



Financial Risk Caused by Climate Change and Its Countermeasures

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Abstract. In 2022, high-temperature weather continued in many parts of the world. Natural disasters occurred frequently in the world, thus causing huge economic losses. Not only that, water transportation, tourism, and other industrial economies have been seriously affected. Based on the existing literature and information, this paper specifically points out which economic and financial risks will be caused by climate change and puts forward specific measures on how to deal with the financial risks caused by climate change from the perspectives of insurance financial institutions, various government departments, and investors.

Keywords: climate change · financial risk · response · measures

1 Introduction

In 2022, the global climate was very abnormal, with the highest temperature in 71 national weather stations breaking the historical extremes. For example, based on the NOAA's Climate Divisional Database, the Contiguous U.S. May - July Maximum Temperature Anomaly (degrees F) from 2012 to 2022, as shown in Fig. 1, according to the statistics, the Land temperature in June 2022 was the second highest on record, while the global ocean temperature was the fifth highest on record. Both Asia and Europe saw the second hottest June on record, with North America and Africa seeing their seventh and tenth hot June on record, respectively. Under the condition of high temperatures, there are also some cases of death caused by heat stroke in many parts of China. On August 17, 2022, (China) National Climate Center's WeChat official account released news that according to the recent monitoring and assessment of (China) National Climate Center, considering the average intensity, impact range, and duration of high-temperature heat wave events, the comprehensive intensity of regional high-temperature events from June 13, 2022, to August 17, 2022, has reached the highest level since 1961 when complete meteorological observation records were available in China. [1] Today, we are not only coping with the invasion of many variant strains of the novel coronavirus epidemic, but we are also being tested by the unprecedented high-temperature environment, and at the same time, we have to bear the economic losses caused by the high-temperature weather.

Climate change will continue to pose a serious threat to human production, life, and economic development in the coming centuries. At the same time, the financial industry has suffered huge losses from the risks brought by climate change. With the

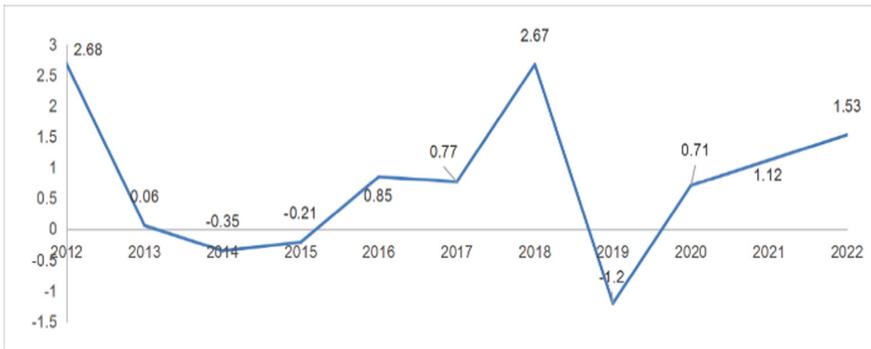


Fig. 1. Contiguous U.S. May – July Maximum Temperature Anomaly (degrees F) from 2012 to 2022. Source from the NOAA’s Climate Divisional Database

change in climate environment, the risk of sudden impairment or loss of assets in regions sensitive to the risk of climate change will increase. These risks will directly or indirectly cause a large number of physical asset losses, which in turn will lead to the devaluation of the collateral of financial institutions and increase their exposure to climate risks, which will ultimately affect the normal operation of financial markets. According to the 2022 Global Risk Report released by the World Economic Forum in early 2022, climate change has rapidly emerged in the form of droughts, fires, floods, lack of resources, and loss of species. In the next 10 years, the health of the earth will be a major concern: environmental risks are considered one of the five most critical long-term threats to the world and the most potential damage to human beings and the earth, “failure of climate action”, “extreme weather” and “loss of biodiversity” are the top three most serious risks [2]. In a speech delivered on June 9, 2022, the chairman of the IPCC said: that human activities have warmed the earth at a rate never seen before in at least the past 2000 years, and we are moving towards global warming of 1.5 °C in the next two decades.

According to the Report of the Recommendations of the Working Group on Climate-related Financial Information Disclosure released by TCFD in June 2017, climate-related risks are divided into two categories: one is physical risks, i.e. risks associated with the physical impacts of climate change, and the other is transition risks, i.e. risks associated with the transition to a low-carbon economy [3]. Physical risks cover the risks caused by sudden and disastrous weather-related events and the risks brought by long-term global climate change, such as floods, mountain fires, and sea level rise; The transition risks mainly refer to the risks arising from the transition of human beings from a fossil fuel-based economy to a clean energy-driven economy, such as economic risks and reputation risks caused by changes in policies and laws during the transition. It can be seen from this that the impact of climate-related risks on the world economy cannot be ignored. Therefore, it is urgent to prevent the financial risks caused by climate change.

Recently, various countries have successively released reports on the risks brought about by climate change and the stability of financial markets. Examples are the Climate-Related Financial Risk Report released by the U.S. Financial Stability Oversight Committee (FSOC) in October 2021 [4], and the Climate-related Risks and Financial Stability reported by the European Central Bank in May of this year [5]. However, countries and

banks are still facing challenges in taking effective precautions against the financial risks caused by climate change.

The purpose of this paper is to point out the related financial risks caused by climate change and to propose how countries and banks should prevent this financial risk. The objective of this paper is to provide readers with a snapshot of the current climate finance situation and to summarize the relevant literature.

2 Various Economic and Financial Risks Caused by Climate Change

Regarding climate change, the goal of the Paris Agreement (United Nations, 2015) is “to keep the global average temperature rise well above the pre-industrial level of 2 °C and strive to limit the temperature rise to 1.5 °C above the pre-industrial level”. However, it is not an easy task to achieve this goal. Many countries have formulated a series of policies to adapt to their national development. Among them, China is the country with the highest carbon dioxide emissions in the world, in 2018, the “Research Report on Climate Change Risks and Carbon Social Costs” and the “Research on Energy Emission Scenarios for China to Achieve the Global 1.5 °C Target” were released. The two reports pointed out the necessary path for the development of the 1.5 °C temperature control target. The reports believed that to achieve the temperature control target, China’s energy sector’s carbon dioxide emissions should peak between 2015 and 2020, and enter a rapid decline phase after 2020. After 2020, the annual decrease in carbon dioxide should be about 384 million tons, which is higher than the annual emission reduction of about 240 million tons from 2014 to 2016. The risk of climate change and the social cost of carbon emissions in China are also analyzed and evaluated. In the process of achieving this temperature control target, many industries are facing transformation, which will bring about the transformation risk proposed by TCFD.

In financial markets, financial risks can generally be classified into five categories: market risk, credit risk, operational risk, liquidity risk, and other risks. Other risks include strategic risk, reputation risk, etc. However, at present, the financial risks of climate change, namely: physical risks and transition risks, have not yet been included. The reason is that climate-related risks are a relatively young field, and we know little about studying the market’s response to climate change, so climate-related risks need additional attention. As early as 2016, relevant research believed that if the average temperature on the earth’s surface increased by 2.5 °C from the pre-industrial level, about 2% of the world’s financial assets would be converted into risk assets. According to a report jointly released by the European Central Bank (ECB) and the European Committee on Systemic Risk (ESRB) in July 2022 on how climate shocks affect the European financial system, the research results show that climate risks can quickly harm companies and banks, and when financial market losses are caused by sudden repricing of climate risks, they may affect investment funds and insurance companies and lead to corporate defaults and bank credit losses [6].

2.1 Causes Natural Disasters and then Causes Economic Losses

Climate change, especially in today's extreme weather, is extremely easy to cause natural disasters. The occurrence of natural disasters will not only cause casualties but also cause a lot of economic losses. According to the Report on the Status of Climate Services in 2020 released by the World Meteorological Organization, over 11,000 climate-related natural disasters have occurred in the world in the past 50 years, killing 2 million people and causing global economic losses as high as US\$ 3.6 trillion. Although records show that the death toll from natural disasters is decreasing year by year, economic losses are increasing year by year. Natural disasters in the first half of 2022 were mainly weather-related disasters. Extreme tornadoes in the United States caused billions of dollars of losses, as reported by Sigma in March 2021, the global economic losses caused by natural disasters in 2020 were US\$ 190 billion. Based on a 10-year moving average, the loss grew by 1.6% between 1970 and 2020, based on GDP standardization. [7] According to the 2022 Global Assessment Report released by the United Nations on April 26, 2022, by 2030, the social and economic progress achieved globally will be exhausted and 1.5 disasters will occur every day. In addition, the economic impact of disasters is more severe in developing countries, where the average annual GDP loss due to disasters is 1%, compared with 0.1–0.3% in developed countries. The Asia-Pacific region has the highest share of capital, with an average annual GDP loss from disasters of 1.6%. From the perspective of China, as an agricultural country with 7% of the world's arable land, the continuous high temperature has brought severe challenges to China's agricultural production. Since July 2022, the water levels in the mainstream of the Yangtze River, Dongting Lake, and Poyang Lake are 5.2 to 7.9 m lower than the corresponding period of the previous year, the lowest in the same period of history. Many rivers in the country are almost dried up due to the high-temperature climate, and water supply in many areas is difficult. According to the statistics of China's emergency management department, the affected area of crops has reached 55.5 million mu due to the impact of the current drought, among which autumn crops and forest and fruit crops in the growing period have suffered great economic losses. In addition, from the perspective of behavioral finance investment, Professor Raghavendra Rau once said that when he invests, he may look at whether the region where the company's managers are located will often suffer from natural disasters, as this may affect the management of the company by the manager and thus affect the company's share price. It can be seen that the occurrence of natural disasters will also affect investors' investment decisions, thereby affecting the financial industry.

2.2 The River Drying up Will Affect the Waterway Transport and then Cause Economic and Financial Losses

As a result of the impact of climate change, high-temperature weather has caused many rivers to stop flowing. So water transportation is no longer possible. As a result, some countries that rely on water transportation are greatly affected. The Rhine River has been the economic backbone of Switzerland, Germany, and the Netherlands for centuries. Once the Rhine River runs dry, it will block the flow of large amounts of diesel and coal. As early as 2018, the German industry lost nearly \$3 billion because the Rhine could not

deliver goods and fuel on time. According to Albert Jan Swart, a transport economist at ABN Amro Bank NV, bad conditions are expected to drag down the region's economy, far worse than the € 5 billion (\$5.1 billion) hit by the Rhine traffic problem in 2018. At present, Germany is trying to use trucks instead of freighters to transport goods. However, the cargo capacity of 40 trucks can only match the capacity of a freighter. As a result, the price of fuel in Germany has also increased due to an insufficient supply of fuel. At the same time, the heat wave also affected other rivers across the African continent. French energy giant electricity de France (EDF) said that due to the high water temperature, the output of its two nuclear power plants would be impacted. Not only that, but the Danube from Central Europe to the Black Sea is also drying up. The Rhone and Garonne rivers are too hot to effectively cool the nuclear reactors. The economic impact of the drying up of these rivers on all countries in the world is extremely serious.

2.3 Climate Change Will also Seriously Affect the Local Tourism Economy, Resulting in Financial and Economic Imbalance Phenomenon

Climate change will also affect the tourism industry. According to the data released by the Ministry of Transport of the People's Republic of China, as shown in Table 1, from 2019 to July 2022 (after the outbreak of COVID-19), the number of tourists traveling decreased significantly. Apart from the epidemic, people's desire to travel was significantly reduced due to the influence of high-temperature weather, and they mostly chose regions with lower temperatures for sightseeing. Therefore, a large number of tourists poured into cities with a cool climate. According to the data on the "Where to Go" platform, as shown in Fig. 2, the hotel bookings around NO.1 Xishuangbanna Starlight Night Market, NO.2 Yuxi Fuxian Lake Scenic Area, NO. 3 Beijing Universal Studios, NO.4 Dali Shuanglang Scenic Area, NO. 5 Lijiang City, NO.6 Diqing Dukezong Ancient City, NO. 7 Zhangjiajie City, NO. 8 Zhoushan Centipede Dock, NO. 9 Weihai East Coast, and NO.10 Zhangjiajie Forest Park increased significantly year-on-year in the summer of 2021. Take Sanya City in the Hainan Province of China as an example, the number of tourists received in this area during the Spring Festival in winter is generally higher than that in July during the summer vacation peak season, as shown in Fig. 3.

This is because the climate in Hainan Province is still warm in winter, and many tourists from the cold regions in the north choose to go there for winter shelter. From this, we can see that the climate will affect people's travel choices, and therefore it will affect the tourism economy of various places.

3 How to Deal with Economic and Financial Risks Caused by Climate Change

3.1 From the Perspective of Insurance and Financial Institutions

Possible economic losses from climate risks can be minimized by way of insurance or reinsurance. Torsten Jeworrek, a member of the Munich Reinsurance Management Committee, said on July 28, 2022: "The IPCC has issued a report warning that insurers need to adjust their loss models to adequately assess changing risks. Loss prevention is

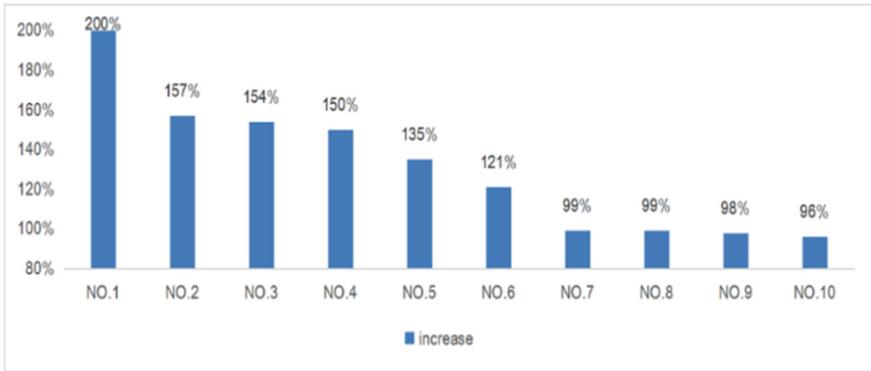


Fig. 2. Summer hot business districts increase TOP10 compared to 2021. Source from Where to go

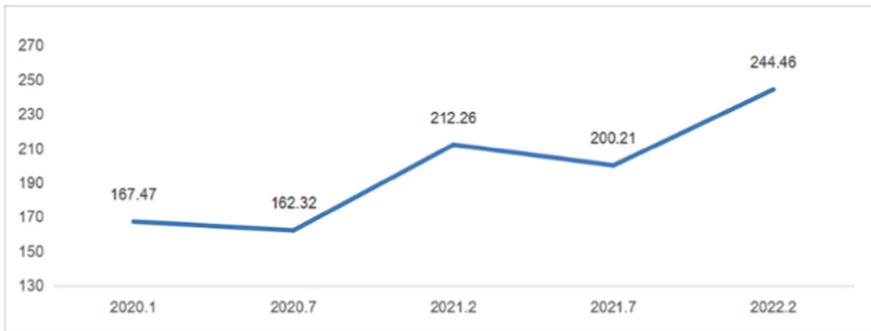


Fig. 3. Number of tourists in Sanya, Hainan, China. Source from Sanya tourism, culture, radio, television and ports Bureau

Table 1. Total traffic volume of China’s four modes of transportation (unit:10,000 people).

Particular year	Total passenger volume	Railway passenger volume	Passenger transport volume by water	Civil Aviation domestic route traffic volume	Total transportation volume
2019	581,890	35,570	2514	5271.4	627,264
2020	410,539	20,737	1399	3894.1	436,569
2021	473,226	30,847	1944	4898.5	510,916
2022	399,172	22,615	1701	3384.9	426,873

Source from Ministry of transport of the people’s Republic of China

Table 2. Natural catastrophes in the first half of 2022.

	The first half of 2022	The first half of 2021	The first half of 2020	The first half of 2019
Overall losses in US\$ bn	65	105	100	87
Insured losses in US\$ bn	34	47	33	21
Fatalities (approx.)	4,300	2,300	3,300	4,700
Jul-22				

Source From Munich Re NatCatSERVICE

an essential component of mitigating the economic effects of climate change. Because the insurance coverage rate in developing countries and emerging countries is far below 10%, there is still much room for improvement even in industrial countries.” [8].

Although for insurance financial institutions, the occurrence of extreme weather may lead to a higher payout ratio in the market, which will eventually affect the institution and even lead to a decline in its credit rating. According to the data of Munich Re, as shown in Table 2, natural disasters in the first half of 2022 caused losses to the insurance industry of up to US\$ 3.4 billion. According to the data, the losses of the insurance industry in respect of natural disasters have increased year by year in recent years, which means that the cost of the insurance industry is also increasing year by year, but this trend should be reversible. According to Veronica Scotti, global chairman of Swiss Re’s public interest risk business, the economics of Swiss Re’s climate adaptation research shows that by using positive economic externalities to finance sustainable projects and using Risk absorbing capital in sustainable industries and practices, up to 65% of the risks can be met through appropriate adaptation measures [9]. In the first half of 2022, severe thunderstorms in the United States caused a total of \$22 billion in losses, with an insured loss of \$17 billion. In early April 2022, a thunderstorm front destroyed more than \$3 billion worth of assets, but three-quarters of them were insured, illustrating how high insurance densities can help absorb the economic impact of natural disasters. [8].

All insurance and financial institutions should first raise their awareness and strengthen research on ESG risks such as climate change, the results of Inna Khovrak’s comparative analysis of six ESG ratings based on four main criteria show that a corporate ESG risk assessment is the most appropriate rating for assessing an insurer’s ability to manage its sustainability using an ESG-driven approach [10]. In recent years, more and more managers have incorporated ESG viewpoints into their day-to-day management. The benefits of ESG information can be quantified as an increase in the maximum Sharpe ratio, and the company’s value can be enhanced through ESG management, thereby driving the improvement of other aspects of a business. Not only can we use Lasse Heje Pedersen, Shaun Fitzgibbons, and Lukasz Pomorski’s ESG efficient frontier to make responsible investment choices by deriving optimal portfolio boundaries and corresponding sets, but also [11]. Relevant climate risk management products can also

be designed to meet market demand. Strengthen risk assessment and management, and develop a risk identification and management assessment platform more suitable for the current situation. It should also introduce appropriate response methods based on the characteristics of its institutions. For example, Swiss Re has its unique assessment method: each company will receive an ESG rating based on its relative position in the industry of ESG standards. The ratings are based primarily on corporate information disclosure, professional organization data (including NGO data), and media sources of public information. The rated company can review the assessment results and can also correct the public information. Some ESG ratings share the same marking system as those of institutions such as Standard & Poor's, ranging from AAA (best rating) to CCC (lowest rating) [9]. Conclusions from Boffo & Patalano, When measured by market capitalization, the availability of ESG ratings is higher, favoring companies with larger market capitalizations to earn ESG scores, thereby keeping them away from less resourceful peers [12]. In general, companies with higher ESG ratings are generally better at predicting potential risks and will be more conducive to the creation of long-term value for the company. But these days, it can be a bit difficult to judge how one company is performing versus another based solely on ESG ratings, as different ESG rating agencies use different rating methods.

In response to the global climate change challenge, a series of insurance and reinsurance services can provide the funds needed to protect against natural disasters caused by climate change, post-disaster compensation, and increase insurance solvency. These are all effective ways for insurance/reinsurance to quickly help the government or enterprises or individuals to recover from the pre-disaster life.

3.2 From the Perspective of Various Countries and Government Departments

1. Professional departments such as the Climate Change Related Financial Risk Committee should be set up and an appropriate supervision and management system should be established. All levels and departments work together to identify and manage climate-related financial risks from the top down and take actions at the national level to mitigate possible related financial risks. Enhance the popularity of the climate-related risk assessment system, strengthen communication with departments or enterprises involved in climate-related work, and intervene in the entire financial market from the macro-level as a whole to minimize the impact of financial risks caused by climate change on the entire market.
2. Taking climate change-related risks into account in the macro-prudential management framework. Due to the characteristics of climate risk, its impact on the macroeconomy and the whole market financial system is far-reaching. Compared with traditional risk, climate risk is highly uncertain, and it is difficult to predict its impact on the ecological environment and productive economic activities. Relevant research results show that climate change will cause macro-financial risks, such as production reduction in the corporate sector, accumulation of non-performing loans in the financial sector, and reduction of employment level in the residential sector [13]. Therefore, the government may consider adding climate change-related risks to the macro-prudential management framework to monitor the possible macro-financial

risks. This method can also play a role in encouraging financial institutions to assess and manage their climate risks.

3. Effective prevention and response to climate-related financial risks through international cooperation and exchanges. Today, organizations such as the Green Financial Cooperation Network (NGFS) between central banks and regulators and the Climate-Related Financial Information Disclosure Working Group (TCFD) have been set up around the world. Because each country has different levels of economic development, its ability to cope with risks is also different. Dealing with climate change is not the responsibility of a single country, but requires the world to unite and take joint actions to jointly deal with the crisis. Some institutions have taken the lead in starting international cooperation. For example, Swiss reinsurance companies have participated in many activities in China. PPP Cooperative projects, including major natural disaster insurance schemes in rural areas of Heilongjiang and Shaanxi provinces and Maoxian County, Sichuan Province, also signed contracts with several Chinese insurance companies [9].
4. Strengthen the disclosure of information related to climate risks. It is proposed to issue laws, regulations, and policy documents on the disclosure of climate change information, clarify the content, information disclosure subject, social obligations, and specific responsibilities of climate risk-related information, and readjust the disclosure standard of existing policies to achieve appropriate comparability and consistency in the disclosure of climate-related financial risks. This will promote data sharing and data analysis among all levels and departments of climate-related financial risks.
5. Banking institutions are required to improve credit management systems. International organizations proposed to reduce the weight of green credit risk to guide the transformation of credit resources to green and low-carbon fields (Bolton et al., 2020). Due to the impairment of assets caused by climate risk, the profitability of enterprises will decrease and the balance sheet will deteriorate, thus the operation of relevant enterprises will be interrupted. As a result, the banks will have an increase in default probability and default loss of credit business, which will lead to relevant credit crises and thus threaten the credit system of banking institutions. Credit is the main means of profit for commercial banks. Whether a banking institution's credit system is perfect or not determines whether the bank's economic business is trustworthy.
6. Conduct relevant scenario analysis and stress testing to assess possible future climate-related financial risks. The TCFD 2021 Status Report released by TCFD said. In the past year, the number of companies disclosed under the TCFD recommendations has grown rapidly, rising from 4 percentage points from 2018 to 2019 to 9 percentage points from 2019 to 2020. For the first time, more than 50% of the examined companies have disclosed their climate-related risks and opportunities. Despite the rapid growth in the number of enterprises disclosing information, the overall information disclosure work needs to be further improved [14]. Departments at all levels should develop detailed scenario analysis plans and flexibly use emerging instruments of climate-related financial risks, such as innovative use of climate-value-at-risk risk measurement to estimate the number of losses incurred by companies, portfolios,

or financial markets as a result of climate change over a specific investment period. [15] Climate stress testing and associated scenario analysis must be addressed over a longer period to address the concretization of climate risks. However, at present, the difficulty of climate change lies in converting physical risks and excessive risks into these macros or microeconomic and financial variables, so that they can be easily inserted into the usual stress testing tools.

3.3 From the Perspective of Investors

Having a reasonable investment philosophy can help investors make correct decisions about climate change. Responsible investing today increasingly emphasizes research techniques for positive environmental, social, and governance factors. Responsible investing is broadly interpreted to include issues related to corporate social responsibility, corporate purpose, sustainable finance, and environmental, social, and governance policies and measures. It also covers shareholder activism, the impact of divestment and social screening funds, board governance issues and shareholder voting, and impact investing. The results of Miriam von Wallis & Christian Klein show that many studies acknowledge that SR investments outperform traditional investments, and some studies even find a negative correlation between SR investments and traditional investments, and studies also point out the impact of SRI activities implemented by companies on their financial performance is positive influence [16].

Although public and private sources of climate finance have increased significantly in recent years, there is still a long way to go before the scale of financing is expected to meet the financial risks posed by climate change. Investors should actively respond to the global call for low-carbon transformation, pay attention to climate-related changes, choose to invest in low-carbon stocks and bonds, choose to invest in companies that are willing to use alternative energy sources or are committed to reducing energy consumption, to drive the market to deal with the financial risks associated with climate change. Just as Stefano Giglio, Bryan T. Kelly, and Johannes Stroebe discussed various ways to incorporate climate risk into macro-financial models, they then reviewed the pricing of climate risk for a wide range of asset classes, including real estate, equities, and fixed-income securities, and in this context, they also discussed how investors can use these assets to build portfolios that hedge climate risk [17]. Climate financing is now on the rise, but the pace of increase is not fast. Apart from individual investors, social and non-governmental enterprises, charitable organizations and other organizations need to speed up the pace of investment together to minimize the related financial risks caused by global climate change.

4 Conclusion

This paper provides an in-depth analysis of the economic impact of global climate change. First, it clarifies the severe economic situation faced by countries around the world under the current climate change environment and proposes climate-related reports issued by global organizations, such as the “Climate-Related Financial Information”

issued by TCFD. Disclosure Task Force Recommendations Report and the World Economic Forum's 2022 Global Risks Report. Then, it specifically pointed out two types of climate-related risks, namely physical risks, and transition risks, and explained their occurrence. At the same time, it was pointed out that climate risks will have an impact on the financial system, which may affect investment funds and insurance companies and even lead to corporate defaults and Bank credit losses. Then it will be introduced that climate change will easily cause natural disasters, not only crops will suffer great economic losses, but even affect the decision-making of investors to a certain extent; Countries that rely on water transportation suffer heavy economic losses. Some countries are good at using waterways to transport raw materials such as diesel, coal, etc., but now because the raw materials cannot be delivered in time, the price of fuel oil has also been rising, which will greatly drag down the economy of the region; It will have an impact on the tourism industry because the climate will affect people's travel choices and travel desires. This paper analyzes the data on the number of tourist trips in China in recent years. The results show that most tourists tend to choose places with comfortable temperatures to play, which will lead to The formation of financial and economic imbalances.

The following is a brief introduction to the specific measures that this paper focuses on from three perspectives on how to address the economic impacts of climate change.

First, from the perspective of financial institutions in the insurance industry, in addition to mitigating risks through reinsurance and reinsurance, it is also possible to strengthen research on ESG risks, master ESG rating methods, apply ESG perspectives in daily management, and use ESG effectively. Frontiers and other now hot strategies to absorb the economic shock of climate change.

Second, from the perspective of various countries and government departments, establish appropriate supervision and management systems, and take actions at the national level to mitigate possible financial risks; include climate change-related risks into the macro-prudential management framework, and monitor possible macroeconomic Financial risks; use international cooperation to prevent and respond to relevant climate financial risks, and establish relevant organizations with a global perspective to jointly address climate change risks; strengthen the disclosure of relevant information, and promote data sharing and analysis across all levels and departments; Testing and scenario analysis to correctly assess the financial risks that may be faced in the future, and it is also recommended to flexibly use emerging tools for climate-related financial risks in the assessment to concrete climate risks.

Third, from the perspective of investors, this paper believes that investors should first have a responsible investment philosophy, and also emphasizes the importance of responsible investment. At the same time, it calls on investors to invest in low-carbon stocks and bonds, and carry out investment transformation to drive the market. to address climate-related financial risks. Finally, it is pointed out that the current pace of climate financing is slow, and investors need to accelerate the pace of investment in order to minimize the related financial risks caused by global climate change.

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