by subjecting the MD&A documents to word frequency text analysis, the researchers could know the concentration the reports devoted by the corporations over time, thus offering an objective index for evaluating the corporate performance in environmental sustainability. These documents are a great reserve in literature research on climate risk disclosure because of their wide breath, management perspective, and the reliability of the information.

At the same time, the format and content of MD&A documents are subject to rigorous regulatory standards, which enable consistent and comparable information to be provided, thereby representing a prerequisite for comparisons between companies and across different sectors. Such standardization helps not only maintain the consistency of the analysis but also in extracting and comparing data available in reports from different companies. Moreover, since annual reports and MD&A disclosure are prepared for disseminating information by corporate management and are a subject of

verification by independent auditors and regulators, the information provided is highly credible and valid. Such an official and formal way of information disclosure increases the reliability of the data being analyzed. Considering the wide availability of annual reports and MDAs, they offer a good data source for the current research. These documents are practically available to researchers, and therefore substantial data, regularly updated almost every year, is accessible, thereby making it possible to analyze climate risk disclosure on a long-term and systematic basis. Therefore, inspired by the previous research of Du et al. (2023); Li et al. (2020), and gathering the "climate risk" lexicon existed, this study will try to depict climate risk disclosure indicators in a more comprehensive manner by realizing machine learning methods and manual review for deciding on the "climate risk" dictionary of Chinese corporations with Chinese listed companies in China from 2011-2022, and this study will, in particular, go through the following steps:

Step 1: Collect and organize the MD&A reports of Chinese listed companies from 2011 to 2022.

Step 2: Develop a seed word set for "Climate Risk" in annual reports and MD&A reports by using the existing word sets for "Climate Risk" in previous studies and combining them with the China Meteorological Disasters Yearbook and China Environmental Statistics Yearbook.

Step 3: In order to improve the objectivity of the climate risk vocabulary established in this study, the CBOW (Continuous Bag of Words) model was used to train the text corpus by machine learning techniques to expand and optimize the climate risk

vocabulary list by training the text corpus to ensure the objectivity and coverage of the vocabulary list, based on the study of (Hu et al., 2021). This step utilizes machine learning techniques to identify and add words that are similar to the seed word set, thus improving the accuracy and representativeness of the glossary.

Step 4: Taking into account expert opinions, the finalized seed word set for climate risk disclosure by companies in this study is 123 words, of which 71 are related to climate physical risks and 52 are related to climate transition risks (see Appendix 1 for details of the categorized seed word set).

Step 6: Organize the word frequencies by company code and year and calculate according to the following formula. Calculate the total climate risk word frequency, the physical climate risk word frequency, and the climate transition risk word frequency as a ratio of the total word frequency in the text. Finally, obtain the variable indicator for climate risk disclosure. The larger the indicator value, the more extensive the climate risk disclosure by the corporation.

$$CRD_{i,t} = Ln \sum (Total\ word\ frequency_{i,t} + 1)$$

To ensure the validity of the variable measures, this study also refers to the word frequencies of the measures of climate risk disclosure in previous studies (Li et al., 2020; N. Wu et al., 2022; Yang et al., 2023), which are uniformly summarized and collected, imported into Python, and used as proxy variables for climate risk disclosure for hypotheses testing. The word frequency table of the proxy variables for climate risk disclosure is shown in Appendix 2.

Before conducting empirical analysis, this article matches the industry average of climate risk disclosures with the industry level, and tests the validity of the constructed climate risk text indicators from the industry level. This article averages the climate risk disclosure values in the sample according to industry and sorts them from large to small. The industry classification in this study adopts the 2012 industry classification of the China Securities Regulatory Commission, and the industry codes are taken from the largest classification code for analysis. As shown in Table 3.2. Based on the analysis of climate risk disclosure (CRD) averages across different industries, it can be found that there are significant differences in CRD across industries. These differences may reflect the level of concern and pressure across industries to address climate change and disclose related information.

First, the CRD values of the electrical industry and water conservancy and environment industry are 0.037 and 0.030 respectively. This shows that these industries have their own business nature. These industries have a close relationship with the environment when carrying out business activities and can be closely related to climate change. The electrical industry and water conservancy and environment industry usually also face greater policy pressure and social concern (Cheng & Yang, 2023), so climate risk information needs to be disclosed more actively to respond to social concerns and alleviate policy pressure.

In contrast, although mining (0.017) and manufacturing (0.015) are also high environmental impact industries, their average CRD values are relatively low. This may reflect some of the challenges these industries face when disclosing climate risks, such as insufficient information transparency or regulatory pressure for relevant disclosures.

Despite this, these two industries still show a certain emphasis on CRD, probably due to its energy-intensive and resource-consuming nature, which makes climate change have a direct impact on their operations.

The CRD averages for the construction industry (0.012) and the general industry (0.012) are at medium levels. Although these industries have some relevance to climate change, they may be subject to less external pressure in actual operations, resulting in them being less proactive in disclosure than energy and environment-related industries. However, as global attention to sustainable development increases, these industries may face greater disclosure pressure in the future, pushing them to improve their CRD levels.

The average CRD values of transportation, warehousing and postal industry (0.010) and agriculture, forestry, animal husbandry and fishery (0.010) are relatively low. This may be because CRD in these industries currently does not receive sufficient attention. In addition, although the transportation industry has made a large contribution to climate change (Chapman, 2007), its disclosure level is still low, which reflects that the transportation industry still needs to make changes in climate information disclosure at the global and regional levels. Greater effort.

Finally, the resident services, repairs and other services industry (0.003) has the lowest average CRD, which may reflect that these industries have a smaller direct impact on climate change, or that companies have weaker awareness and capabilities in this regard. However, as society and consumers demand greater sustainability, these industries may face pressure to increase CRD in the future.

Overall, the CRD averages across different industries reveal differences in climate risk management and disclosure across industries, reflecting the maturity and pressure of each industry in addressing climate change and information disclosure. In the future, as global attention to climate change intensifies, various industries may need to further improve their disclosure levels to meet the needs of policy, market and society.

Table 3.4
CRD Industry Comparison Table

Industry Code	Industry Name	CRD Mean Value
D	D-Electricity, Heat, Gas and Water Production and Supply	0.037
N	N-Water Conservancy, Environment and Public Facilities Management	0.030
B	B-Mining Industry	0.017
C	C-Manufacturing Industry	0.015
E	E-Construction Industry	0.012
S	S-Comprehensive Industry	0.012
G	G-Transportation, Warehousing, and Postal Services	0.010
A	A-Agriculture, Forestry, Animal Husbandry, and Fishery	0.010
F	F-Wholesale and Retail Trade	0.009
M	M-Scientific Research and Technical Services	0.009
H	H-Accommodation and Catering Industry	0.008
I	I-Information Transmission, Software and IT Services	0.008
P	P-Education	0.008
L	L-Leasing and Business Services	0.007
K	K-Real Estate Industry	0.007
R	R-Culture, Sports, and Entertainment	0.006
Q	Q-Health and Social Work	0.005
O	O-Resident Services, Repairs, and Other Services	0.003

3.6.3 Moderating variables

3.6.3.1 Media attention

The media plays an important role in modern society as a disseminator of information and a shaper of public opinion. Through news reports, thematic investigations and

public opinion guidance, the media can influence the public, investors and other stakeholders' perception and judgment of corporate behavior. Media coverage can not only increase corporate transparency, but also amplify or weaken the impact of a company's CRD behavior. When the media focuses on a firm's CRD, the information is widely disseminated and may trigger strong reactions from the public and the market, which in turn affects the firm's market performance and ESG performance. Especially in the context of increasing attention to environmental issues, the media's monitoring and exposure of corporate environmental behavior can prompt companies to pay more attention to their ESG performance.

Therefore, media attention, as a dimension of media perspective, reflects the degree of public and market attention to corporate environmental behavior. The frequency and depth of media coverage can affect a firm's reputation and market performance, which in turn can prompt a firm to strengthen its ESG performance. In this study, media attention will be quantified by analyzing the quantity and quality of coverage of corporate environmental issues, including the frequency of coverage, the negative or positive bias of coverage, and the public's reaction to such coverage (Ksiazek, 2018). The data source for this study comes from the CNRDS (Chinese Research Data Services Platform) database, which is an authoritative platform for data collection and statistics in China. The online news in the platform covers news reports from more than 400 important online media in China, such as Hexun.com, Sina Finance and Oriental Fortune, and more than 20 mainstream online financial media. The platform covers news reports from more than 400 major online media outlets, such as Hexun.com, Sina Finance, and Oriental Fortune, and more than 20 mainstream online financial media outlets, as well as more than 400 other major websites. The number of times a

company's name is included in the headlines of online news in the CNRDS database is often used to measure media attention in past studies (Dong et al., 2022; Xu et al., 2023). The higher value of $Media_{i,t}$ represents the higher media attention.

$$Media_{i,t} = \ln(Head_{i,t} + 1)$$

Among them, $Media_{i,t}$ represents the natural logarithmic value of the media attention of the i -th firm at time t . The variable $Head_{i,t}$ indicates the number of reports containing the name of the i -th firm in the network news in the same time t . Adding 1 is to avoid the situation that the logarithmic function cannot be calculated when $Head_{i,t}$ and t are zero, and to ensure the numerical stability and calculation feasibility.

3.6.3.2 Government intervention.

The government has an irreplaceable role in promoting firms to fulfill their social responsibility, comply with environmental regulations and improve their governance structure. The government guides and restrains corporate behavior through policies, regulations and regulatory measures to ensure that corporate operations are in the overall interest of society (Leipziger, 2017). Particularly in China, government intervention and guidance to firms play a key role in their strategic decisions (Zhao et al., 2006). Due to China's unique situation, China is a socialist country and the Chinese government is able to play an important intervention role in the economic and political spheres.

Previous studies have found that government intervention can directly affect firms' ESG performance (Gao et al., 2024; Zhang, 2023). For example, the government can induce firms to increase their investment in environmental protection measures and enhance environmental performance by introducing strict environmental regulations

(Yu & Li, 2020). China had introduced an environmental law in 2014 that requires Chinese companies to contribute to environmental performance while conducting business activities. Meanwhile, government incentives can also encourage companies to take more social responsibility initiatives. Therefore, the degree of government intervention was chosen as a moderating variable to measure the government's influence in the relationship between corporate CRD and ESG performance, and by analyzing how government intervention moderates the relationship between corporate CRD and ESG performance, the study can reveal the actual effect of the government in this process.

This study chooses the degree of government intervention as one of the moderating variables, aiming to explore its potential moderating effect on the relationship between the main variables in the research model. The measure of the degree of government intervention is based on the ratio of the general budget revenue of local finance to the gross regional product (GDP) as a way to reflect the degree of government intervention in economic activities (Song et al., 2018; Wang & Hui, 2017). The specific calculation formula is as follows:

$$Gov_{i,p} = \frac{\text{General budget revenue of regional finance}_{i,p}}{\text{Gross regional product}_{i,p}}$$

Where i stands for year and p stands for province. $Gov_{i,p}$ represents the measure of government intervention in the I-th region at time p, which is a ratio and reflects the relationship between regional fiscal revenue and the overall economic scale of the region. Molecular general budget revenue of regional finance; p refers to the general budget revenue of the I-th region at time p, which usually includes tax revenue and non-tax revenue, and is an important indicator to measure the financial capacity of the region.

The denominator Gross regional product represents the regional gross product (GRP) of the same region and time, that is, the total economic output of the region, which is a macroeconomic indicator to measure the economic scale and total economic activities of a region. Specifically, this ratio was chosen as a measure of government intervention based on its ability to reflect the relationship between local fiscal revenue and the overall economic size of the region. Local fiscal revenue usually includes tax revenue and non-tax revenue, which are important indicators of the fiscal capacity of local governments, while regional GDP represents the economic size and total economic activity of the region. By calculating the ratio of general budget revenue to regional GDP, the degree of local government intervention in economic activities can be effectively reflected.

The rationality of this method lies in that it can provide a relatively stable and macro indicator for measuring the regulatory capacity and intervention strength of local governments in the economy. At the same time, the subdivision calculation based on the province level ensures the accuracy and reliability of the data. In order to obtain accurate data on the degree of government intervention, this study calculates by province, and then manually matches the company's year and code with the data of the corresponding province. This process ensures that each company-year data point accurately reflects the degree of government intervention in its province. The adoption of this method aims to improve the accuracy and reliability of the data and provide a solid data foundation for subsequent analysis.

In order to obtain accurate data of government intervention, this study calculates by province, and then matches the company's year and code with the data of the

corresponding province by manual matching. This process makes sure that each point in the data for a company year can properly show how much the government is involved in its province. When this method is used, the goal is to make data more accurate and reliable and to build a strong base for future research.

3.6.3.3 Investors Concern

In modern financial market research, investor attention is one of the important factors affecting market dynamics. Investors play an important role in the capital market, and their decisions can have a significant impact on a company's ability to raise capital and market performance (Khan et al., 2017). With the growing global investor interest in sustainability, investors are increasingly focusing on the ESG performance of firms, especially how they manage the risks associated with climate change.

Investors' attention can directly influence firms' climate risk-related matters (Zhang, 2022). When investors pay attention to a firm's climate risk management, the firm may increase disclosure to meet investor expectations and obtain better market evaluations. At the same time, investor pressure may also motivate firms to improve their ESG performance (Sheehan et al., 2023). Therefore, by analyzing how investor attention affects this relationship, the study can reveal the key role of investors in promoting corporate sustainability.

In order to quantify the level of investor attention to a particular stock, this study uses the frequency of internet search as a proxy variable. Specifically, this study measures the level of investor attention by the frequency of searches using stock symbols as

keywords, which reflects the intensity of the public's interest and information-seeking behavior for specific stocks.

The specific calculation method of investor attention level is as follows: first, the internet search frequency data with each stock code as keyword is collected. Then, the search frequency value corresponding to each stock code is added to one (to avoid mathematical problems in logarithmic conversion), and finally its natural logarithm is taken (Granitzer et al., 2023). Therefore, the formula of investor attention is expressed as:

$$Investor_{i,t} = Ln(Web\ search\ index_{i,t} + 1)$$

This method ensures that the larger the value, the higher the investor's concern. In this way, this study can effectively transform web search behavior into a quantifiable investor attention index, providing a practical measurement tool for further analysis.

3.6.4 Control variables

In the selection of control variables, this study combines the main research contents of this study and refers to the selection of control variables in previous literature (Alareeni & Hamdan, 2020; He et al., 2023; Nekhili et al., 2021; S. Wu et al., 2022; Yuan et al., 2022).

The selection of control variables is designed to isolate other factors that may affect ESG performance, thereby improving the accuracy of the estimated results. When analyzing the impact of CRD on ESG performance, this study selects control variables from two aspects: (1) Management level; (2) Company level.

At the management level, the following control variables are selected in this study. Dual considers the impact of combining the positions of chairman and CEO on corporate decisions and policies, which may affect the company's strategic direction including ESG-related actions (Hu et al., 2023). Equity Balance refers to the balance of equity structure. Companies with higher equity balance may have more effective supervision mechanisms to promote the improvement of ESG performance (Ngatno et al., 2021). The proportion of independent directors (Indep) is related to the quality of corporate governance, and independent directors may advocate for better ESG practices.

At the firm level, the following variables are selected as control variables in this study: asset-liability ratio (Lev) reflects the financial leverage level of a company, which is related to the company's ability to take risks and capital structure, and may affect its ESG investment and risk management (Herciu & Ogorean, 2017). Intangible assets (Intangible assets) are often related to innovation capabilities and intangible assets, which are closely linked to the sustainable development of the business. Book-to-market ratio (BM), as an indicator of the valuation of a company, may reflect the market's expectation of the company's ESG performance. Net profit margin on total assets (ROA) indicates a company's profitability, and more profitable companies may have more resources to implement ESG-related strategies. FirmAge refers to the years of establishment, and companies that have been operating for a long time may have more experience in dealing with ESG issues. In summary, these control variables were selected to ensure that the study results more accurately reflect the relationship between CRD and ESG performance, rather than other potential confounding factors.

In addition, in order to avoid the influence of year and industry differences on the research results, this study adds annual control variables and industry control variables.



Table 3.5

Variable Definition Table

Type	Variables	Symbol	Description
IV	Climate risk disclosure	CRD	Variables built using word frequency through MDA documents
DV	Esg performance	ESGP	Bloomberg Database ESG rating index
	Media attention	Media	The number of times a company's name is included in an online news headline
MV	Government intervention	Gov	The ratio of the general budget revenue of the local finance to the gross regional product (GDP) is calculated
	Investor concern	Investor	Search frequency data with ticker symbol as keyword
	Combining the positions of chairman and CEO	Dual	Chairman and general manager are the same person 1, otherwise 0
	Equity balance	Balance	Second largest shareholder shareholding/First largest shareholder shareholding
CV	The proportion of independent directors	Indep	Independent directors divided by the number of directors
	Asset-liability ratio	Lev	Total liabilities at year-end/total assets at year-end
	Intangible assets	Intangible	Net intangible assets/total assets
	Book-to-market ratio	BM	Book value/total market value
	Net profit margin on total assets	ROA	Net profit/Average balance of total assets
	Years of establishment	FirmAge	Ln (Year of the year - year of establishment +1)

3.7 Model Construction

Combining the previous analysis and hypotheses, in order to test the non-linear relationship between CRD and ESGP, this study constructed a regression equation containing quadratic terms of independent variables. Specifically, by introducing the squared term CRD^2 of climate risk disclosure in the regression model, a U-shaped or inverted U-shaped relationship can be effectively captured and tested.

The introduction of quadratic terms is because the simple full linear relationship assumed in the traditional linear regression models between independent and dependent variables may not be able to capture the complexity in the dynamics between CRD and ESG performance. In general, the existence of nonlinear relationships for influences of independent variables on dependent variables in respect to different values of the independent variables may be revealed. Now, if the model introduced a squared term of CRD—that is, CRD^2 —then this change could be captured, describing quite accurately what the effect given from CRD could be on the ESGP.

In terms of plausibility, the quadratic term model is a common and effective tool for identifying and validating nonlinear relationships. Precisely, including the quadratic term in the model allows the regression curve to hold an extreme point representing a U-shape or inverted U-shape trend. For instance, if the positive and rather strong coefficient of the quadratic term is confirmed, then the regression curve holds a U-shape trend, that is, CRD first decreases and then increases ESG performance. If, on the other hand, the negative and rather strong coefficient of the quadratic term is

confirmed, the regression curve takes an inverted U-shape, that is, CRD first increases and then decreases ESG performance.

It is this linear influence that the regression equation above enables this research to test for ESG performance concerning the possible nonlinear relationship. The model further increases its power of explanation and prediction, giving a comprehensive theoretical underpinning to later policy prescriptions. All these are feasible and effective research designs. Thus, it is conceivable that a regression equation, when combined with quadratic terms, be implemented in the research design to investigate the nonlinear relationship between the CRD and the ESR performance.

The method is not only theoretically rational but also applied quite extensively to verify previous literature. It is a common and general empirical practice that in empirical papers, the regression equations cited quadratic terms used to evaluate the non-linear relationship (U-shaped or inverted U-shaped relationship) between the independent variable and the dependent variable. Similar research design and application in the previous literature and study can be found. For instance, Aiken et al. (1991) estimated the non-linear relationship by introducing the quadratic terms to their tests, thereby yielding the opportunity of showing different levels of the independent variable and its variety effects on the dependent variable. For instance, Haans et al. (2016) also employed a quadratic term regression model in carrying out a study regarding the association between corporate innovation activities and corporate performance, and it shows a U-shaped relationship. These studies indicated that by introducing quadratic terms, the coefficients can effectively capture and test the non-linear relationship, which raises the model's explanation and prediction ability.

In other words, the introduction of quadratic terms in the linear regression model would allow this study to test for the linearity effect of CRD on ESG performance and at the same time reveal possible nonlinear relationships. Methodologically, in this respect, it is theoretically grounded and has found wide verification in practice, and it is with such strong support that this line of research has received the design accordingly.

Initially, construct model (1) to investigate the prospective U-shaped relationship between the independent variable—CRD—and the dependent variable—ESGP. The regression analysis is conducted by contrasting the signatures of the coefficients of the linear term (CRD) and the quadratic term (CRD²) of the independent variable. one could illustrate if the connection between CRD and ESGP is U-shape or inverted U-shape. When the coefficient α_1 of the linear term of CRD is a positive coefficient and the coefficient of the quadratic term is negative, the regression curve is as given in model (1). It exhibits an inverted U-shaped relationship, indicating that ESGP may diminish in the early stages as the level of CRD increases. However, after reaching a specific minimum value, as CRD further increases, ESGP will start to increase. When the linear term coefficient α_1 of CRD is when the coefficient α_2 of the quadratic term is positive and negative, the regression curve shows a relationship that is inverted U-shaped, meaning that ESGP will increase in the early period as the level of CRD increases. However, after reaching a certain high point, as CRD further increases, ESGP will start to decline.

Model (1) is shown in the following formula:

$$ESGP_{i,t} = \alpha_0 + \alpha_1 CRD_{i,t} + \alpha_2 CRD_{i,t}^2 + \sum_{k=8} \alpha_3 Controls + \sum Year + \sum Industry + \varepsilon_{it} \quad (1)$$

In order to verify the adjustment function of media perspective, on the basis of model (1), the variables of media attention are multiplied to construct model (2) to verify the moderating effect of media attention (Media):

$$ESGP_{i,t} = \alpha_0 + \alpha_1 CRD_{i,t} + \alpha_2 CRD_{i,t}^2 + \alpha_3 CRD_{i,t} * Media + \alpha_4 CRD_{i,t}^2 * Media + \alpha_5 Media + \sum_{k=8} \alpha_6 Controls + \sum Year + \sum Industry + \varepsilon_{it} \quad (2)$$

In order to verify the moderating effect of the government perspective, on the basis of model (1), the degree of government intervention is multiplied to build model (3) to verify the regulatory role of government intervention (Gov):

$$ESGP_{i,t} = \alpha_0 + \alpha_1 CRD_{i,t} + \alpha_2 CRD_{i,t}^2 + \alpha_3 CRD_{i,t} * Gov + \alpha_4 CRD_{i,t}^2 * Gov + \alpha_5 Gov + \sum_{k=8} \alpha_6 Controls + \sum Year + \sum Industry + \varepsilon_{it} \quad (3)$$

In order to verify the moderating effect of investors' perspective, on the basis of model (1), this study build a model (4) to verify the moderating effect of investors' concern (Investor):

$$ESGP_{i,t} = \alpha_0 + \alpha_1 CRD_{i,t} + \alpha_2 CRD_{i,t}^2 + \alpha_3 CRD_{i,t} * Investor + \alpha_4 CRD_{i,t}^2 * Investor + \alpha_5 Investor + \sum_{k=8} \alpha_6 Controls + \sum Year + \sum Industry + \varepsilon_{it} \quad (4)$$

Among them, $ESGP_{i,t}$ represents the dependent variable, representing the degree of social responsibility fulfillment of the I-th firm in the t year; $CRD_{i,t}$ is the independent variable, indicating the level of CRD of the I-th firm in the t year; $\sum_{k=8} Controls$ are other characteristic variables that affect the ESG performance of companies; $\sum Year$ is the annual fixed effect; $\sum Industry$ is the fixed effect of industry; $\varepsilon_{i,t}$ is a random interference term.

When constructing the model, considering that this study selected the period of 2011-2022 as the sample frame, this study fully considered the economic events that may have a significant impact on corporate performance and market environment during this period. During this period, the Chinese economy has experienced many important policy adjustments and market fluctuations. For example, the stock market fluctuations in 2015, the Sino-US trade frictions in 2018, and the outbreak of the global COVID-19 pandemic in 2020 are all important economic events that may affect corporate financial performance and information disclosure behavior. These events may cause companies to perform abnormally in certain years, thereby affecting their CRD behavior and ESG performance. In order to control these potential biases, this study introduces time fixed effects and industry fixed effects in the model setting to ensure that the impact of these macroeconomic events is properly controlled, so as to make the research results more robust.

In addition, this study also analyzes the performance differences of different industries during this period, considering that industry characteristics may have different effects on corporate CRD and ESG performance. For example, energy and manufacturing companies may be subject to more external pressure than service industry companies when facing climate risks. Therefore, this study incorporates industry classification variables in the discussion of heterogeneity in further research to further control differences between industries and avoid the impact of industry characteristics on the results.

Through these supplementary discussions and methodological improvements, this study strives to ensure the universality and reliability of the research in different periods

and industry contexts. These control measures enable this study to more accurately assess the impact of CRD on ESG performance, while taking into account the possible impact of different economic events and industry characteristics on corporate behavior, thereby enhancing the robustness and credibility of the research conclusions.



CHAPTER FOUR

RESULTS& DISCUSSION

4.1 Introduction

The relationship between disclosure of climate risk and corporate ESG performance has been discussed and its possible mechanism is explained. This research chapter tries to adopt a serial empirical analysis method according to the theoretical framework and the research design. Descriptive statistical analysis regarding the performance for CRD and ESG performance of the companies is firstly carried out, considering the difference between industries and years, so as to ensure the wide applicability and explanation power of the results. Subsequently, Pearson correlation coefficient analysis, variance expansion factor (VIF) test for the existence of multicollinearity, and panel data are used for major regression analysis, and Utest and Haans et al. (2016) methods are used to help verify the U-shaped relationship between CRD and ESG performance.

Furthermore, in order to enhance the robustness and reliability of the empirical results, a series of robustness and endogenous problems tests are carried out in this article. These are to identify the analysis findings' robustness and provide a solid support for the conclusion of research.

After confirming the influence of CRD on ESG performance, this study further discusses the regulatory role of media, government, and investors from the perspective of the three key stakeholder engagement, relying on the literature review in Chapter 2 and hypothesis derivation in Chapter 3, discussing the differences in the impact between

different stakeholders on the dynamics and complexity of the relationship of CRD and ESG performance.

Moreover, this study also carried out a further subdivision study according to the heterogeneity of companies and climate risk disclosure behavior. This study therefore attempts to impute the findings within a more detailed and practical notion by encouraging the decision-making process of companies and policymakers in the ESG field to analyze how different firm characteristics or different types of CRD affect ESG performance.

4.2 Descriptive statistics

Figures 4.1 and 4.2 represent average ESG performance scores and the status of CRD of Chinese firms over the period from 2011 to 2022, respectively. The general trend is somewhat fluctuating. That is to say, the average level of implementation of ESG performance in Chinese firms generally stayed at a low level and did not rise significantly over the period 2011–2014. From 2015, a noticeable upward trend in the average ESG performance of Chinese firms appeared over almost every year until 2022. Since 2015, the ESG performance of Chinese firms has improved dramatically, with policy guidance, market dynamism, public awareness continually enhanced, and international cooperation factors.

In 2014, the Chinese government officially promulgated the "Environmental Protection Law" after the first environmental protection act was enacted in 1979, which, up to now, is still in the academic circles' eyes, the "history's strictest environmental protection law" (Zhang et al., 2017). Undoubtedly, the promulgation of this law provided a legal

basis for the improvement of the ESG performance of firms in China. Also, the official implementation of the "Environmental Protection Law" in 2015 means that the Chinese government, through relevant policies and regulatory systems, continuously tightened the requirements of firm environmental protection and social responsibility and governance structure and continuously promoted the deep integration of the ESG concept (Yu & Morotomi, 2022).

In 2015, the "Paris Agreement" was signed, which further promoted the ESG performance of firms under the combination of domestic and international policies and formed a beneficial driving force for ESG performance. The public awareness of sustainable development and social responsibility also elevated the ESG performance of companies. Furthermore, the cross-border collaboration and the standard setting at that time provided Chinese firms with guidelines on how to practice ESG and, in the meantime, incentives for them to enhance their international competitiveness. It is these overall factors that have actively pushed the ESG performance of Chinese firms to significantly improve since 2015 and into an uptrend track.

The results in Figure 4.2 answer whether the climate risk disclosure of Chinese corporations in general has increased over 2011 – 2022. In general, the degree of CRD by Chinese corporations fluctuates from year to year but has been on the rise. More specifically, from 2011 to 2022, the degree of CRD fluctuated yearly and then manifested an increasing trend over time.

First is the announcement of the "Green Book of Climate Change" in 2019 by the government of China, which reflects the government's concerns and determination to

resolve the issue of climate change, and bodies clear policy guidance and future trend expectation for the corporation. Strengthened attention enhances the corporation's incentives to pay attention to CRD in the face of government policy guidelines and regulatory demands. The upsurge of green finance and sustainable investment made the voice of disputes of the financial market put forward higher requirements for the corporation's disclosure of climate risk. Therefore, banks, insurance companies, and investors have been gradually viewing the climate risks of entities as an important factor in the affective corporate credit and investment risks. This trend has been incentivizing the enhanced disclosure of the related corporations to attract investment and financing.

In general, the policy pull domestically and internationally, along with market and financial institutions' pressure, combined with the rising public awareness and the advancement of technology, will push the climate risk information of the corporation to be continuously enhanced and refined and gradually lead to a remarkable change in practice disclosure among Chinese corporations, notably after 2019 when the influence of these factors became more direct.

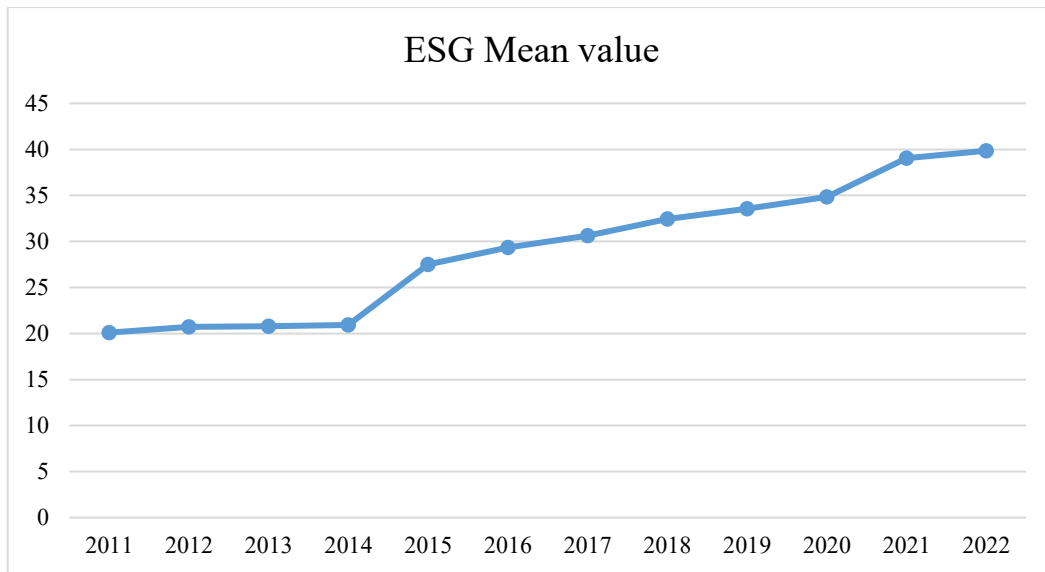


Figure 4.1
Average ESG of each year
 Source: Draw by author

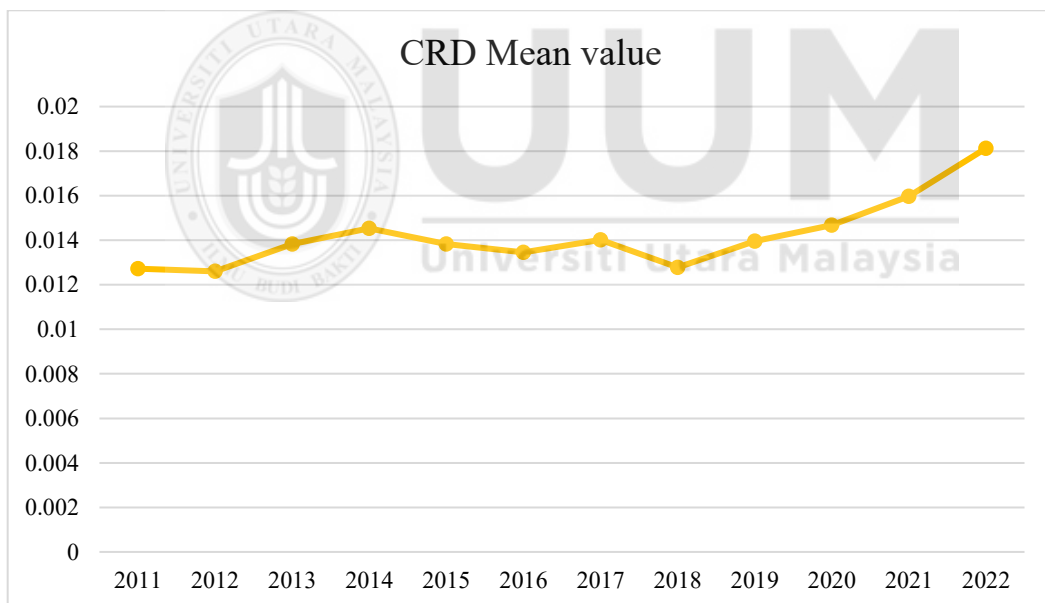


Figure 4.2
Average CRD for each year
 Source: Draw by author

Table 4.1 shows the descriptive statistics of the main variables of this study. It shows the distribution characteristics of Chinese companies' ESG performance among sample

companies. The average score is 29.583 and the standard deviation is 9.305, revealing a certain degree of variation. The significant difference between the lowest value (11.983) and the highest value (57.570) further emphasizes the wide gap in ESG performance among firms, with the ESG scores of most Chinese firms concentrated around 28.498. The three variables E, S, and G represent ESG scores respectively. The average value of E is 9.743, the average value of S is 14.092, and the average value of G is 65.317. This shows that on environmental and social dimensions the company scores relatively low and on governance dimensions it scores high.

Secondly, the low mean (0.014) and small standard deviation (0.012) of CRD in Table 4.1 point to the overall low level of disclosure by companies in this area, which indicates that companies have poor performance in CRD. The differences are small, with most companies disclosing values in the lower range. Statistics on corporate debt levels show that the average debt ratio is 0.478. Compared with the maximum debt ratio of 0.886, this result shows significant differences in the use of financial leverage among companies. The average balance sheet balance is 0.338, and the difference between its maximum value (0.985) and minimum value (0.009) may reveal the diversity of firms in asset liability management.

In the descriptive statistics of the moderator variable of stakeholder participation, it can be seen from Table 4.1 that the average value of media attention (Media) is 4.577 and the standard deviation is 1.186, which shows that there are certain differences in the level of media attention to the company. The average value of investor concern (Investor) is 11.548, and the standard deviation is 2.248, indicating that investors' attention to the company has a wide range of changes. The mean value of the degree of

government intervention (Gov) is 0.120, and the standard deviation is 0.036, showing that the intensity of government intervention has certain differences among different companies.

The average ratio of independent directors is 37.569%, which shows that independent directors account for a relatively stable proportion of the board of directors. The average value of the CEO concurrently serving as chairman is 0.208, indicating that a small number of companies have CEOs concurrently serving as chairman, which may have an impact on the effectiveness of the corporate governance structure. The average value of the intangible asset's ratio is 0.050 and the maximum value is 0.443, indicating that intangible assets may occupy a large proportion in the asset structure of some firms. The average price-to-book ratio is 0.666 and the standard deviation is 0.277, indicating that there are certain differences in the market valuation of companies. The data range reflects the differences in the market's assessment of corporate value. The descriptive statistical results are basically consistent with the current literature.

Table 4.1

Descriptive statistics

	(1) count	(2) mean	(3) sd	(4) min	(5) p50	(6) max
ESGP	11165	29.583	9.305	11.983	28.498	57.570
E	11165	9.743	12.962	0.000	2.416	55.331
S	11165	14.092	7.596	0.000	12.031	39.087
G	11165	65.317	13.457	32.029	69.296	87.718
CRD	11165	0.014	0.012	0.001	0.010	0.062
Media	11165	4.577	1.186	0.693	4.727	6.914
Investor	11165	11.548	2.248	0.000	11.870	13.572
Gov	11165	0.120	0.036	0.065	0.111	0.214
Lev	11165	0.478	0.199	0.069	0.491	0.886
Balance	11165	0.338	0.287	0.009	0.245	0.985
Indep	11165	37.569	5.511	33.330	36.360	57.140
Dual	11165	0.208	0.406	0.000	0.000	1.000
Intangible	11165	0.050	0.065	0.000	0.033	0.443
BM	11165	0.666	0.277	0.113	0.673	1.227
ROA	11165	0.049	0.063	-0.168	0.041	0.249
FirmAge	11165	2.940	0.333	1.792	2.996	3.526

This study also conducts a multicollinearity test on the main control variables, and the results show that there is no multicollinearity problem, and subsequent regression analysis can be performed. According to the VIF (variance inflation factor) results in Table 4.2, it can be seen that most of the VIF values of each variable are at a low level, indicating that the multicollinearity problem is not serious. However, the VIF values of CRD and the square term of CRD are relatively high, 9.14 and 8.92 respectively, which indicates that there is strong collinearity between the two variables. The emergence of complete collinearity usually means that there is a high correlation between one or more independent variables, which will lead to unstable parameter estimation in the regression model, thus affecting the interpretability of the regression results. In this study, the high collinearity between CRD and the square term of CRD is expected, because the square term is generated from the original variable, so there must be a strong correlation between them. In order to deal with this problem, it is necessary to retain these variables in the model because the square term plays a key role in capturing nonlinear relationships (such as U-shaped relationships). Despite the high VIF value, retaining these variables in this case helps to better explain the impact of CRD on ESG performance. Therefore, although there is some collinearity, it does not significantly affect the conclusions of this study because the model has been appropriately adjusted to deal with this issue.

Table 4.2

<i>VIF</i>		
Variable	VIF	1/VIF
CRD	9.14	0.109444
CRD ²	8.92	0.112054
Lev	1.47	0.678883
Balance	1.41	0.710646
Indep	1.32	0.758190
Dual	1.05	0.956566
Intangible	1.04	0.965312

Variable	VIF	1/VIF
BM	1.02	0.978505
ROA	1.02	0.983790
FirmAge	1.02	0.984405
Mean VIF		2.74

4.3 Correlation Analysis

The correlation coefficients between the main variables are presented in Table 4.3. The correlation coefficient between CRD and ESGP is significantly positive at a confidence level of less than 1%, indicating that corporations' engagement in CRD can enhance their ESG performance. Among the control variables, with the exception of dual roles (Dual), leverage (Lev), equity balance (Balance), the proportion of independent directors (Indep), the proportion of intangible assets (Intangible), book-to-market ratio (BM), return on assets (ROA), and the company's age (FirmAge) are also significantly correlated with corporate ESGP. This suggests that corporations with higher leverage, greater equity balance, a higher proportion of independent directors, a higher proportion of intangible assets, a higher book-to-market ratio, and a higher return on assets are likely to have higher ESG performance.

Table 4.3

Pearson Correlation analysis

	(1) ESGP	(2) E	(3) S	(4) G	(5) CRD	(6) Lev	(7) Balance	(8) Indep	(9) Dual	(10) Intangible	(11) BM	(12) ROA	(13) FirmAge
ESGP	1.000												
E	0.844***	1.000											
S	0.723***	0.665***	1.000										
G	0.795***	0.398***	0.330***	1.000									
CRD	0.122***	0.140***	0.097***	0.056***	1.000								
Lev	0.065***	0.051***	0.013	0.043***	0.185***	1.000							
Balance	0.136***	0.106***	0.115***	0.125***	-0.029***	-0.053***	1.000						
Indep	0.067***	0.041***	0.052***	0.064***	-0.068***	0.013	-0.028***	1.000					
Dual	0.012	0.006	-0.001	0.029***	-0.071***	-0.092***	0.072***	0.092***	1.000				
Intangible	0.033***	0.036***	0.018*	0.020**	0.053***	-0.031***	0.030***	-0.024**	-0.050***	1.000			
BM	0.122***	0.114***	0.083***	0.081***	0.215***	0.468***	-0.065***	-0.005	-0.162***	0.052***	1.000		
ROA	0.031***	0.057***	0.061***	-0.019**	-0.112***	-0.450***	0.006	0.016*	0.101***	-0.039***	-0.373***	1.000	
FirmAge	0.326***	0.190***	0.140***	0.361***	0.052***	0.144***	0.026***	-0.033***	-0.053***	0.001	0.154***	-0.113***	1.000

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.4 Assessment of Measurement Model

In this study, the empirical analysis is conducted by constructing a regression model of company-year panel data based on its wide application and recognition in econometric analysis. As stated in Weisberg (2005), regression analysis provides an effective estimation method when the data meets the assumptions of the regression model. In addition, Cameron and Trivedi (2005) pointed out that even when some classical assumptions are violated, regression analysis can be used as a preliminary analytical tool, and its results can be verified and robustly tested by other methods (Cameron & Trivedi, 2005).

It is necessary to control the year effect and industry effect in processing cross-sectional and time series data. Baltagi and Baltagi (2008) emphasizes that it is a standard practice to introduce fixed effect or random effect in panel data analysis to control unobservable heterogeneity. The control of year effect can capture the influence of macroeconomic trends and policy changes in time series on ESG performance, while the control of industry effect can isolate systemic risks and unique norms within the industry, such as the method adopted by Fama and French (1993) in its research.

Although the regression model of panel data has certain limitations, such as possible endogeneity problems and omitted variable bias, the estimation accuracy can be significantly improved by introducing supplementary techniques such as discontinuity regression, Heckman two-stage and instrumental variables method (2SLS). accuracy and robustness of results, as discussed by Wooldridge (2010). The comprehensive use of these methods provides solid support for regression analysis of panel data, ensuring

the credibility of the research results and the depth of the empirical analysis. Therefore, this study chooses the regression model of panel data as the main analysis tool, and ensures the reliability and comprehensiveness of the research results by introducing a wealth of control variables and using a variety of robustness testing methods.

4.5 Baseline regression

Table 4.4 shows the multiple regression analysis results of CRD on ESGP of companies. Column (1) shows the regression results between the linear term (CRD) and quadratic term (CRD²) and ESG performance (ESGP); Column (2) is consistent with column (1) after the control variables are added. At this time, the linear term (CRD) coefficient is significantly negative ($\beta = -55.392$, $P < 0.01$), and the quadratic term (CRD²) coefficient is significantly positive ($\beta = 1660.754$, $P < 0.01$). Therefore, from the results of column (1) and column (2), it can be seen that with the increase of companies, the ESG performance of companies will be reduced; Subsequently, after the climate risk disclosure of companies reaches a certain peak, with the increase of CRD, the ESG performance of companies will be gradually improved. Therefore, it is preliminarily confirmed that there is a U-shaped connection between CRD and ESG performance.

However, Haans et al. (2016) once proposed in the study that when studying the U-shaped relationship, previous studies only judged whether there is a U-shaped connection between two variables based on the opposite directions of the coefficients of the linear term and the quadratic term, but this is not sufficient. Therefore, this study refers to the three-step method proposed by Lind and Mehlum (2010) to test the curve connection between CRD and firm ESG performance. Lind and Mehlum (2010) proposed the following three-step method:

First of all, the coefficients of the linear and quadratic terms of the independent variables are significant, and the signs are opposite, which is consistent with the theoretical expectation;

Secondly, at the maximum and minimum values of independent variables, the slope of the U-shaped relationship must be significant and steep enough, otherwise the curve relationship displayed can only be the average of the U-shaped.

Finally, the 95% confidence interval of the turning point of the U-shaped relationship should be within the range of independent variables.

This study uses the above three-step method to re-verify the U-shaped connection between CRD and ESG performance. Firstly, Utest test was carried out. In the main regression model (2), the extreme point of the curve relationship is 0.017, which is included in the 95% confidence interval [0.001~0.062], and the linear term coefficient of CRD is significantly negative and contrary to the quadratic term coefficient. Secondly, in order to confirm that the curve relationship is U-shaped, this study takes the minimum value and the maximum value of CRD respectively according to the research of Zhu and Zhou (2018) to test whether the sign of the curve slope is negative and positive. This study mainly focuses on the connection between CRD and ESG performance, and the control does not affect the shape of the curve relationship, so the model (1) is simplified and the first derivative is obtained to obtain the curve slope ESGP' as formula (1):

$$ESGP' = \alpha_1 + 2\alpha_2 CRD \quad \text{Formula (1)}$$

Subsequently, according to the range of CRD values in descriptive statistics in Table 4.1 [0.001~0.062], it is calculated that $ESGP'_{CRD_{min}} = \alpha_1 + 2\alpha_2 CRD_{Low}$ is -52.070, and $ESGP'_{CRD_{max}} = \alpha_1 + 2\alpha_2 CRD_{High}$ is 150.541. Refer to Zhu and Zhou (2018), This implies that the curve's slope is negative when CRD_{min} is used as the CRD, and the slope is positive when CRD_{max} is used as the CRD, thereby satisfying condition (2).

Finally, this study verifies whether the value of inflection point (symmetry axis) CRD'' is within the value range of independent variable CRD [0.001~0.062]. The inflection point of the curve is the value at which the slope $ESGP'$ of the curve is equal to 0. Consequently, the inflection points CRD'' of the curve can be determined by applying formula (1), and it is calculated that the value of CRD'' is 0.017, which is within the value range of CRD and satisfies condition (3). To sum up, conditions (1) to (3) are all satisfied, which demonstrates a U-shaped relationship between the CRD and the ESG performance of companies. Specifically, the ESG performance of companies will decrease as the CRD increases, but it will improve once the threshold is reached.

Moreover, this study also tests whether three dimensions of ESG performance and CRD are connected in a U-shaped. As shown in Table 4.4, columns (3), (5) and (7) are the performance of E, S and G dimensions respectively, and the coefficient of CRD is significantly negative and coefficient of the quadratic term of CRD (CRD^2) is significantly positive; After adding control variables, column (4), column (6) and column (8) are the performance of E, S and G dimensions after adding control variables, the results does not change. This shows that from the perspective of ESG performance sub-dimension, CRD still has a U-shaped relationship with the most dimensions indicator performance, and the results are still stable.

In this study, it finds a U-shaped connection between CRD and ESG performance, which means in the initial stage to disclose climate risk, CRD is in the low disclosure level, increasing disclosure may temporarily lead to a decline in ESG performance. However, when company execute more disclosures then crossing the threshold (X-point in U-Shape), as the CRD level further increases, ESG performance begins to gradually improve.

The emergence of this U-shaped relationship may be due to the fact that when firms begin to strengthen CRD, they often need to invest a lot of resources in environmental management, data collection and information disclosure. These initial investments may not immediately bring obvious performance improvements, and may even temporarily lower ESG performance due to increased costs. However, as firms gradually adapt and optimize their environmental management strategies, the transparency and quality of disclosed information will also be improved, thereby gradually improving their ESG performance.

In this process, firms may also face higher expectations from regulators, investors and the public. This external pressure may prompt firms to further improve their ESG management, thereby achieving higher ESG performance in the long run. Therefore, although the initial CRD may bring challenges and pressure, as companies improve their adaptability and adjust their strategies, it will eventually promote the improvement or efficient strategy of ESG performance and form a U-shaped performance trend.

In summary, the U-shaped connection between CRD and ESGP reflects the transformation process that companies go through when dealing with climate risks, from initial adaptation and investment to later optimization and improvement. This relationship emphasizes the importance of continuous improvement and strategic disclosure in promoting corporate sustainable development.

This study attempts to explain the research results from the following 3 aspects, namely: (1) disclosure burden in the early stage; (2) enhancing transparency and trust; (3) dynamic feedback mechanism.

First of all, in the early stages of corporate CRD, companies may encounter poor market feedback because they begin to implement CRD, thus affecting their own stock value and corporate value (Bratten & Cheng, 2023; Mahmudah et al., 2023). Not only that, companies will also encounter higher direct and indirect costs in the early stages of disclosing climate risks (Burton, 2010; Ginglinger & Moreau, 2023), for example, the costs of collecting data and information when making climate risk disclosures, the costs incurred in managing climate risks in company-related reports, etc., as well as the related costs invested in stabilizing the market, consumers and other stakeholders after disclosing climate risks.

Secondly, as companies' climate risk disclosures continue to deepen and mature, investors, the public, and various stakeholders have gradually begun to increase their confidence and transparency. This sense of trust and transparency is brought about by companies' disclosures for the climate related information (Flammer et al., 2021; Foerster et al., 2017), increasing transparency and trust with stakeholders can achieve

long-term strategic benefits. Not only that, over time, companies' improved capabilities in climate risk management and improved communication with stakeholders will help improve their ESG performance. This positive effect gradually appears as the level of CRD increases, eventually transforming into a positive relationship with ESG performance.

Finally, a high level of CRD promotes positive interactions within and outside the company. Companies can better deal with environmental problems and meet the needs of stakeholders for information sharing by managing risks better and becoming more flexible when suffering climate change. Businesses' exposure of climate risks directly shows that environmental performance is getting better and that environmental performance is clear (Kim et al., 2023). At the same time, this progress is reflected not only in direct E dimension performance, but also in improvements in S and G dimensions. Corporate CRD enhances stakeholder communication and trust, and enhances the corporate social image and brand value (Eleftheriadis et al., 2015). Not only that, in terms of governance performance, corporate implementation of high-level CRD also They are required to have an effective governance structure (Elliott et al., 2023), ensure that climate risks can be accurately identified and assessed, and establish relevant internal control and supervision mechanisms based on the climate risks they face (Braasch & Velte, 2023). Therefore, with the overall improvement of corporate CRD, a positive feedback loop has been formed, further motivating companies to increase their investment in CRD and related ESGP.

In the Table 4.4 of regression results, there is a U-shaped connection between CRD and ESGP, which can be explained by legitimacy theory. Legitimacy theory holds that the

social legitimacy of a company is the basis for its continued operation, and companies maintain and enhance their legitimacy in society through information disclosure, especially CRD. However, the U-shaped connection between CRD and ESGP reflects a nonlinear dynamic change in the process of companies improving their legitimacy.

In the early stages of CRD, companies may be forced to invest a lot of resources in CRD in order to meet external compliance requirements or initially respond to social concerns about climate change. At this time, due to the high cost and resource consumption in the disclosure process, the company's ESG performance may temporarily decline. This decline can be partly attributed to the internal pressure and external doubts faced by companies when adapting to new disclosure requirements and resource allocation (Child & Tsai, 2005). In addition, in the early stages of disclosure, incomplete or inadequate information may cause external stakeholders to doubt the company's actual commitment, thereby affecting the company's social legitimacy and ESG performance.

As the level of disclosure gradually increases, companies gradually improve their climate risk management systems through continuous information disclosure and establish a more transparent and credible image in the public and the market (Li et al., 2017). In this process, companies gradually gain social recognition and support through continuous efforts and improvements, thereby enhancing their social legitimacy. This enhanced legitimacy is reflected in the improvement of ESG performance, which ultimately leads to the rising part of the U-shaped relationship. At this point, companies can not only demonstrate their commitment to environmental responsibility through disclosure behavior, but also further consolidate their legitimacy in the market by

actively responding to external pressure and expectations, and promote the overall improvement of ESG performance.

Therefore, the U-shaped connection between CRD and ESGP can be explained by legitimacy theory as the process of legitimacy acquisition and consolidation experienced by companies in the process of information disclosure. Companies may face challenges in legitimacy construction in the early stages, resulting in a decline in ESG performance, but with the deepening of disclosure and the enhancement of legitimacy, companies will eventually be able to achieve a significant enhancement in ESG performance, and then gaining long-term sustainable development capabilities in the fierce market competition.



Table 4.4

Baseline regression

	(1) ESGP	(2) ESGP	(3) E	(4) E	(5) S	(6) S	(7) G	(8) G
CRD	-43.039** (-2.151)	-55.392*** (-2.843)	-45.402 (-1.349)	-58.054* (-1.754)	-33.581* (-1.659)	-30.673 (-1.520)	-64.393*** (-2.645)	-77.124*** (-3.192)
CRD ²	1635.375*** (4.125)	1660.754*** (4.347)	2253.709*** (3.412)	2213.610*** (3.432)	1270.883*** (3.361)	1138.198*** (3.048)	1563.424*** (3.449)	1634.168*** (3.679)
Lev		5.169*** (13.046)		6.644*** (9.795)		1.495*** (3.404)		4.288*** (8.750)
Balance		2.586*** (11.470)		3.662*** (9.571)		2.324*** (9.722)		2.414*** (8.424)
Indep		0.067*** (5.699)		0.073*** (3.707)		0.048*** (3.828)		0.072*** (4.755)
Dual		-0.432*** (-2.829)		-0.265 (-0.999)		-0.485*** (-2.910)		-0.269 (-1.422)
Intangible		3.199*** (2.653)		4.045** (2.055)		0.835 (0.693)		3.609** (2.483)
BM		3.673*** (11.562)		5.690*** (10.262)		3.239*** (9.680)		2.652*** (7.351)
ROA		19.823*** (18.157)		29.288*** (15.129)		14.868*** (12.480)		12.111*** (9.306)
FirmAge		0.088 (0.390)		-0.529 (-1.438)		-0.953*** (-3.920)		0.423 (1.384)
_cons	18.243*** (34.698)	9.735*** (10.593)	0.396 (0.401)	-9.221*** (-5.928)	6.837*** (12.112)	3.933*** (4.054)	48.153*** (72.946)	39.899*** (32.954)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	11165	11165	11165	11165	11165	11165	11165	11165
adj. R ²	0.519	0.547	0.282	0.310	0.189	0.212	0.654	0.663
Extreme point	0.013	0.017	0.010	0.013	0.013	0.013	0.021	0.024

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.6 Endogenous and Robustness Test

4.6.1 Substitution variables

The necessity of replacing variables is that they can verify the robustness of the main results, and even under different data sources and measurement methods, the relationship found in the research is still stable. Through this method, this study can be sure that the research conclusion is not driven by the specificity of specific data sets or measurement tools, thus enhancing the external effectiveness of the research. In addition, considering that different databases may have different methods of collecting and processing information, the robustness test using substitute variables is also an important supplement to the original conclusion, which helps to provide more solid support for the research conclusion.

To ensure the reliability of the result, this study tests the robustness of substitution variables, and systematically reanalyzes the CRD and the ESG performance. In the process of replacing independent variables, this study draws on and integrates the frequency database of climate risk-related words (Li et al., 2020; N. Wu et al., 2022; Yang et al., 2023), and uses Python language to collect word frequency, taking the comprehensive word frequency data set in Appendix 2 as a substitute index (Sub_CRD). As shown in Table 4.5, the data in column (2) shows that the linear term of Sub_CRD is statistically significantly negative ($\beta=-40.089$, $p<0.05$), while the quadratic term of Sub_CRD is significantly positive ($\beta=1772.458$, $p<0.01$), which is consistent with the results of main regression analysis.

In this substitution variable robustness test, this study also uses Wind's ESG rating database as an alternative indicator of ESG performance for verification. The reliability of this choice is mainly based on the wide application of Wind ratings in the market and the coverage of its data.

First, as a leading data provider in China's financial market, Wind's ESG rating contains a large number of listed companies and has a high market recognition (Chen et al., 2023). Wind ratings use a set of systematic indicators to comprehensively evaluate the ESG performance to the companies (Xu & Zhao, 2024). Since Wind's data sources are extensive, updated in a timely manner, and its evaluation standards are in line with international standards, its ESG ratings can provide a reliable alternative indicator for this study and ensure the robustness of the main results.

Secondly, using of Wind ratings can further verify whether the main result of this study is universal. By comparing with the original ESG performance indicators, if the results of using Wind ratings are consistent or similar to the original results, it means that the result of this study are robust under different data sources and rating systems, which enhances the credibility of the research.

In addition, Wind's ESG rating system has been developed and improved over the years, covering multi-dimensional ESG performance and taking into account industry characteristics and market dynamics. Therefore, it can provide an independent and representative perspective for this article to evaluate the influence of CRD on ESG performance.

In summary, Wind's ESG rating database was selected as an alternative indicator in the robustness test based on the extensiveness of its data, market recognition and compatibility with international standards. This method can more comprehensively verify the result of this study and enhance the reliability and applicability.

Therefore, this study refers to previous research (Chen et al., 2023; Wang & Li, 2023), in this study, the ESG rating provided by Wind ESG rating is selected to replace the ESG rating index in Bloomberg database, thus serving as a substitute variable for ESG performance. In the Table 4.5 of the column (4), the coefficients of CRD and its quadratic term CRD^2 are negative and positive respectively, which are statistically significant, which once again confirms the robustness of the U-shaped connection between CRD and ESG performance.

Table 4.5
Substitution Variables

	(1) ESG	(2) ESG	(3) Wind	(4) Wind
Sub_CRD	-29.141 (-1.534)	-40.089** (-2.168)		
Sub_CRD ²	1720.050*** (4.208)	1772.458*** (4.496)		
CRD			-15.687*** (-3.086)	-15.158*** (-2.972)
CRD ²			259.776*** (2.733)	248.926*** (2.653)
_cons	18.122*** (35.036)	9.500*** (10.333)	5.810*** (71.173)	5.801*** (24.286)
Controls	No	Yes	No	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	11165	11165	2934	2934
adj. R ²	0.520	0.548	0.126	0.137

* p < 0.1, ** p < 0.05, *** p < 0.01

4.6.2 Lag period

As a result of better ESG performance, businesses may be more likely to talk about climate risks, so there may be a reverse causal relationship, so this study specially tests the robustness of lag period.

Considering that higher ESG performance may prompt companies to disclose climate risks more actively, there may be reverse causality, so this study specifically conducted a lagged robustness test.

Referring to previous studies(Coen et al., 1969; Wilkins, 2018), using lagged CRD one and two periods for robustness testing is a reliable method, especially when dealing with data periods spanning 12 years and involving different economic cycles and time periods. This method helps to minimize the influence of the potential impact of economic cycles and other time factors on the results, thereby improving the robustness of the research results.

First, the introduction of lagged variables can effectively identify the long-term impact of CRD on ESG performance. Economic cycles usually affect the operating environment and market performance of firms. Direct use of current CRD data may be disturbed by short-term market fluctuations or economic cycles. By introducing lagged CRDs of one and two periods, the impact of CRD on current ESG performance at different time points in the past can be observed, thereby reducing the interference of economic cycles and other time-related factors on the research results.

Second, the use of lagged CRD can also help detect the directionality of causality. If the impact of CRD on ESG performance is lagged, then by analyzing the impact of CRD on ESG performance with a lag of one and two periods, the long-term contribution of disclosure behavior to performance can be better determined. This is especially important in studies with a long time span, because the impact of certain policies or corporate behaviors may take time to manifest.

Finally, using lagged CRD for robustness testing can also verify the persistence of the results. If the impact of CRD on ESG performance with a lag of one and two periods is consistent with the impact trend of the current CRD, it means that the research results are highly robust and can withstand the test of time.

Therefore, as shown in Table 4.6, regression analysis is carried out by lagging ESG performance indicators by one and two periods, aiming at eliminating the potential adverse influence of dependent variables on independent variables, that is, verifying that the change of ESG performance is driven by the previous level of CRD, not the other way around. The key of this step is to prove that the impact of CRD on ESG performance is forward-looking and causal, rather than the reaction caused by the change of ESG performance. In this study, this study chooses to forward the ESGP by one period and two periods to test the lag regression results. Table 4.6 shows the results of the test in the lag period. In the Table 4.6 of columns (1) and (2) show the results of ESGP in advance by one period, and Table 4.6 of columns (3) and (4) show the results of ESGP in advance by two periods. The test results are consistent with the main regression, and the primary coefficient of CRD is significantly negative, and the secondary coefficient is significantly positive, the result has still no change.

Table 4.6
Lag Robustness Test

	(1) F.ESG	(2) F.ESG	(3) F2.ESG	(4) F2.ESG
CRD	-47.968** (-2.150)	-54.617** (-2.518)	-50.846** (-2.065)	-59.456** (-2.485)
CRD ²	1825.589*** (4.112)	1772.069*** (4.170)	1899.878*** (3.873)	1846.537*** (3.942)
_cons	18.760*** (33.618)	10.005*** (9.985)	18.552*** (30.810)	9.328*** (8.695)
Controls	No	Yes	No	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
<i>N</i>	9416	9416	8163	8163
adj. <i>R</i> ²	0.492	0.520	0.453	0.483

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.6.3 Instrumental Variable Check

In order to further alleviate the endogenous problems, this study also uses the two-stage least squares method of instrumental variables (IV-2SLS) to test. IV-2SLS method is based on the assumption that although the variables in the previous period may be related to the error term, which leads to endogenous bias, the value of the lag period is not related to the error term in the previous period. Moreover, according to the research of (Kang & Sivaramakrishnan, 1995), it is considered that the lag period of the independent variable can be used as an effective tool variable. In view of this, this study chooses the lagging period of CRD and the quadratic term of lagging period as instrumental variables (L.CRD). Secondly, considering that there may be weak instrumental variables in the U-shaped relation, this study refers to (Du et al., 2023; Terza, 2018), introduced the residual of CRD (CRD_resid) as the incremental climate risk, and carried out the second set of instrumental variables.

In the Table 4.7 of column (1) and column (2), they show the results of the first stage and the second stage of the instrumental variables, respectively. Column (2) indicates regression result of the second stage, which demonstrates that the linear term coefficient of CRD is significantly negative ($\beta=-73.584$, $p<0.01$), while the coefficient of the quadratic term CRD^2 is significantly positive ($\beta=1980.482$, $p < 0.01$), and the instrumental variables can be verified by the weak instrumental variable test, which rejects the original hypothesis that there are weak instrumental variables and passes. This demonstrates that the U-shaped relationship between the ESG performance of companies and their CRD remains valid even after the potential endogenous issues have been addressed.

Table 4.7
IV-2SLS

	(1) CRD	(2) ESG
CRD		-73.584*** (-3.692)
CRD ²	20.837*** (39982440.035)	1980.482*** (5.686)
L.CRD	-0.000* (-1.900)	
CRD_resid	1.000*** (3.327e+08)	
L.CRD ²	0.000 (1.497)	
CRD ² _resid	-20.837*** (-3.980e+07)	
_cons	0.005*** (50507721.728)	9.814*** (9.315)
Controls	Yes	Yes
Industry	Yes	Yes
Year	Yes	Yes
N	9474	9474

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.6.4 Heckman two-stage method

Because not all sample companies have disclosed their climate risks to a certain extent or level, biased conclusions may result from sample selection bias. This study uses Heckman two-stage method to test verify this type of sample selection bias. In this study, the binary dummy variable (DummyESGP) is set with the median of ESGP, and if it is higher than the median, it is the group with higher ESG performance, and it is assigned with 1; otherwise, it is assigned with 0 for the first stage of Probit regression (Chae et al., 2009; Li et al., 2021), while controlling the year and industry, the results of one-stage regression are shown in column (1) of Table 4.8. It can be seen that although CRD and CRD² are not significant, the sign of the coefficients is one negative and one positive respectively, which is consistent with the main regression. Subsequently, the inverse Mills ratio (IMR) is constructed based on the first-stage regression results, and it is added to the regression model (1) as a control variable to reduce the influence of sample selection bias. The results of two-stage regression are shown in column (2) of Table 4.8. The primary coefficient of CRD is significantly negative, and the secondary coefficient is significantly positive, which meets the conditions of U-shaped curve.

Consequently, this study employs the propensity score matching (PSM) method to mitigate the endogenous issues resulting from sample self-selection bias. Firstly, dummyCRD of CRD is set, and it is divided into experimental group and control group according to whether it is greater than the median. Logit regression is conducted by using the control variable set in this study, and the tendency score of sample companies is calculated, Subsequently, regression is conducted using the matched samples. The linear term coefficient of CRD is considerably negative, as demonstrated in column (3)

of Table 4.8, and the quadratic term coefficient is also significantly negative. The U-shaped relationship between the firm's ESG performance and its CRD has been reconfirmed. After solving the possible endogenous problems, the conclusion of this study is still robust.

Table 4.8
Heckman-two stage and PSM

	(1) dummyESG	(2) ESG	(3) ESG
main			
CRD	-3.717 (-1.160)	-190.120*** (-5.371)	-103.981*** (-4.162)
CRD ²	89.361 (1.526)	5182.301*** (6.368)	2289.048*** (5.403)
IMR		76.166*** (5.683)	
dummyCRD			0.491*** (2.856)
_cons	-0.996*** (-6.278)	-97.339*** (-5.028)	10.493*** (11.446)
Controls	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	11165	11165	11134

* p < 0.1, ** p < 0.05, *** p < 0.01

4.7 Moderating Effect

The main regression results and robustness test above show that The ESG performance of companies will decrease as the CRD increases, as evidenced by the U-shaped relationship between CRD and ESG performance, but after reaching a certain threshold, the ESG performance of companies will be improved with the increase of CRD. This study examines the manner in which these significant stakeholders modify the relationship between ESG performance and CRD from the viewpoints of three distinct stakeholder engagements: media, investors, and government. Through the examination

of these moderating effects, this study aims to reveal the potential impact mechanism of different stakeholder engagement on corporate CRD behavior and its impact on ESG performance, and provide more detailed insights for understanding how companies can effectively manage their climate risks in a multi-stakeholder environment.

This study refers to Haans et al. (2016) to test the moderating effect of U-shaped curve.

4.7.1 Media perspective

Table 4.9 displays the regression results of the media perspective's moderating effect, in which columns (1) to (2) specifically discuss the influence of media attention as moderating variable on the connection between CRD and ESG performance. Specifically, the coefficient of interaction between media attention and CRD is significantly positive ($\beta=73.450$, $p<0.01$), while the coefficient of interaction with the quadratic term of CRD (CRD^2) is significantly negative ($\beta=-848.863$, $p<0.05$). This outcome indicates that the U-shaped correlation between ESG performance and CRD remains valid even after media attention is incorporated.

In this study, the research methods of Haans et al. (2016) and Zhu and Zhou (2018) were used for reference when analyzing the moderating effect of U-shaped relationship. Especially, through the in-depth analysis of the regression results of column (2), this study calculates the inflection point curvature k of the curve, where $K=ESGP''=2\alpha_2+2\alpha_4Media$.

$K=2*(5550.742-848.863*Media)$ is calculated by using specific coefficient values. On this basis, given the range of Media attention (Media), this study can further analyze the influence of media attention on the shape of U-shaped relationship curve.

In the U-shaped relationship, the curvature k of inflection point directly affects the steepness of the curve: when the value of k is large, the shape of the curve is steep; A smaller value of k makes the curve smoother. The results of this study indicate that the value of k decreases progressively as media attention increases, resulting in a flat U-shaped curve. In addition, refer to the study of Liu et al. , the value of $\alpha_1\alpha_4-\alpha_2\alpha_3$ is negative through calculation, which means that with the increase of media attention, the inflection point of the U-shaped curve moves to the right, indicating that the U-shaped connection between CRD and ESG performance is somewhat weakened by media attention.

The U-shaped relationship with moderating effect indicates that the third variable is influenced by the existence of a U-shaped connection between two variables (ie, the moderating variable) can affect the strength or shape of this relationship. In this study, There is a U-shaped relationship between ESG performance and CRD. Specifically, ESGP may initially decrease as CRD increases, but it begins to increase after a certain threshold is reached. The introduction of media attention as a moderating variable can alter the complexity and dynamicity of this U-shaped relationship.

Specifically, media attention, as an external monitoring and information dissemination mechanism, can significantly influence market performance and corporate behavior. When a company's climate risk disclosure behavior is given greater attention by the

media, the external pressure and social expectations faced by the company will increase (Borghei et al., 2023), which may prompt companies to take more active measures in ESG aspects to improve its ESG performance. Therefore, increased media attention can adjust the U-shaped connection between CRD and ESGP, making the originally steep curve flatter.

The moderating effect of media attention on CRD and ESGP may be due to the following reasons: First, due to the enhanced supervisory role of the media, companies may be more prudent in CRD to avoid negative evaluation due to insufficient disclosure, which makes the U-shaped The curve of the relationship is smoother. Second, the moderating effect may cause the inflection point of the U-shaped relationship to shift to the right, meaning that companies need to achieve higher levels of CRD before they can start to see significant improvements in ESG performance. This is because media attention delays the time for companies to obtain positive effects from disclosure, but once an inflection point is reached, companies' ESG performance will improve.

In general, the role of media attention as a moderating variable is to change the relationship dynamics between CRD and ESGP by increasing external pressure and social expectations (Li et al., 2023). By flattening the U-shaped curve and delaying the turning point, media attention delays the time for companies to benefit from CRD, but ultimately promotes companies to improve their ESG performance. This moderating effect occurs because of the power of the media in disseminating information and guiding public opinion. Legitimacy theory points out that media attention prompts companies to improve their legitimacy and transparency (Li, 2024).

Companies must pay more attention to their disclosure behaviors and sustainable development strategies when facing social and market supervision (Wu et al., 2022).

In summary, this study not only confirms the moderating effect of media attention on the U-shaped connection between CRD and ESG performance, but also further reveals how media attention affects this complex relationship through changes in the shape of the curve and the position of the inflection point. These findings highlight the importance of considering media attention when analyzing corporate CRD behavior and its impact on ESG performance, providing a new perspective for understanding and explaining corporate behavior in the context of different media attention.

4.7.2 Government perspective

The regression results of the regulatory variables from the perspective of the government as the stakeholder engagement are shown in columns (3) to (4) of Table 4.9, which show the regression results of the degree of government intervention as the regulatory variable. Among them, in column (4), the coefficient of interaction between Gov and CRD is positive but not shows significant ($\beta=500.168$); The interaction between Gov and CRD² is negative ($\beta=-12040.025$), but the coefficients are not significant. From this result, this study can see that although government intervention may have a significant impact on the connection between CRD and ESG performance in theory, this moderating effect has not been fully supported by statistics in the specific analysis of this study. This finding shows that the U-shaped connection between CRD and ESG performance has not been significantly affected, at least in the existing samples and model settings. Specifically, although the interaction coefficients between government intervention and CRD and its quadratic terms are positive and negative

respectively, theoretically this may imply that government intervention has the potential to strengthen or weaken the impact of CRD on ESG performance to some extent, but these effects are not statistically significant, which means that the role and influence of government intervention may not be as obvious as expected in the current data set.

Considering the government as the stakeholder engagement, the lack of significance of the U-shaped connection between CRD and ESG performance may be attributed to a variety of factors, including government intervention. First of all, under China's unique political and economic system, the form and intensity of government intervention are significantly different. The process of government intervention in China is often influenced by political factors (Chen et al., 2011), and there may be problems such as low efficiency (Gao, 2011), so its regulatory role is not significant statistically. Secondly, the practice of China companies in CRD may be influenced by both national policy guidance and market expectation, while there may be some lag and uncertainty in the implementation of government policies (Su et al., 2022; Zhu et al., 2021), these factors together weaken the moderating effect of government intervention. Addition to that, China is quickly developing and putting into place laws on climate change and ESG performance., and the immaturity of information communication channels, information disclosure standards and regulatory mechanisms between the government and companies may also be an important reason for the insignificant role of government intervention and regulation (Ma et al., 2018). Finally, the diversity of firm scale, industry characteristics and ownership structure in China market may also lead to the heterogeneity of government intervention effect, further affecting its statistical significance in the connection between CRD and ESG performance.

4.7.3 Investor's perspective

Table 4.9 displays the regression results of the moderating effect of investors' perspective, while columns (5) to (6) display the regression results of investors' concern as a moderating variable. Among them, the coefficient of interaction between Investor and CRD is significantly negative ($\beta = -35.965$, $p < 0.01$); The interaction between Investor and CRD² is significantly positive ($\beta = 566.024$, $p < 0.01$). After investor concern is introduced as a moderating variable, the results in Column 6 show that the connection between CRD and ESGP changes. First of all, the direct impact of CRD becomes positive ($\beta = 356.053$, $p < 0.01$), indicating that under high investor attention, the increase of CRD has an immediate positive impact on ESGP. In addition, the coefficient of the square term of CRD becomes negative ($\beta = -4811.078$, $p < 0.01$), which means that in the case of high investor concern, the connection between CRD and ESGP changes from U-shaped to inverted U-shaped.

Therefore, when investor's attention is added as a moderating variable, the original U-shaped relationship undergoes a transformation into an inverted U-shaped one. This implies that the positive impact of CRD on ESG performance will increase as the disclosure amount increases at the initial stage. However, after surpassing a specific threshold, further increase will lead to the decrease of ESG performance.

The phenomenon that the connection between CRD and ESG performance changes from U-shaped to inverted U-shaped after investors' concern is added as a moderating variable can be explained from the perspectives of information processing, market reaction and resource allocation. First of all, from the perspective of information processing, the increase of initial CRD can meet the needs of investors for firm climate

risk management information, enhance investors' trust and support for companies, and thus promote the improvement of firm ESG performance. However, when the amount of disclosure exceeds a certain threshold, excessive information may lead to an increase in the information processing burden of investors, resulting in information overload (Impink et al., 2022), which makes it difficult for investors to distinguish the importance of information and reduces the effective utilization of information (Chapman et al., 2019), thus having a negative impact on the ESG performance of companies.

Secondly, from the perspective of market reaction, when investors are highly concerned, the market is more sensitive to CRD (Cormier et al., 2011; Ziegler et al., 2011). At the initial stage of disclosure, the increased climate risk information can improve the transparency of companies, attract more investors concerned about sustainable development, and support ESG-related activities of companies. However, when the amount of information is saturated or excessive, investors may regard excessive disclosure as a signal of potential problems in the firm, or feel that the firm may pay too much attention to image building and ignore substantive ESG improvement, thus questioning the true intention of the firm and the authenticity of ESG performance, leading to a decline in investor confidence.

Finally, from the perspective of resource allocation, companies can effectively use limited resources to support ESG strategy and achieve performance improvement by increasing CRD in the initial stage. However, when the disclosure activities exceed the optimal level, it may lead to excessive concentration of resources on the disclosure activities rather than the substantive ESG improvement measures (Hoang, 2018), which

leads to insufficient allocation of resources for the substantive performance improvement of ESG, which in turn damages ESG performance.

This shift suggests that when investors pay close attention to a company's CRD, the company may be more proactive in ESG management to meet investor expectations, so when CRD increases, ESGP immediately shows a positive effect. However, as the CRD level increases further, companies may face the risk of excessive information disclosure or improper resource allocation, leading to a decline in ESGP. This result shows that investor attention can indeed moderate the connection between CRD and ESGP, and this relationship may shift from a U-shaped to an inverted U-shaped relationship under different levels of investor attention.

The importance of this moderating effect lies in that it highlights the important role of investors as key stakeholders in promoting corporate ESG practices. Highly concerned investors may prompt companies to take active ESG measures in the early stages, but if companies do not allocate resources reasonably, investor pressure may have negative effects. This finding provides important management implications for companies when formulating CRD and ESG strategies, indicating that companies should balance short-term and long-term ESG goals in consideration of investor attention to avoid the potential negative impact of excessive disclosure.

To sum up, investors' concern to joining as a moderating variable reveals the complexity of the connection between CRD and ESG performance, which shows that information disclosure strategies need to find a balance between meeting investors' needs and avoiding information overload in order to optimize ESG performance.

Table 4.9

Moderating effect

	(1) ESG	(2) ESG	(3) ESG	(4) ESG	(5) ESG	(6) ESG
CRD	-56.753*** (-2.961)	-398.770*** (-5.431)	-46.328** (-2.390)	-106.910* (-1.665)	-58.266*** (-2.988)	356.053*** (3.580)
CRD ²	1634.058*** (4.356)	5550.742*** (3.547)	1496.795*** (3.919)	2953.817** (2.317)	1700.199*** (4.453)	-4811.078*** (-2.780)
Media	1.040*** (16.730)	0.362*** (2.843)				
Media*CRD		73.450*** (4.668)				
Media*CRD ²		-848.863** (-2.537)				
Gov			22.547*** (11.923)	19.689*** (4.550)		
GovCRD				500.168 (0.979)		
Gov*CRD ²				-12040.025 (-1.233)		
Investor					0.098*** (2.829)	0.374*** (5.633)
Investor*CRD						-35.965*** (-4.300)
Investor*CRD ²						566.024*** (3.878)
_cons	5.239*** (5.636)	8.408*** (7.820)	7.384*** (7.968)	7.729*** (7.621)	8.841*** (8.941)	5.585*** (4.671)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	11165	11165	11165	11165	11165	11165
adj. R ²	0.560	0.563	0.553	0.553	0.547	0.548

* p < 0.1, ** p < 0.05, *** p < 0.01

4.8 Further research

This study also carried out a series of heterogeneity tests.

4.8.1 Environmental protection behavior

In the heterogeneity test section of this study, a binary dummy variable specifically introduced for engaging or not in environmental protection behavior was used for group regression in order to dig further into the heterogeneities of the connection between CRD and ESG performance under different corporate backgrounds. The grounding of understanding the differences in the connection between corporate CRD and ESG performance introduces environmental protection behavior to group heterogeneity. The grouping strategy identifies how the modulation of environmental proactiveness modulates this relationship to further landscapes reveal potential influence mechanisms of proactive environmental behavior on climate risk management and ESG effectiveness, providing a theory basis of disclosure and environmental tactics development differentially. It will be possible to compare, hence, whether a corporate cluster with higher proactiveness in environmental responsibility is related to CRD, enabling a more granular perspective overall. It would help to understand the complicated link between performance and company climate policies.

Columns (1) to (2) of Table 4.10 show the heterogeneity test for environmental protection behavior, presenting a significant negative linear connection between CRD and ESG performance ($\beta=-78.333$, $p<0.05$), while its quadratic term CRD^2 shows a significant positive relationship ($\beta=1792.702$, $p<0.01$), supporting the U-shaped hypothesis. Conversely, in corporations without environmental protection behavior, the

negative impact of CRD and the positive impact of CRD² are also significant, at ($\beta=-43.597$, $p<0.1$) and ($\beta=1669.191$, $p<0.01$), respectively, but the U-shaped relationship in corporations without environmental protection behavior is weaker than in those with such behavior.

The analysis results suggest that a corporation's environmental protection behavior may strengthen the nonlinear connection between CRD and ESG performance. Corporations with environmental protection behavior may initially have a negative impact on ESG performance due to their proactiveness in CRD, but as the depth and quality of disclosure improve, this relationship turns positive, forming a U-shaped curve. This is indicative of the complex and dynamic connection between the efforts in climate risk management and long-term ESG performance; it is more pronounced in corporations that are active in protecting the environment.

4.8.2 Ownership Nature

The classification according to the heterogeneity by the nature of corporate ownership is based on some fundamental differences, which may exist in resource allocation, management strategies, and responsibility responses among different kinds of corporations. The state ownership factor creates the possibility of policy orientation and social responsibility for SOEs, and by contrast, non-SOEs are usually obliged by the government, which may affect their attitudes and measures towards climate risk, thus possibly showing a heterogeneous situation in the depth and breadth of CRD. Since SOEs may face government guidance and government regulation, or at least pay more attention to environmental protection by the public, they probably take more initiative in CRD or are stronger in their environmental protection measures.

Second, the nature of the ownership may also influence the corporate governance structure of the corporation and the expectation of external stakeholders. The SOE probably faces a stricter ESG behavior due to more onerous governmental regulation and social scrutiny, but then it probably is the opposite. Non-SOEs perhaps are more aware of market-driven factors, and their ESG actions are significantly influenced by market competition and efficiency. Therefore, it can deepen the understanding of the connection between corporate ownership nature, CRD, and ESG performance, and also will make it possible to offer more effective strategies and directions to formulate effective climate change policies and to enhance corporate ESG performance under the related theoretical framework. The following not only enriches the theoretical framework of corporate ESG performance, but also provides the empirical evidence for the consideration of climate risk management by the decision-maker and manager.

This study further explores the potential heterogeneity effects of corporate ownership nature on the connection between CRD and ESG performance. By classifying the sample into State-owned enterprises (SOE=1) and non-state-owned enterprises (nonSOE=0) and conducting group regression analysis on these two distinct types of corporations, columns (3) to (4) of Table 4.10 display the heterogeneity test results for ownership nature. SOEs exhibit a significant negative relationship in the CRD term ($\beta=-156.976$, $p<0.01$) and a significant positive relationship in the quadratic term CRD^2 ($\beta=3038.556$, $p<0.01$), likewise supporting the U-shaped hypothesis. In the non-SOEs sample, although the coefficients for CRD and CRD^2 are in the expected direction (negative for CRD and positive for CRD^2), they are not significant which suggests that the nature of ownership may have significant implications on the link between CRD

and ESG performance. Only SOEs have a U-shaped link between CRD and ESG performance that is important.

The empirical analysis results indicate that the U-shaped connection between CRD and ESG performance is statistically significant within the group of State-owned enterprises (SOEs). Specifically, in SOEs, CRD exhibits a significant U-shaped curve relationship with ESG performance, meaning that ESG performance is better at the lower and higher ends of CRD, while it is relatively weaker in the medium disclosure range.

This finding may relate to the particularities of SOEs in governance structure, policy compliance, and social responsibility. SOEs are often directly influenced by government policies and objectives, potentially receiving more policy guidance and regulatory requirements in executing CRD. Initially, ESG performance may be affected due to the lack of standardization and systematization in disclosure. However, as disclosure gradually deepens and matures, SOEs might exhibit positive growth in ESG performance due to better resource allocation, government support, and attention to public image. The relationship is more significant for SOEs than for non-SOEs, possibly because the latter are more influenced by the market and other non-policy factors in CRD.

Table 4.10
Environmental protection and nature of ownership

	(1) EnvProtect	(2) Non EnvProtect	(3) Soe	(4) Non-Soe
CRD	-78.333** (-2.517)	-43.597* (-1.706)	-156.976*** (-5.825)	23.482 (0.803)
CRD ²	1792.702*** (3.241)	1669.191*** (3.104)	3038.556*** (6.341)	393.663 (0.625)
_cons	11.799***	8.381***	7.778***	13.358***

	(1) EnvProtect	(2) Non EnvProtect	(3) Soe	(4) Non-Soe
	(7.255)	(7.628)	(5.084)	(10.972)
Controls	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
<i>N</i>	3583	7582	5670	5244
adj. <i>R</i> ²	0.571	0.541	0.574	0.562

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.8.3 Regional Grouping

In the empirical study of the connection between CRD and ESG performance, considering the differences in economic development levels and environmental policies across regions in China, this research selects regional heterogeneity as a dimension for group testing. This grouping allows us to explore the potential impacts of different regional development levels and environmental governance intensities on CRD and its relationship with ESG performance, reflecting the influence of regional economic and policy backgrounds on corporate behavior.

The basis for grouping is the economic development level and the enforcement intensity of environmental policies in different regions of China (Shen et al., 2021), dividing the sample into Eastern (East), Western (West), and Central (Mid) regions. The economy is the greatest in the east, with a higher level of development and a more complete industrial system; meanwhile, the environmental policies are strictly enforced, but the west and central areas may be relatively backward.

Empirical results show that in the Eastern region, the U-shaped connection between CRD and ESG performance is significant, where the coefficient of CRD is negative ($\beta = -35.386$, $p < 0.05$), and the coefficient of the quadratic term of CRD (CRD^2) is

positive ($\beta=944.735$, $p<0.05$). This indicates that in the Eastern region, as CRD increases, ESG performance may initially decline, but after surpassing a certain point, the impact on ESG performance turns positive, forming a significant U-shaped curve.

The U-shaped relationship is only significant in the Eastern region and not significant in the Central and Western regions. This may be because businesses in the Eastern region face higher environmental disclosure requirements and social responsibility pressures, and may also possess better resources for climate risk management and disclosure (Wu et al., 2019). This may be because confront more severe environmental disclosure requirements and social responsibility pressure; the east firms at the same time also have richer resources in climate risk management and other disclosure. Meanwhile, the highly developed financial market and the mature investor may put forward the higher requirements for the corporate ESG behavior, so this U-shape relationship can be more obvious in the east area.

While the central and western firms have not reached the same high level in terms of the maturity of the CRD, or they face less pressure from the outside, the connection between CRD and ESG performance does not yet show a clear U-shaped feature. This further reflects the importance of regional development differences in corporate CRD strategies and ESG performance impact, and requires differentiation between environmental policies and corporate strategies to be framed for different regions.

4.8.4 Heavy pollution and non-heavy pollution

In the study of CRD and ESG performance of companies in China, based on the consideration of environmental impact(Wang et al., 2023), this study refers to the

method of grouping companies according to the degree of pollution, forming a heavy pollution group and a non-heavy pollution group. This classification is to explore and compare the different effects of corporate CRD on ESG performance under different environmental sensitivity conditions.

In heavily polluting companies, such companies often directly face stricter environmental regulations and higher social responsibility pressure. Therefore, the CRD behavior of heavily polluting companies may have a more significant impact on their ESG performance. The empirical results are shown in columns (4) to (5) of Table 4.11. In the heavily polluted group, the U-shaped connection between CRD and ESG performance is more significant, the negative coefficient of CRD is stronger ($\beta = -76.012$, $p < 0.05$), and the quadratic term (CRD^2) coefficient of CRD shows a stronger positive influence ($\beta = 1774.333$, $p < 0.01$).

In contrast, although there is a U-shaped connection between CRD and ESG performance in the non-heavily polluted group, its coefficient is weaker than that in the heavily polluted group. The negative coefficient of CRD is ($\beta = -58.378$, $p < 0.05$), and the positive coefficient of CRD^2 is ($\beta = 1838.066$, $p < 0.01$). This shows that although there is a U-shaped connection between CRD and ESG performance in non-heavily polluting companies, the relationship curve is relatively mild. This study also uses Chow test to test the difference of coefficients between the two groups. Through the application of Chow test, this study finds that there is a significant difference between the heavily polluted group and the non-heavily polluted group in the coefficient of CRD on ESG performance (P-Value=0.000).

These results show that companies in heavily polluting industries are more sensitive to the impact of CRD on ESG performance. In these companies, the initial CRD may lead to the decline of ESG performance due to insufficient information or failure to effectively convey it to stakeholders. However, with the improvement of disclosure level, these companies may significantly improve their ESG performance by enhancing transparency and improving environmental management. Even though this effect also happens in companies that don't contribute to pollution heavily, it may not be as strong as it is in companies that do pollute a lot because they don't have to deal with as much environmental pressure. These results show how important it is to think about how companies affect the environment and how their industry works when making corporate CRD strategies and rules.

Table 4.11
Regional group and heavy pollution group

	(1) East	(2) West	(3) Mid	(4) Pollute	(5) Non Pollute
CRD	-35.386** (-1.581)	-67.251 (-1.045)	53.638 (1.099)	-76.012** (-2.028)	-58.378** (-2.402)
CRD ²	944.735** (2.300)	2624.581* (1.663)	-72.442 (-0.079)	1774.333*** (2.885)	1838.066*** (3.383)
_cons	9.005*** (7.748)	11.975*** (5.927)	13.828*** (5.191)	12.091*** (6.655)	9.429*** (9.335)
Controls	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
N	7587	1947	1631	2918	8247
adj. R ²	0.547	0.603	0.631	0.563	0.541

* p < 0.1, ** p < 0.05, *** p < 0.01

4.8.5 Subdivision CRD

In previous studies, while assessing climate change-related risks, mostly, climate risk has been categorized into two major dimensions: physical risk and transitional risk (Ginglinger & Moreau, 2023; Stroebe & Wurgler, 2021). The physical risk of climate

is the impact on extreme climate events, and changes in the long-term trend of climate, such as the effect of natural perils like sea-level rise, extreme temperature oscillation, flood, drought, etc., on the social and economic fabric and human activities (Bua et al., 2022). In the process of shifting towards the low carbon economy, economies could encounter a host of market and financial hazards, and this would be comprised of the climate transition risk. These climate risks are emanated from factors like policy shifts, technological advancement, and alterations in market inclinations that affect firm worthiness and market constancy (Carattini et al., 2023; Monasterolo et al., 2018).

Physical risks and transition risks are the main classifications of climate risks. As argued by the study of Li et al. (2020); Sautner et al. (2023); Stroebl and Wurgler (2021). Therefore, this study classifies climate risk exposure into the physical risk disclosure of climate risk and the climate transition risk disclosure at an firm level. Since the population is made of different people, but majority Chinese, this study sets to evaluate the Chinese context by using machine learning and manual study in the classification of phrases.

Word frequency analysis is used in assessing the risk exposure arising from physical and transformational risks. Specifically, the frequencies serve as proxy variables for the measurement of the intensity of the physical and transformational risks with which each organization is confronted by measuring the frequency of those keywords in which climate change-related corporate reports generally focus. The frequency of the word associated with physical risk (PhysiRisk) relates to extreme weather events and natural disasters, such as the alteration in frequency and intensity. The frequency of words associated with transition risk (TransitRisk) is in reference to policy adjustment,

technological innovation, and market demand changes, among others. (See Appendix2 for word set classification by risk type.).

$$ESGP_{i,t} = \beta_0 + \beta_1 \text{PhysiRisk}_{i,t} + \beta_2 \text{PhysiRisk}_{i,t}^2 + \sum_{k=8} \beta_3 \text{Controls} + \sum \text{Year} + \sum \text{Industry} + \varepsilon_{it} \quad (5)$$

$$ESGP_{i,t} = \beta_0 + \beta_1 \text{TransitRisk}_{i,t} + \beta_2 \text{TransitRisk}_{i,t}^2 + \sum_{k=8} \beta_3 \text{Controls} + \sum \text{Year} + \sum \text{Industry} + \varepsilon_{it} \quad (6)$$

Among them, $\text{PhysiRisk}_{i,t}$ in model (5) is the physical risk-related variable, while $\text{PhysiRisk}_{i,t}^2$ is the square term of the physical risk variable, which is used to explore the nonlinear connection between physical risk and ESG performance. Similarly, the $\text{TransitRisk}_{i,t}$ in model (6) represents the transformation risk-related variable, and $\text{TransitRisk}_{i,t}^2$ is the square term of the transformation risk variable, which is also used to test the nonlinear connection between transformation risk and ESG performance. The set of control variables $\sum_{k=8} \beta_3 \text{Controls}$ includes other factors that may affect ESG performance, such as company size, financial leverage and profitability. By controlling these variables, this study can more accurately estimate the impact of risk variables on ESG performance. The fixed effects of Year and Industry are included in the model to control the influence of industry characteristics that do not change with time and macroeconomic or policy factors that may change with time. Finally, ε_{it} is an error term, which captures the influence of all other factors not observed in the model on ESG performance. The error term of each model is assumed to be normal distribution with zero mean and constant variance. Through these regression models, researchers can evaluate how physical risks and transition risks affect the ESG performance of companies independently and interactively with other control variables.

The empirical results of the connection between climate physical risk disclosure and ESG are shown in Table 4.12. Column (1) reports the regression results between the disclosure of climatic physical risks (Physisrisk) and ESG performance (ESGP), and column (2) reports the regression results after adding control variables, and the regression results are consistent. According to the results of column (2), the coefficient of Physisrisk is positive at 1% significance level, which means that when companies improve the disclosure of climatic physical risks, their ESG performance will usually improve. This may be because investors and stakeholders value the transparency and response measures of companies to climate risks, and think that this reflects the sense of responsibility and risk management ability of companies, thus improving the ESG score of companies. However, the quadratic coefficient PhysiRisk² is significantly negative at the 1% significance level, indicating that although an increase in physical risk disclosure initially improves a company's ESG performance, continuing to increase disclosure after reaching a certain threshold will lead to a decrease in ESG performance. This effect may be due to the fact that when the level of disclosure is very high, investors may feel that the risks faced by the firm are too high, or believe that there may be problems in managing these risks, which can have a negative impact on the ESG evaluation of the firm.

Overall, there is an inverted U-shaped connection between climate physical risk disclosure and ESG performance, indicating that an initial increase in CRD can promote an improvement in ESG performance. Much further beyond a threshold of disclosure, increased disclosure decreases ESG performance. Since the characteristics of climate physical risks are all physical risk incidents, the reasons of inverted U shaped dynamic connection between climate physical risks and ESG performance can be analyzed from

many aspects. On the one hand, this may be interpreted to mean that in the case of excessive disclosure of businesses, physical risks tend towards more serious characteristics by violating not only some specific assets, but also compromising long-term sustainability and survival prospects (Herweijer et al., 2009). In addition, excessive risk disclosure may raise concerns among investors and other stakeholders about the company's operating conditions, affecting their confidence and willingness to invest in the company (Ren et al., 2022). Physical risks cause an increase in the possibility of disclosure, and the possibility of adverse evaluation from the outside; therefore, it can create a pessimistic mood for the firm in the market and increase capital costs, which will further influence ESG performance of firms. This example shows that although transparency is an important point for increasing the corporate ESG performance, the design of the disclosure strategy must be worked out with special care to avoid unnecessary negative impact.

Furthermore, the Utest result further confirms the existence of an inverted U-shaped curve, i.e., the relationship of climate physical risk disclosure and ESG performance first increases and then decreases. The second is the ESG performance subscale regression result, which is based on the results in column (2), and is robust in the inverted U-shaped curve, as shown in columns (3) to (5). However, this is contrary to the U-shaped relationship found in the main regression between CRD and ESG performance. This difference may be due to the fact that climate physical risk disclosure and transition risk disclosure reflect the risk awareness and management measures of companies in different aspects. Physical risk disclosure may be more related to a company's transparency and ability to respond to uncontrollable natural risks, while

transformational risk disclosure may be related to a company's ability to adapt to policy changes and market transformation.



Table 4.12

Climate Physical Risk Disclosure and ESGP

	(1) ESG	(2) ESG	(3) E	(4) S	(5) G
PhysiRisk	1382.210*** (4.912)	1113.721*** (4.078)	1751.426*** (3.756)	937.261*** (3.195)	781.234** (2.338)
PhysiRisk ²	-496062.281*** (-4.887)	-420653.821*** (-4.254)	-700068.978*** (-4.030)	-273652.260** (-2.536)	-341174.987*** (-2.788)
_cons	17.775*** (33.490)	9.371*** (10.091)	-9.510*** (-6.023)	3.507*** (3.567)	39.519*** (32.330)
Controls	No	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
<i>N</i>	11165	11165	11165	11165	11165
adj. <i>R</i> ²	0.517	0.546	0.308	0.211	0.662

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The empirical results of the connection between climate transition risk disclosure and ESG are shown in Table 4.13. The regression results between climate transition risk disclosure (TransitRisk) and firm ESG performance are presented in column (1) of Table 4.12. The regression results with control variables are included in column (2), and the coefficient of TransitRisk is negatively correlated at the 1% significant level. Then Utest test was carried out, which indicated that with the increase of climate change risk disclosure, it would reduce the ESG performance of companies, but after crossing the threshold, it would improve the ESG performance of companies with the increase of climate change risk disclosure. Columns (3) to (5) of Table 13 also test the sub-dimensions of ESG performance, and the results are consistent with the results of U-shaped curve relationship in column (2).

There is a U-shaped connection between climate change risk and ESG performance, which means that the initial disclosure of climate change risk may damage the ESG performance of companies. This may be because the initial disclosure of transformation risks emphasizes the challenges and uncertainties faced by companies, such as technical upgrading, strategic change or policy adjustment, which may be regarded as short-term costs and risks, resulting in a decline in ESG performance. However, once a certain threshold is exceeded, the increase of disclosure will improve the ESG performance of the firm. This U-shaped relationship may be because, although the initial disclosure of transition risk may be regarded as the cost faced by companies, as companies disclose more relevant information, investors and other stakeholders may begin to realize the commitment and ability of companies to cope with climate change. This enhanced transparency and confidence in the future may enable businesses to better manage these risks in the long term and potentially leverage the opportunities brought about by

transformation, such as improving efficiency and innovation through new technologies or markets.

In addition, when companies disclose enough information, they may have already taken practical actions to reduce or manage these risks, which may also improve their ESG performance. Therefore, beyond a certain point, climate transition risk disclosure may begin to reflect the positive efforts of companies towards sustainable development and their ability to adapt to climate change.



Table 4.13

Climate transition risk disclosure and ESGP

	(1) ESG	(2) ESG	(3) E	(4) S	(5) G
TransitRisk	-45.529** (-2.269)	-57.512*** (-2.945)	-59.467* (-1.790)	-31.786 (-1.572)	-80.116*** (-3.305)
TransitRisk ²	1697.918*** (4.227)	1723.639*** (4.457)	2280.366*** (3.493)	1152.469*** (3.054)	1724.582*** (3.831)
_cons	18.242*** (34.947)	9.712*** (10.583)	-9.240*** (-5.947)	3.927*** (4.058)	39.852*** (32.993)
Controls	No	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
N	11165	11165	11165	11165	11165
adj. R ²	0.519	0.547	0.310	0.212	0.663

* p < 0.1, ** p < 0.05, *** p < 0.01

4.9 Summaries of Testing Hypotheses

The main point of this chapter's research findings is that hypothesis H1a was proven. They show that there is a non-linear U-shaped connection between CRD and ESG performance. The study does, however, show that the connection between the two is in the shape of a U. Once a certain level of disclosure is reached, CRD starts to have a good effect on ESG performance. However, as disclosure grows, the effect on ESG performance changes for the better. It is clear that the effects of CRD on ESG performance are very different at different times.

From the perspective of H2 Media, empirical analysis shows that the media perspective plays a significant moderating role in the connection between CRD and ESG performance. This indicates that media attention may enhance the impact of CRD on ESG performance. This will increase public knowledge of corporate climate risk management and motivate companies to be more proactive in their performance of ESG practices and ESG performance as a consequence of media paying more attention to corporate CRD, supported by H2.

No significant moderating effect of government intervention was observed in the relationship of CRD and ESG performance when analyzed H3 in the government perspective. It may be indicative of the fact that in the sample of the present study, the degree of government intervention did not significantly affect the relationship of CRD and ESG performance. It perhaps is because there is not enough direct or obvious connection between the way, intensity, or time scale of government intervention and the ESG performance of companies. Moreover, government intervention may need a

longer time span to become effective, which may be beyond the time period of observation of the present study.

It was also found that the investor perspective had significant effects on the connection between CRD and ESG performance if the H4 perspective is taken into account. As shown in H4, this means that the link between CRD and ESG performance can be changed by how worried investors are. By reading businesses' climate risk disclosures, investors may be able to get them to care more about being environmentally responsible and do better in ESG. This might be because investors are such important stakeholders that their actions and attention can have a big effect on how and what decisions are made by company management.

Based on the above analysis, this study reveals the nonlinear connection between CRD and ESG performance, and identifies the different roles of stakeholder engagements in it, providing new insights for companies to formulate effective strategies on climate change issues. Meanwhile, these findings also provide valuable theoretical and practical guidance for future research in related fields.

4.10 Chapter Summary

This chapter looks at the link between CRD and a company's ESG performance using real-world data, and explores moderating effects from three different perspectives of stakeholder engagements. This study first tests the U-shaped connection between CRD and corporate ESG performance, which means that the effect of CRD on ESG performance is not linear, but rather at some particular level an effect that affects the change of performance direction. With the low-level disclosure situation, CRD is

negatively correlated with ESG performance, but if the disclosure level exceeds the turning point, the relation between disclosure and performance will turn positive.

There are several robustness tests that are done to make sure that the U-shaped link between a more abundant CRD surface and a company's ESG performance is still valid. First, using this method, the study ensured that the discovered U-shaped relationship would not be limited by means of specific variable measures. Second, the measurement indicators of corporate ESG performance are replaced to strengthen the universal applicability of research conclusions through the test of the consistency of the U-shaped relationship under different performance evaluation methods.

The potential reverse causality and the sample selection bias are addressed using the lag regression and the Heckman two-stage regression methods, respectively, in this study. These methods can help raise the credibility of causal inference and the guarantee of the accuracy of the analysis results. In addition, to avoid the potential endogeneity problems, the present study also adopts the two-stage residual instrumental variable method (IV-2SLS) to eliminate the correlation between the independent variables and the error term, and further improve the reliability of the estimated results. Finally, the propensity score matching (PSM) technology is first used to reduce the possible selection bias due to the nonrandom distribution, and thus the stability of the result can be guaranteed.

These comprehensive robustness tests would serve to confirm the U-shape of the relationship of climate-risk disclosure with firm-level ESG performance, thereby providing a solid evidence base for this study.

Further analysis focuses on three different perspectives of stakeholder engagement: media, government and investors. It is found that media attention has a significant moderating effect on the connection between CRD and ESG performance. This means that the media, as an information intermediary, can enhance the positive correlation between disclosure and performance by raising public awareness of corporate climate action. In addition, investors' concern also shows a significant moderating effect, indicating that investors' supervision and pressure can moderate the connection between CRD and ESG performance.

However, government intervention, as a moderating variable, did not show significant influence in this study. This may indicate that in the field of climate risk management, the government's policies and measures may not have reached the level of effectively regulating firm behavior, or the appearance of this moderating effect needs longer-term accumulation and observation.

Finally, this study subdivides CRD, and discusses the connection between climate physical risk disclosure and ESG performance of companies respectively. The empirical results show that the connection between climate physical risk disclosure and ESG performance is inverted U-shaped, and the connection between climate transition risk disclosure and ESG performance is U-shaped.

To sum up, the results of this chapter emphasize the importance of considering the perspective of stakeholder engagement in the study of CRD. The significant moderating effect of media and investors' perspectives reveals the key role of stakeholder engagement in the connection between corporate CRD behavior and ESG performance.

Relatively speaking, the regulatory role of government intervention is not significant, suggesting that future research needs to further explore the mechanism of policy intervention between CRD and sustainable development of companies. The empirical analysis in this chapter provides a new perspective and evidence for understanding the complex effects of CRD and its dynamics under the influence of different stakeholders.



CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Overview of the Chapter

This study takes listed companies on the main board of China from 2011 to 2022 as the research object, and deeply discusses the connection between CRD and ESG performance of companies, and its moderating effect under the attention of media, government intervention and investors. Through empirical analysis of a large amount of data, this study reveals a complex U-shaped connection between CRD and corporate ESG performance, and further examines the moderating effects of three different perspectives with stakeholder engagements.

On the basis of the previous research, this book clarifies the role of CRD on ESG performance and the analysis of the moderating role of the stakeholder participants of firms, and investigates the different effects of this relationship under different firm natures respectively. Combining the analysis results of the previous chapters, this chapter mainly summarizes the findings and points out the implications of the rounds for Chinese corporate practice, as well as the feasible paths and suggestions to enhance the ESG performance of Chinese firms. Afterwards, on the basis of analyzing the possible research limitations, it proposes the improvement methods and directions that can be tried in future research, so as to provide certain reference and reference for further promoting the progress of related research

5.2 Recapitulations of study

As environmental problems get worse and climate change becomes a real threat, CRD and ESG performance have slowly become important issues that people care about. The legitimacy theory is used to look at the connection between CRD and ESG performance. The signaling theory and stakeholder theory are also used to look more closely at how the media, investors, and government, as examples of stakeholders, affect the connection between CRD and ESG performance. Further, the paper also investigates whether the connection between CRD and ESG performance is affected by different characteristics of firms under different firm properties. This study selects four different firm characteristics to carry out the heterogeneity study, namely: whether the firm carries out environmental protection behaviors, state-owned versus non-state-owned firms, regional distribution, and whether it is a heavy polluter. Finally, this study further investigates the categorization of climate analysis disclosure. Referring to previous studies, this study categorizes the content of CRD into climate physical risk disclosure and climate transition risk disclosure to further explore the different impacts of this different disclosure nature on ESG performance.

Therefore, this study establishes a theoretical framework unfolding with legitimacy theory, and identifies a framework of moderating effects of media attention, investor attention and government intervention based on signaling theory and stakeholder theory. This study selects the public data of Chinese listed companies with a time span of 12 years, containing 11,165 observations for 1,403 companies, and establishes a regression model for panel data through literature review and hypothesis derivation. In order to ensure the robustness of the empirical results, this study also constructs alternative variables for CRD (independent variable) and ESG performance (dependent variable)

respectively, and the results remain unchanged. In addition, one-period lag and two-period lag tests, instrumental variable method (IV-2SLS) test, Heckman two-stage test, and PSM test are conducted to ensure the robustness of the empirical results of this study and that all the constructs of the variables are valid and reliable.

In summary, this study is mainly designed to fulfill the following research objectives:

RO1. To investigate the ESG performance level of companies in China.

RO2. To test the impact of China companies' climate risk disclosure on ESG performance.

RO3. To test the moderating effect of climate risk disclosure on ESG from the perspective of stakeholder engagement.

Through the theoretical and empirical analyses in this study, this study has accomplished the above research objectives, and in the next section, this study will elaborate the research objectives and conclusions of this study in detail.

5.3 Discussion

5.3.1 The Relationship Between CRD and ESG Performance

This study collects the ESG rating data from the Bloomberg database, which is a sample of 1,403 Chinese listed companies with 11,165 observations. It is found that the ESG performance of Chinese listed companies is generally low and the fulfillment of ESG performance is poor. Specifically, during 2011-2014, the ESG performance level of Chinese companies generally remained at a low level, with no obvious upward trend.

Starting from 2015, the average ESG performance of Chinese companies showed an obvious improvement trend, and until 2022, the average ESG performance of Chinese companies maintains an upward trend year by year. Above the industry, industries with strong innovation ability have higher ESG performance levels. This study accomplishes the research objectives in RO1 through descriptive statistical analysis.

Subsequently, this study draws on legitimacy theory, and based on theoretical analysis and hypothesis development, it proposes the hypothesis that there is a U-shaped/inverted U-shaped relationship between CRD and ESG performance (H1a/H1b). Hypothesis H1a, that is, a U-shaped connection between CRD and ESG performance, is verified through the empirical analysis of building a quadratic term regression model with panel data. In this study, the variable of CRD is constructed through Python, and after building a quadratic term regression model based on panel data, Stata is used to analyze the data, and in order to verify the robustness of the conclusions, this study also uses multiple empirical methods to verify the hypotheses again after the main regression has been conducted. This study accomplishes the research objectives in RO2.

The results show that CRD makes companies' ESG performance worse in the early stages of sharing. This is because the first disclosure only talks about how the risks the company faced turned out. It doesn't go into enough detail about the strategies and steps the company took to deal with those risks, which would make investors and other stakeholders more hopeful about the company's future performance. This can be perceived by the market as potential uncertainties and challenges facing the company in the future, which negatively impacts the company's ESG performance. When the level of disclosure increases, this negative impact gradually diminishes and eventually

evolves into a positive force for ESG performance improvement. This therefore implies a higher level of disclosure. In information about climate risk, companies are recognized as more transparent and committed to risk management, thus positively affecting ESG performance.

This study finds a U-shaped connection between CRD and ESG performance, a result that provides an important addition to the existing literature. First, research by Achenbach (2021) suggests that the cost and complexity of CRD may be financially burdensome for some firms, especially small firms with limited resources. This complements the U-shaped connection between CRD and ESG performance found in this study. The initial cost investment may lead firms to exhibit lower ESG performance in the short run, which explains the downward part of the U-shaped curve.

Secondly, Kim et al. (2023) argued that CRD can significantly improve firms' environmental performance, which is consistent with the finding at the beginning of this study that firms may experience a short-term decline in environmental performance due to higher cost and resource inputs at the initial stage of CRD. However, as the level of disclosure increases further, firms' environmental performance begins to gradually improve, resulting in a U-shaped relationship. This suggests that CRD is not only challenging in the short term, but also requires firms to make sustained efforts and inputs to ultimately achieve significant improvement in environmental performance. In addition, Yang (2023) mentioned that CRD also helps to build and maintain public trust.

Therefore, combining the negative impacts in the early stage and the positive impacts of long-term disclosure in the later stage, thus forming a U-shaped relationship. This

suggests that although CRD may be challenging at the initial stage, in the long run, this strategy can bring significant environmental and social benefits to the organization. By combining these two points, this study not only validates the ideas in the existing literature, but also reveals the complex dynamic relationship of CRD in enhancing ESG performance, providing new perspectives and directions for future research.

Not only that, Huang and Lin (2022) pointed out that from a societal perspective, CRD enhances the public perception of CSR, especially in terms of actions to address climate change. The findings of this study extend this view, suggesting that as the level of corporate disclosure increases, social trust and recognition of corporations gradually grows, which not only contributes to the improvement of corporate social performance, but also has far-reaching impacts on the governance structure. In addition, Yang (2023) mentioned that CRD helps to build and maintain public trust, which is further supported by the U-shaped relationship in this study, revealing a dynamic connection between disclosure level and corporate social and governance performance.

Finally, in conjunction with Khan et al. (2021), this study further explores how CRD can influence firms' relationships with stakeholders by enhancing transparency and accountability. As firms become more transparent on climate change issues, stakeholders' trust increases, which in turn drives firms' performance in all aspects of ESG. This result suggests that CRD is not only beneficial to environmental performance, but can also further strengthen a firm's position in the market through the social and governance dimensions.

This is further illustrated by the U-shaped relationship in this study. As the level of disclosure increases, firms can not only respond to public concerns through transparent environmental disclosure, but also gradually enhance public trust in the firm. When a firm's disclosure reaches a certain level, the accumulation of public trust further promotes the firm's social and governance performance. This finding extends the research of Yang (2023), which suggests that CRD not only contributes to the improvement of environmental performance, but also promotes firms' overall ESG performance by enhancing public trust.

5.3.2 The Moderating Effect of Stakeholder Engagement

5.3.2.1 The Moderating Effect of Media

This is the initial part of the signaling theory. Companies use CRD to let others know about their efforts and promises to fight climate change. When firms disclose more information related to climate risk, they are actually sending a positive signal to investors, consumers and other stakeholders that their management is concerned about and actively addressing environmental challenges. However, the empirical results of this study show that media attention and investor attention play different moderating roles between CRD and ESG performance. This study accomplishes the research objective in RO2.

It finds that media attention moderates the U-shaped connection between CRD and ESG performance, making the U-shaped curve flatter and the inflection point shifted to the right. This result can be explained by signaling theory: when the media frequently report on a firm's CRD, this information is received and understood by a wider public. Such exposure not only increases the transparency of the firm, but also increases the

social pressure on the firm to pay more attention to its ESG performance. As media attention increases, companies' actions on climate risk management are noticed by a wider audience, and external stakeholders (e.g., consumers and communities) exert more pressure on companies to continuously improve their ESG performance. This also explains why the U-shaped curve flattens and shifts to the right, i.e., at higher media attention, firms may manifest significant ESG performance improvement only at higher CRD levels.

First, the findings validate Tsfaty et al. (2020) and Farbotko (2019) that the media is not only a purveyor of information but also an amplifier of legitimacy signals. It is found that when a firm's CRD receives high media attention, the signaling effect of such disclosure is amplified, further enhancing the firm's social legitimacy and ESG performance. This result deepens the understanding of the key role of the media in conveying and amplifying corporate legitimacy signals.

Second, this study extends the findings of past literature by further emphasizing the important role that the media (Manetti & Bellucci, 2016; Wang & Huang, 2018), as a key stakeholder, plays in shaping the connection between firms and other stakeholders. The study suggests that media attention can enhance the social visibility and legitimacy of firms by amplifying the effects of climate risk disclosure and enhancing public perceptions of firms' environmental actions. The finding of this moderating role leads to a more comprehensive understanding of the mediating role of the media in corporate stakeholder relations.

In addition, studies by Kim et al. (2023) and Li (2023) suggest that climate risk disclosure contributes to the construction of a firm's environmental image and social legitimacy, and that increased media attention further enhances a firm's social visibility and legitimacy. The findings of this study are consistent with these findings and further reveal that under high media attention, firms not only demonstrate their environmental responsibility through climate risk disclosure, but may also further enhance their environmental management and sustainability practices to meet social expectations, thereby enhancing ESG performance. In the existing research, this result adds to what is known about the link between media attention and corporate ESG performance. It also shows how important the media is as an amplifier in this process.

Finally, the study also validates N. Wu et al. (2022) and Du et al. (2016) that media attention promotes positive interactions between firms and the public, which, in turn, contributes to firms' ESG performance. The study found that media attention through climate risk disclosure makes firms' behavior in environmental management and social responsibility more transparent and open, resulting in higher market competitiveness and social image. This result suggests that firms can effectively amplify the positive impact of their climate risk disclosure by utilizing media attention, thereby achieving improved ESG performance.

In conclusion, this study's results on the moderating effect of the media not only add to the existing literature on the role of the media, but they also help us learn more about how the media can improve companies' ESG performance by making climate risk disclosures louder. This result shows how important media attention is in corporate

communication strategies. Companies should use all media platforms to get the most out of the good effects of climate risk disclosure on their ESG performance.

5.3.2.2 The Moderating Effect of Investor

The research in this study also finds that investor concern plays a different moderating role between CRD and ESG performance, and even reverses the original U-shaped relationship into an inverted U-shaped relationship. This suggests that when investors pay high attention to firms' CRD, firms may face greater market pressure at higher CRD levels, especially when significant ESG performance improvement cannot be demonstrated in the short term, and this pressure may lead to firms adopting more conservative governance strategies, which in turn affects their long-term performance. This inverted U-shaped relationship may be due to the fact that investors' confidence in firms is weakened when they see that firms have invested significant resources in CRD without significant financial returns in the short term. This is consistent with stakeholder theory, which states that investors, as important stakeholders, have expectations of corporate behavior that directly influence corporate strategic decisions.

First, the results of this study validate the signaling theory application of Farbotko (2019) that firms send positive signals to investors about their response to climate change through CRD. Investors, as important stakeholders of firms, can not only improve the transparency of information, but also enhance the legitimacy of firms in the capital market by keeping an eye on the CRD behavior of firms. This result deepens the understanding of the application of signaling theory to investor behavior and emphasizes the important role of investor attention in driving improvements in corporate transparency and ESG performance.

Second, the findings further extend the application of stakeholder theory by Wang and Cheng (2023) and C. W. Wong et al. (2021). These studies point out that investors' evaluations and investment decisions directly affect firms' access to and cost of capital. This study finds that when firms realize the high level of investor interest in climate risk and ESG-related information, they tend to proactively improve the quality and quantity of disclosure, thereby satisfying investor demand for transparency and accountability. This finding backs up the concept that investors can help close the gap between firms' ESG performance and disclosure. It also shows how important investors are in encouraging companies to be more open and responsible.

In addition, studies by Abramova et al. (2020) and Arvidsson and Dumay (2022) point out that investor concern improves the quality of corporate disclosure and serves as a watchdog in terms of corporate ESG performance. The results of this study show that high levels of investor attention to specific ESG topics motivate firms to provide more information in these areas and to take substantial actions to improve their performance, thus changing the impact of disclosure on ESG performance to some extent. The findings further expand on this literature by revealing how investor concern moderates the dynamic connection between disclosure and ESG performance by increasing information transparency and monitoring CSR performance.

In summary, this study's research on the moderating effect of investor concern complements and extends the existing literature's understanding of the critical role of investors in the connection between CRD and ESG performance by emphasizing the importance of investor concern in promoting corporate transparency, enhancing social

responsibility, and fostering long-term sustainability performance. This finding further clarifies the important role of investors as a moderating variable and provides new theoretical support for corporate legitimacy and competitiveness in capital markets.

5.3.2.3 The Moderating Effect of Government

In contrast, the findings of this study suggest that the moderating effect of government intervention between CRD and ESG performance is not significant. This finding may reflect insufficient government efforts or limited regulatory effectiveness in promoting corporate climate responsibility. Although government policies may require firms to make climate risk disclosures, in practice, firms may only make formal disclosures to comply with regulations and lack substantive actions. This is consistent with some of the literature that insufficient government intervention may not actually motivate firms to improve their ESG performance (Bonham & Riggs-Cragun, 2022; Qian, 1996), but may instead result in firms adopting responsive and superficial measures that do not contribute effectively to their actual sustainable development.

This study did not find evidence of the moderating role of government intervention in making CRD effective in improving firms' ESG performance. In examining the moderating role of government intervention on the connection between CRD and corporate ESG performance, in the particular context of China, the findings do not significantly confirm the direct moderating role of government intervention in comparison to global practices. The results actually show how complicated the link is between government policies and how markets act, and how much it changes from country to country or region to region.

In summary, this study enriches the existing theoretical framework of the connection between climate risk disclosure and ESG performance by analyzing the moderating effects of different stakeholders. Signaling and stakeholder theories provide the theoretical basis for understanding these moderating effects, explaining why media and investor attention have significant but different impacts on the connection between CRD and ESG performance, while the moderating effect of government intervention is not significant. These findings provide new perspectives for firms in formulating and implementing climate risk management strategies, as well as important references for policymakers in designing relevant policies.

5.3.3 The Heterogeneity Test

An in-depth heterogeneity test in this study shows that the U-shaped curve link between climate risk disclosure and ESG performance is very different for different types of companies. This U-shaped relationship is more important for companies that care about the environment and companies that pollute a lot. On the other hand, this U-shaped curve connection between climate risk disclosure and ESG performance is only important for state-owned companies and companies in the eastern region. These results give policymakers and business leaders important information for planning their strategies.

5.3.4 The Subdivision Research of Climate Risk on the Relationship Between CRD and ESG Performance

After categorizing the two types of climate risk disclosure, climate physical risk and climate transition risk, the relationship between climate physical risk disclosure, climate transition risk disclosure and corporate ESG performance is investigated

separately, and the results of the study found that there is an inverted U-shape connection between climate physical risk disclosure and corporate ESG performance, which implies that when a corporation discloses an increase in climate physical risk to a certain extent, its ESG performance increases, but beyond a certain point, continuing to increase physical risk disclosure leads to a decrease in ESG performance. This may be due to the fact that an excessive focus on climate physical risk disclosure may consume too many resources, thus affecting firms' performance in other ESG areas. In contrast, the U-shaped connection between climate transition risk disclosure and ESG performance suggests that initially increasing transition risk disclosure may negatively affect ESG performance due to increased uncertainty and adjustment costs, but as firms adjust and optimize their strategies, increased transition risk disclosure will help to improve their ESG performance.

5.4 Research Implication

5.4.1 Theoretical Implication

By exploring the U-shaped connection between climate risk disclosure (CRD) and ESG performance, this study provides a number of important theoretical insights. These insights not only expand existing research on CSR and sustainability, but also provide new perspectives and ideas for the development of related theories.

This study proposes a connection between climate risk disclosure and ESG performance based on legitimacy theory, and further explores the moderating roles of the media, investors, and the government as key stakeholders in this relationship by applying signaling theory and stakeholder theory. Through this synthesis of multiple theoretical

perspectives, this study contributes important theoretical insights to research in the field of CSR and sustainability.

First, this study deepens the application of legitimacy theory in corporate sustainability research. Legitimacy theory emphasizes that the legitimacy of corporate behavior is the basis for sustainable business operations, and that corporations enhance their legitimacy by gaining social recognition and support through climate risk disclosure. The findings of this study show a U-shaped connection between CRD and ESG performance, which suggests that firms may face the challenge of cost and resource investment when disclosing at the initial stage, resulting in a short-term decline in ESG performance. However, as the level of disclosure increases, firms' legitimacy gradually increases, which in turn leads to an increase in ESG performance. This finding enriches the role of legitimacy theory in explaining firms' environmental behavior, especially in providing new perspectives on how firms gain and maintain social legitimacy through environmental disclosure.

Second, this study further explains the behavioral performance of firms under different stakeholders' concerns through signaling theory. Signaling theory suggests that firms communicate their internal states and future intentions to the outside world through disclosure. This study's research finds that media and investor attention significantly moderate the connection between CRD and ESG performance, reflecting how firms send signals to these key stakeholders through their climate risk disclosures, thereby affecting their legitimacy and market performance. Specifically, media attention amplifies firms' disclosure signals, flattening the U-shaped relationship and shifting the inflection point to the right, suggesting that firms can only achieve significant ESG

performance gains at higher levels of disclosure. In contrast, investor attention may reverse the U-shaped relationship to an inverted U in some cases, suggesting that firms may face greater market pressures and short-term challenges under high levels of investor attention. These findings extend the application of signaling theory in the field of CSR, revealing how firms respond to the expectations of different stakeholders through disclosure strategies.

Also, this work adds greatly to the collection of research on how to use stakeholder theory. Stakeholder theory says that for long-term sustainable growth, businesses need to balance and meet the needs of different types of stakeholders. The study goes on to show how the media, investors, and government play different roles and have different effects on the link between CRD and ESG performance. The results show that investors and the media have a big impact on how the CRD-ESG performance link is shaped, but government involvement doesn't have a big impact. This discovery makes us rethink the government's role in encouraging businesses to be environmentally friendly. It also gives us new ideas about how to use stakeholder theory in various situations.

Finally, the theoretical insights in this study not only enrich the existing research on legitimacy theory, signaling theory and stakeholder theory, but also provide a theoretical basis for how firms can develop and optimize their climate risk disclosure strategies in the context of global climate change. Through the comprehensive application of these theories, this study provides a new theoretical framework and empirical support for how companies can enhance ESG performance, market competitiveness and social legitimacy through effective disclosure strategies.

In summary, this study uses legitimacy theory, signaling theory, and stakeholder theory together to look into the complicated link between climate risk disclosure and ESG performance. It also gives new theoretical perspectives and important theoretical insights for the development of related theories.

5.4.2 Practical Implication

This study shows how important it is for companies to deal with climate change and improve their ESG performance by looking at the U-shaped link between climate risk disclosure and ESG performance. The study suggests the following real implications for companies to keep in mind as they work to improve their ESG performance:

When companies want to improve their ESG performance, they should first fully think about their unique goal in protecting the environment and being socially responsible. Companies must disclose climate risks if they want to show they care about the earth and also if they want to show the world, they are positive about climate change. Companies should not only share important data with the public, but they should also use that data to show they care about social justice and long-term growth. This will help them build a good reputation with the public and other important people, and they should not ignore their environmental duties in order to focus only on making money. Companies should understand that disclosing climate risk is not only the law, but also a key way to improve their long-term ESG performance. In the beginning stages of disclosure, companies may have to spend a lot of money and time, which could put extra pressure on their finances or cause their ESG performance to temporarily drop. However, as the level of disclosure keeps going up, companies will gain trust from the public and the market, which will greatly improve their ESG performance. Therefore,

companies should adhere to a long-term climate risk management and disclosure strategy, focusing not only on current compliance needs, but also on future sustainable development goals.

Second, companies need to balance the economic and environmental paths when improving ESG performance. The effectiveness of climate risk disclosure depends not only on the economic value of the disclosed content, but also on its impact on society, environment and culture. Firms should fully consider the cultural significance and social impact of environmental protection in information disclosure to avoid over-emphasizing economic benefits and neglecting the fulfillment of environmental responsibility, which in turn leads to the damage of the image of firms in the public. Firms should closely integrate climate risk disclosure with ESG strategies and fully utilize CRD as an effective means to enhance ESG performance. It was found that CRD and ESG performance are related in a way that benefits both parties. This means that companies can improve their performance in protecting the environment, being socially responsible, and having good corporate governance all at the same time while encouraging climate risk disclosure. Companies can make the best use of their resources, become more competitive, and have a bigger impact on society by combining CRD and ESG policies.

Third, the key for firms to enhance ESG performance lies in internal and external synergy. Internally, firms should focus on building a positive corporate culture, enhancing employees' recognition and initiative of environmental responsibility, and forming a conscious motivation to promote climate risk management from the inside; externally, firms should keep in close contact with stakeholders, and obtain ESG-related

information in a timely manner through active communication, so as to respond quickly to external needs and expectations, thus realizing the effective enhancement of the firm in the field of ESG. Corporate managers should realize that although climate risk disclosure may initially face pressure on funds and resources, the process actually brings long-term rewards and advantages to the company. By continuously improving and optimizing climate risk management, companies can not only respond to external regulatory and market requirements, but also use this disclosure to improve their overall ESG performance, thus taking advantage of global sustainability trends. Consequently, in order to attract additional investors and partners and improve their market competitiveness, companies should implement an effective disclosure strategy and actively engage in climate risk management to demonstrate their dedication to environmental and social responsibility.

Fourth, firms can combine climate risk disclosure with their overall strategy, integrating ESG performance with their environmental governance and market competitiveness enhancement strategies. Through such a combination, firms can not only reduce the cost of environmental responsibility fulfillment, but also improve the effectiveness of disclosure, so that climate risk management becomes a viable method for firms to improve their competitive edge. Firms should emphasize communication and interaction with stakeholders, and enhance relationships with investors, customers, and the public through climate risk disclosure. As the level of disclosure increases, firms can utilize this platform to demonstrate their positive actions in addressing climate change and fulfilling their social responsibilities, and garner the confidence and backing of external stakeholders. This not only contributes to the improvement of firms' ESG performance, but also promotes their performance and brand value in the capital market.

Fifth, when enhancing ESG performance, firms should fully utilize the influence of relationship networks, especially in climate risk disclosure, to enhance their voice and influence in environmental responsibility by building a good firm-society relationship network. The government and other stakeholders can also make use of these relational networks to exert influence on the ESG performance enhancement of firms, thus promoting the harmonious development and comprehensive benefits of the whole society.

In summary, the U-shaped connection between climate risk disclosure and ESG performance suggests that firms can ultimately realize a “Win-Win” situation in the process of investing resources in CRD. Companies should strategically recognize and implement climate risk disclosure as a core element of ESG performance and sustainability to ensure long-term success and growth in a changing market and regulatory environment.

5.5 Limitations and Recommendations for Future Research

While this study provides valuable insights in theory and practice, it has some unavoidable limitations.

First, this study focuses on the Chinese market and Chinese companies, and therefore its findings may have some geographical limitations. Because the levels of climate risk and economic development vary across different countries and regions, different legal environments, and different cultures, the results of this research may not be entirely applicable to companies in other countries or regions. Therefore, future studies may

consider cross-country comparisons under a global sample to explore the generalizability and regional specificity of the connection between climate risk disclosure and ESG performance.

Second, this study adopts a quantitative research methodology, which is mainly based on publicly available data from existing databases for data analysis and processing. While this approach can handle a large number of samples and provide statistical evidence, it may overlook some qualitative details and deep-rooted factors, such as China's long-standing Confucian culture and internal strategic decision-making process. In the future, researchers could use qualitative methods like case studies or interviews to look into how these things affect the link between climate risk disclosure and ESG performance.

In conclusion, this study looked at how the media, the government, and investors affected the link between climate risk disclosure and ESG performance from the signaling theory and stakeholder theory points of view. However, it's possible that other significant stakeholders or factors were missed from this study. Some of the factors that may influence this relationship include partners in the supply chain, consumer attitudes and the competitive environment. Therefore, the scope of adjustable variables could be further expanded in subsequent studies to examine more factors that may influence the impact of climate risk disclosure.

Overall, despite these limitations, this study provides useful insights for understanding the complex connection between climate risk disclosure and firms' ESG performance, as well as providing inspiration for future research directions.

Without research and demonstration work, the ESG system will not be able to grow in the long run. First, increase ESG research efforts. With the in-depth promotion of the ESG concept, China has successively set up a number of research institutes with ESG as the main naming element, but the depth and breadth of the research still have more room for development. Research institutes should dig deeper into the problems and challenges of the ESG system, keep abreast of the times, pay attention to the changes in the government's macro strategies and the governance needs of firms at the micro level, and study and put forward useful strategies to help the growth of the ESG system. Secondly, this study will actively carry out ESG demonstration and publicity work. Many domestic companies are paying more attention to climate change and putting ESG ideas into practice. However, due to insufficient publicity and inaccurate targets, companies that actively fulfill their social responsibilities are "walking in the night". Government departments and trading organizations should increase ESG demonstration and publicity efforts, so that more companies actively practicing ESG concepts "on the list".

5.6 Conclusion

This research looks at the connection between CRD and ESG performance. It finds that the two are linked in a way that looks like a U. The results show that companies may have trouble with costs and investing resources when they first start to disclose climate risk. This could cause their ESG performance to drop in the short term. However, as the level of disclosure rises, so does the firms' social legitimacy and market recognition. This leads to a big change in their ESG performance, which is a win-win situation for

everyone. This finding gives us a new way to think about how companies can best take the path to sustainability through sharing when it comes to climate change.

This study makes a theoretical addition in a number of ways. First, this study expands on the use of legitimacy theory in corporate sustainability research by showing how disclosing climate risk can improve a company's ESG performance by making it more believable to the public. The second part of the study shows how signaling theory and stakeholder theory can be used in new ways. It shows how three important groups of stakeholders—investors, the government, and the media—play a part in changing the link between CRD and ESG performance. It is found that media and investor interest can have a big effect on how this relationship works. This adds to our theoretical understanding of how corporations disclose information and what effects it has. This study opens up a new area of research in the field of corporate social responsibility (CSR) by showing that the link between CRD and ESG performance is not linear. It also highlights how complicated and changing companies are in the process of sustainable development.

In terms of practical insights, this study suggests that companies should use climate risk disclosure as an important strategic tool to enhance ESG performance. Although firms may face greater resource pressure at the initial stage, in the long run, climate risk disclosure can help enhance their social image and market competitiveness, thus promoting the continuous improvement of ESG performance. Companies should also integrate CRD with their overall ESG strategy, take full advantage of media and investor attention, and optimize their disclosure strategy to maximize its positive impact on ESG performance. Managers should recognize that while climate risk disclosure

may not be immediately effective in the short term, through sustained efforts, companies can achieve significant returns in the future and enhance their competitiveness in global sustainability.

However, there are some limitations to the research in this study. For example, the limitations of the data sample may affect the generalizability of the results, and differences across regions and industries may also have different impacts on the connection between CRD and ESG performance. Therefore, future research could further explore the impact of these factors on the findings or introduce more stakeholder perspectives to analyze the complexity of this dynamic relationship. By expanding the scope of the study, scholars can gain a deeper understanding of the mechanisms by which climate risk disclosure works in different contexts and provide more targeted recommendations for corporate sustainability on a global scale.

In sum, this study emphasizes the critical role of climate risk disclosure in promoting corporate sustainability. Firms should continue to strengthen their climate risk management and information disclosure in the future, and further enhance their market competitiveness and social influence by optimizing their ESG strategies. This will not only help businesses reach their goals for sustainable growth, but it will also help the world deal with the problem of climate change in a good way.

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Appendix A

Word Frequency of Climate Risk Constructed by Machine Learning

English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words
Disaster	灾害	Torrential Rain	暴雨	Temperature	气温	Underground Water	地下水	Regenerate	再生
Earthquake	地震	Tornado	龙卷风	Rain	降雨	Flood Situation	汛情	Reduce Harmful Emissions	减排
Typhoon	台风	Hail	冰雹	Temperature	温度	Earth's Surface	地表	Environmental Protection	环保
Bore/Seaquake	海啸	Flood	洪灾	Rain Water	雨水	Store Water	蓄水	Green	绿色
Drought And Flood	旱涝	Rain And Snow	雨雪	Rainy Season	雨季	Energy Conservation	节能	Low Carbon	低碳
Extreme	极端	Freeze	冰冻	Rainfall Of a Given Area	雨情	Energy	能源	Reduce Consumption	降耗
Very Bad	恶劣	Blizzard	暴雪	Precipitation	降水	Clean	清洁	Fuel	燃料
Waterlogging	内涝	Winter Injury	冻害	Be Overcast and Rainy	阴雨	Ecology	生态	Save Water	节水
Gale	大风	Drought	干旱	Rainy	多雨	Environment	环境	Photovoltaics	光伏
Dust And Sand	沙尘	Drought	旱情	Extremely Cold	极寒	Transform	转型	High-Efficiency	高效
Hurricane	飓风	Torrential Rain	强降雨	Winter	冬季	Solar Energy/Power	太阳能	Transform	改造
Frost	霜冻	Flood	洪水	Flood Season	汛期	Upgrade	升级	Oil Consumption	油耗
Flooding	水灾	Bitter Cold	严寒	High Humidity	高湿	Circulate	循环	Power Consumption	电耗
Windstorm	风暴	Wind-Borne Sand	风沙	Regimen	水情	Utilization Ratio	利用率	Energy Consumption	能耗
Mud-Rock Flow	泥石流	Climate	气候	Water Level	水位	Nuclear Power	核电	Efficacy	效能
Landslide	滑坡	Weather	天气	Illumination	光照	Wind Power	风电	Intensive	集约
Lingdong	凌冻	Moist	潮湿	Be Short Of Water	缺水	Natural Gas	天然气		
Snow Disaster	雪灾	Water Temperature	水温	Arctic-Alpine	高寒	Synergy	增效		

English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words
Drought	旱灾	Lower Temperature	The 降温	Cold Wave	寒潮	Fuel Oil	燃油		
Waterlogging Due To Flooding	洪涝	Cold	寒冷	Subside	沉降	Efficiency	效率		



Appendix B

Word Frequency of Climate Risk Constructed by Past Literature

English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words
Heat Wave	热浪	Cold Season	冷季	Thunder And Lightning	雷电	Flood	洪灾	Fuel	燃料
Sea Level Rise	海平面上升	Cool Summer	凉夏	Polar Vortex	极地漩涡	Fog	雾	Renewable Sources Of Energy	再生能源
Flooding	水灾	Leng Xia	冷夏	Polar Vortex	极涡	Frost	霜冻	New Energy	新能源
Wildfire	野火	Degree Days	度日数	Precipitation	降水	Tropical Storm	热带风暴	Clean Energy	清洁能源
Storm Correlation	风暴相关	Drought	干旱	Rainfall	降雨量	Bore/Seaquake	海啸	Alternative Fuel	替代燃料
Storm Loss	风暴损失	Drought	旱灾	Rain Water	雨水	Green Winter	暖冬	Solar Energy/Power	太阳能
Storm Activity	暴风雨活动	Earthquake	地震	Rain	降雨	Water Level	水位	Natural Gas	天然气
Extreme Weather	极端天气	Extremely Cold	极寒	Severe Winter	严冬	Weather	天气	Nuclear Power	核电
Snow	雪	High-Temperature	高温	Snow	下雪	Mountain Fire	山火	Wind Power	风电
Heating Season	采暖季	Flood	洪水	Snowfall	降雪量	Wind And Hail	风雹	Photovoltaics	光伏
Flood	大水	Waterlogging Due To Flooding	洪涝	Snow	降雪	Typhoon	台风	Energy Conservation	节能
Ice Disaster	冰灾	Fossil Fuel	化石燃料	Snowstorm	暴风雪	Carbon Dioxide Emission	碳排放	Ecology	生态
Air Pollutant	空气污染物	Global Warming	全球变暖	Windstorm	风暴	Energy Efficiency Utilization Ratio	能源效率	Wind Power Generation	风力发电
Air Pollution	空气污染	Greenhouse Gas	温室气体	Rainstorm	暴风雨	Efficacy	利用率	Energy Technology	能源技术
Air Quality	空气质量	Hail	冰雹	Dust Storm	沙尘暴		效能	Synergy	增效

English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words	English Words	Chinese Words
Carbon Dioxide	二氧化碳	Heating Season	供暖季	Temperature	气温	Oil Consumption	油耗	Reduce Harmful Emissions	减排
Carbon Dioxide Emission	碳排放	Rise	涨潮	Arctic	北极	Power Consumption	电耗	Environmental Protection	环保
Climate Change	气候变化	Intense Heat Of Summer	酷暑	Atmosphere	大气	Energy Consumption	能耗	Green	绿色
Climate Risk	气候风险	Hurricane	飓风	Coldest	最冷的	Energy	能源	Low Carbon	低碳
Cold Season	寒季	Lightning Strike	雷击	The Coldest	最寒冷的	Fuel Oil	燃油		

