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Transmission Mechanism and Macroprudential Policy Framework of Climate Financial Risk: Theoretical Construction and Application Challenges

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ABSTRACT

This article takes climate financial risk prevention and control as the core of research, uses literature review, case analysis and other methods to clarify the transmission mechanism and specific path of climate physical risk and transformation risk, explain the core essence and coordination mechanism of the macro-prudential policy framework of climate financial risk, and analyse the application challenges faced by the existing policy framework in practice in combination with the actual domestic supervision. Based on China's institutional environment, drawing on the experience of international supervision, I put forward targeted improvement suggestions: build an independent, legalised and normalised macro-prudential framework for climate transition risks, pilot the implementation of the internal rating method of climate risks of financial institutions, and build a macro-prudential linkage mechanism for cross-border transformation risks. The research can provide reference for optimising the macro-prudential supervision system of climate financial risks in China, preventing systemic climate financial risks, and helping the coordinated promotion of green transformation and financial stability.

KEYWORDS

Climate Financial Risk; Macroprudential Policy; Physical Risk

1. INTRODUCTION

1.1. Research Background

Under the background of global warming, extreme high temperatures, floods, droughts and other natural disasters occur frequently, causing a significant impact on the production and operation of the real economy and the asset security of the financial system. At the same time, in the process of promoting the global carbon neutrality goal, changes in low-carbon transformation policies and technological innovation have posed new challenges to the financial field. Extreme climate changes and instability have had a great impact on financial markets. Based on data from more than 1,600 regions around the world for 40 years, Kotz et al. (2024) predicts that extreme weather will reduce the total global economy by about 19% in the next 26 years, and climate financial risks have become an important factor threatening financial stability. As the world's largest developing country, China urgently needs to build a targeted risk prevention and control policy framework.

1.2. Research Significance

At the theoretical level, this article systematically integrates climate economics and financial stability theory, fills some gaps in the study of climate financial risk transmission mechanism and macro-prudential policy adaptability, and enriches the theoretical system of climate risk and macro policy in the financial field. At the practical level, in view of the actual dilemma of climate financial risk prevention and control in China, specific suggestions are put forward to optimise the whole framework, provide theoretical reference for regulatory departments to formulate climate-related prudential policies, and help prevent and resolve systemic financial risks.

1.3. Research Content

This paper focuses on the transmission mechanism and macro-prudential policy framework of climate financial risks. The core content includes three parts: First, sort out the literature to explain the cross-market and cross-departmental transmission path of climate physical risks and transformation risks, and reveal the transmission logic of climate financial risks. Second, based on literature and international cases, distil the core goals of the climate-oriented macro-prudential policy framework and analyse its coordination mechanism with monetary, fiscal and industrial policies. Third, in combination with China's institutional environment, identify the application challenges of the current framework in terms of policy coordination, risk identification, tool adaptation, etc., and put forward practical improvement suggestions.

1.4. Research Methods

This study adopts literature research method, case analysis method and comparative research method. Literature research method: systematically sort out the theory and cutting-edge research of climate financial risks and macro-prudential policies, and build an analytical framework. Case analysis method: select the typical practises of the European Union, the United States, Singapore, etc. to summarise the regulatory experience. Comparative research method: compare the differences between Chinese and foreign systems, identify shortcomings in combination with China's national conditions and put forward an optimisation path to ensure that the conclusion is both theoretical and practical.

2. TRANSMISSION MECHANISM OF CLIMATE FINANCIAL RISK

2.1. Definition and Classification of Climate Financial Risks

Extreme Weather/ Weather Changes - Damage to Physical Departments - Deterioration of Financial Assets - Systemic Financial Risks

Climate financial risk specifically refers to the instability and uncertainty brought about by climate change and the policy adopted by humans to mitigate climate change in the financial sector, which is a kind of macro risk. Climate change first produces physical risks and transformational risks. The former refers to the losses caused by natural disasters caused by climate change, and the latter refers to the losses caused by carbon reduction policies adopted by human beings in response to climate change and change investment behaviour. The two affect financial assets and liabilities through various ways, and further evolve into climate change. Various financial risks that endanger the stability of the financial system. (IPCC WGIII, 2022)

Physical risk refers to extreme weather events (such as typhoons, earthquakes, etc.); the risk of direct loss caused by long-term climate change (such as sea level rise) to enterprise production, residents' lives and financial assets, including asset damage, income decline and other types.

Transformation risk refers to the risk of depreciation of high-carbon assets and decline in industry profits caused by policy regulations, technological progress, changes in market expectations and other factors in the process of low-carbon transformation, which will affect the asset allocation and risk status of financial institutions (such as the impact of carbon tax policies on high-energy-consuming enterprises).

2.2. The Transmission Path of Physical Risk

Carbon Neutralisation/Environmental Protection Policy and Technological Change - Impact of High-energy-consuming Industries - Exposure of Financial Risks

Existing research has proved that physical risks directly affect the production and operation of enterprises. For example, natural disasters cause damage to enterprise sites and factories, interruption of supply chain, depreciation of fixed assets, a sharp decline in operating income, and tight cash flow; the agricultural field will be more likely to be affected by extreme weather, and the quality and output of agricultural products will be severely affected by weather reasons. The profits of agricultural-related enterprises were damaged by the heavy decline. Affected by the climate, the economic operation status of the real economy has deteriorated, which in turn affects the stability of the financial system.

Climate financial risks will increase liquidity risk and credit risk. The operating difficulties of enterprises will lead to a decline in the repayment capacity, the non-performing loan rate of financial institutions will rise, and the quality of credit assets will deteriorate. At the same time, banks will shrink the investment of credit indicators in the impacted industries because they are unable to repay loans, further exacerbating the financing difficulties of enterprises and forming a vicious circle. For example, the 2024 annual report of Alltrust Property Insurance Company Ltd. shows that the annual insurance business revenue realised was 6.94 billion yuan, down from 7.213 billion yuan in the previous year. The net profit also turned from profit to loss to -550 million yuan, and its solvency adequacy ratio has also decreased. Due to the heavy damage of the southeast coast by the super typhoon Yagi, the wind power and photovoltaic assets were seriously damaged, and the company's compensation surged by 767 million yuan. Extreme weather has led to huge post-disaster losses, and the large loss of the company's capital has led to a decline in its solvency, resulting in credit risks and rising financing costs.

At the macro level, the physical climate risks at the enterprise level, which are closely connected between banks and enterprises, will be transmitted to the banking system through bank-enterprise lending (Zhao et al., 2025). The general decline in asset prices, the contraction of credit, and the deterioration of confidence will lead to tight liquidity and may trigger regional or industry-specific financial risks.

2.3. The Transmission Path of Transformation Risk

Carbon taxes, production restrictions, energy consumption control, new energy substitution, environmental protection penalties, etc. have impacted high-carbon industries by the government and technology. For example, the costs of coal-fired power, cement, chemical and other industries will soar due to environmental protection policies, and the substitution of new technologies will shrink market demand. The transformation risk will cause high-carbon assets to strand, and the profitability and financing capacity of enterprises will decline, resulting in a sharp increase in liquidity risk and credit risk. For example, Peabody Energy Co. (BTU), the world's largest private coal company, faced a triple blow of policy, market and technology in 2016, and the risk of transformation led to its bankruptcy and liquidity collapse. In the filing documents submitted to the U.S. Securities and Exchange Commission, Peabody said that they had deferred the interest payment of two loans, triggering a 30-day grace period. If the payment is not made within 30 days, the relevant loan will be declared default. The interest of these two loans is the semi-annual interest due in September 2020 and should be paid on March 15 with a scale of $21.1 million; and the semi-annual interest of $50 million should be paid on March 2022 due on the same day. Peabody said in February that it would use the balance of its $1.65 billion revolving credit line. Affected by the news of possible bankruptcy, Peabody's stock price plummeted by nearly 40% before the market on the 16th, returning to the level of about $2.5 per share. Peabody is the world's largest private coal enterprise, operating 26 coal mines in the United States and Australia. At that time, Peabody had lost money for nine consecutive quarters, and its loss in 2015 reached $2 billion. Peabody revenue drops by nearly 24% in 1st 3 quarters of 2016.

At the macro-financial system level, if the proportion of high-carbon assets is too high, it may lead to a decline in the capital adequacy ratio of banks, a deterioration of the balance sheets of financial institutions, regional financial instability, and an increase in financial vulnerability (Yang et al., 2024).

2.4. Cross-risk Transmission

Physical risks and transformation risks do not exist in isolation. The two overlap each other and amplify the impact of risks. Régis et al. (2024) proposed double materiality for the first time in the study, proving that the two types of risks amplify and cross-infect each other, significantly raising the credit risk and financial stability pressure of banks in the Eurozone. Marcin et al. (2026) empirically proved that the two types of risks significantly lower the credit rating of enterprises and push up the bond spread, resulting in a compound effect of 1+1>2. When an enterprise or industry is exposed to a high-carbon structure and a high geographical climate at the same time, revenue, asset value and cash flow are exposed to risks in many aspects, and the probability of default increases. Expectations and negative feedback will circulate. Frequent extreme weather will accelerate the tightening of market expectations and policies. High-carbon assets will be sold in advance. Tight financing will make enterprises unable to prevent and reduce disasters, and physical risk losses will further expand.

3. MACRO-PRUDENTIAL POLICY FRAMEWORK FOR CLIMATE FINANCIAL RISKS

3.1. Core Objectives of the Policy Framework

In the study, D'Orazio and Popoyan (2023) clarified the core goal of the macro-prudential policy framework from the perspective of climate financial risks. Its primary purpose is to prevent systemic financial instability caused by climate-related risks, resolve external and systemic hidden dangers brought about by climate transformation risks and physical risks, and make up for the shortcomings of micro-prudential supervision that only focuses on the risks of individual financial institutions and ignores the risks of the overall system. Secondly, by optimising and adjusting regulatory tools, guide the allocation of financial resources to the green low-carbon field, curb the "brown lock-in" effect caused by the excessive clustering of high-carbon assets, and help the low-carbon transformation process. At the same time, the framework is also committed to improving the resilience of the financial system to climate risks, reduce the vulnerability of the financial system to climate impact through differentiated supervision, risk exposure control and other means, take into account the dual demands of financial stability and green development.

3.2. Policy Tools

In the field of climate financial risk prevention and control, the academic community has carried out multi-dimensional research on the adaptive application of macro-prudential policy tools. D'Orazio and Popoyan (2023) 's research system summarises and analyses several types of mainstream tools: differentiated capital requirements, industry exposure restrictions and concentration limits, climate stress tests, liquidity tools related to green assets, and the combination of information disclosure and macro-prudential supervision.

In view of the systemic and external characteristics of climate-related risks, relevant scholars have explored the low-carbon optimisation path of traditional regulatory tools. They put forward differentiated capital requirements, industry exposure control, climate special stress testing and other tools. These tools can be applied to climate financial risk management after adaptation and adjustment. There is no need to build a new regulatory framework, while taking into account financial stability and green development orientation (D'Orazio & Popoyan, 2023). In the study, Chan et al. (2024) carried out a special analysis of the macro-prudential policy tools adapted to climate risk management for the coordinated goal of green transformation and financial stability. The core macro-prudential tools mentioned in the study include credit exposure restrictions in high-carbon industries, reducing the excessive dependence of the financial system on high-carbon assets by restraining the scale of banks' lending to carbon-intensive industries, and preventing the concentration of transformation risks. Differentiated capital adequacy requirements, adjust the risk weight according to the carbon intensity of assets, implement more relaxed capital accrual standards for green assets, and raise capital requirements for high-carbon assets, so as to guide bank credit resources to lean towards the green field. At the same time, there are also transformation risk credit constraint tools to control asset price fluctuations and excessive accumulation of risk exposure caused by the low-carbon transformation of the financial system. At the same time, the study points out that such macro-prudential tools are not implemented alone. In conjunction with green monetary policies, they can better play the role of risk prevention and control and guiding green investment, and maintain the stable operation of the financial system while smoothly promoting low-carbon transformation.

3.3. Policy Governance and Coordination Mechanism

Existing research has proved that macro-prudential policy is a key link in dealing with systemic financial risks in climate and can make up for the shortcomings of monetary policy, fiscal policy and micro-supervision. All kinds of tools should be used in combination, step by step and internationally coordinated to avoid distortion or regulatory arbitrage caused by a single tool (D'Orazio & Popoyan, 2023).

It is necessary to build a management system with clear powers and responsibilities, upper and lower linkage, internal and external coordination, and closed-loop control: in terms of the top-level structure, we should build a multi-level policy governance structure with central coordination, departmental coordination and practical implementation, set up special management institutions for climate financial risks, and coordinate the responsibilities of the central bank, the Securities Regulatory Bureau, the Ministry of Finance, the Development and Reform Commission and other departments. Formulate a unified national system of climate financial risk prudential supervision rules. Driven by the carbon peaking and carbon neutrality goals, the normalisation of carbon emission reduction constraints makes the transformation risk in the process of economic green transformation a new focus of macro-prudential governance. Existing research shows that the coordinated governance of macro-prudential policies and carbon emission reduction policies is the key path to resolve the risk of transformation and ensure economic and financial stability. Through theoretical analysis and empirical testing, Wang et al. (2023) pointed out that it is difficult to effectively block the transmission of high-carbon sector risks to the financial system with a single-reliance administrative directive-based carbon emission reduction policy, and it is necessary to build a coordination mechanism between macro-prudential policies and carbon emission reduction constraints. The mechanism advocates integrating environmental and climate risks into the macro-prudential management framework. Through differentiated supervision, dynamic risk early warning and incentive constraints and other tools, the concept of green low-carbon is embedded in the whole process of financial resource allocation, so as to maintain the stable operation of the macroeconomic and financial system while achieving the goal of carbon emission reduction.

According to the China Financial Stability Report 2025 released by the People's Bank of China, it set up a special chapter for the first time to systematically analyse climate-related financial risks, integrate them into the overall governance of financial stability, and build a full-chain processing system of "risk identification-monitoring and evaluation-prudential management-market constraints-international coordination", marking the transition of China's climate financial risk management from pilot exploration to institutionalisation and normalisation.

4. APPLICATION CHALLENGES FACING THE POLICY FRAMEWORK

4.1. Practical Challenges

In the practice of maintaining financial stability and preventing systemic risks, macro-prudential policies face multiple realistic constraints and application challenges. Its core contradictions are concentrated in the three dimensions of policy coordination, risk identification and tool adaptation. The People's Bank of China (2026) clearly stated in the Report on the Implementation of China's Monetary Policy in the Fourth Quarter of 2025 that although the Macro Prudential and Financial Stability Commission has been integrated and the management system has been improved. However, macro-prudential policies still need to address cross-departmental coordination barriers, insufficient risk penetration, limited tool flexibility and other challenges.

From the perspective of policy coordination, the coordination mechanism between macroprudence and monetary policy, fiscal policy and industry supervision has not been fully rationalised. The report points out that it is necessary to strengthen the consistency of macro-policy orientation and do a good job in counter-cyclical and cross-cyclical adjustment. However, in practice, short-term conflicts of different policy goals, the difference in the time lag of tools and the misalignment of the implementation rhythm make it difficult to form a synergy between the countercyclical adjustment of macro-prudential policies and the total regulation of monetary policies, affecting the effectiveness of policy implementation. For instance, in the balance of stable growth and risk prevention, macro-prudential risk constraints and the loose orientation of monetary policy are prone to differences in target priorities and weaken policy synergy.

Turning to the perspective of risk identification, the cross-market, cross-industry and cross-border risk transmission of the financial system has accelerated, while the risk penetration ability of the macro-prudential monitoring system is still insufficient. The report emphasises that it is necessary to strengthen risk monitoring and assessment from the perspective of macro, reverse cycle and infection prevention. However, the existing framework lags behind the identification of hidden risks and cross-cutting risks in shadow banks, non-bank financial institutions, cross-border capital flows and other fields. The early warning ability needs to be improved, and it is difficult to accurately grasp the rhythm and transmission path of risk evolution.

As for the perspective of tool adaptation, although the macro-prudential management toolbox continues to be improved, there are still problems of single tools and insufficient flexibility in dealing with differentiated scenarios such as real estate financial risks, capital market fluctuations, and liquidity pressure of small and medium-sized financial institutions. The report proposes to improve the toolbox of macro-prudence and financial stability management. However, some tools have a long transmission chain and high implementation costs, which makes it difficult to quickly respond to dynamic changes in regional and industry risks, which makes it difficult to accurately match the strength and timing of policy intervention.

In summary, the application challenge of macro-prudential policies is essentially a comprehensive problem of institutional coordination, risk governance and tool innovation.

4.2. Recommendations

In view of the above shortcomings, combined with the international frontier practice and the domestic institutional environment, we can build a perfect path that has not been fully implemented in China from the following aspects.

First, accelerate the construction of an independent macro-prudential framework for climate transformation risks, and legalise and normalise it. The European Union has fully integrated climate risks into the macro-prudential framework and carried out regional stress tests. BCBS released 18 principles to promote global regulatory convergence. Although China has included climate risk in

MPA assessment, it has not yet established an independent and statutory climate financial risk sub-module, and it is still combined with traditional financial risk assessment. First of all, it is recommended to add a "special score for climate transformation risks" in the macro-prudential assessment system, and to assess indicators such as exposure to high-carbon industries, sensitivity to carbon price fluctuations, and the completion of transformation planning. Secondly, promote the revision of the PBC Law (Law of People's Bank of China), clearly include climate financial risks in the scope of statutory supervision, and give PBC (People's Bank of China) and NFRA (National Financial Regulatory Administration) the legal authority to coordinate supervision.

Second, implement the pilot of the Internal Climate Risk Rating Method (IRB) for financial institutions. The Federal Reserve and the Bank of England allow large institutions to carry out climate scenario analysis pilots and explore the application of quantitative models. Current situation in China: China still measures climate risks by the standardised method designated by the regulatory authority. The pilot of the internal rating method has not been liberalised, and the accuracy of risk measurement is insufficient to match the actual risk of the institution. By liberalising the pilot of the internal rating method, the accuracy of risk measurement can be improved, making the macro-prudent capital requirements closer to the real risk level of the institution, and avoiding the loss of efficiency caused by one-size-fits-all supervision. Then a rating verification and backtest mechanism can be established, which will be jointly reviewed by PBC and NFRA. Qualified ratings can be used to calculate risk-weighted assets and capital adequacy ratios. For institutions that adopt the internal rating method and perform well, give capital preferences or refinancing support to encourage refined risk management.

Third, establish a macro-prudential linkage mechanism for cross-border transformation risks. The European Union promotes cross-border climate information disclosure and regulatory coordination, and BCBS promotes global regulatory convergence. At present, China's macro-prudential policy mainly focuses on domestic risks. It has not yet established a cross-border climate risk supervision and coordination mechanism with countries and major trading partners along the Belt and Road Initiative. It is difficult to prevent the impact of cross-border carbon leakage and capital fluctuations. It is recommended to sign a memorandum of cooperation on climate financial risk supervision with ASEAN and countries along the Belt and Road Initiative to establish a cross-border risk information sharing, joint stress testing and crisis disposal mechanism. Then promote the mutual recognition of cross-border green financial standards, include assets that meet China's green classification standards in the preferential scope of macro-prudential management of cross-border capital flows, and guide the orderly flow of green capital. At the same time, participate in international platforms such as G20 and NGFS to promote the formulation of globally unified climate risk measurement and disclosure standards, and enhance China's voice in global climate financial governance.

The above proposals are all operable and belong to the institutional arrangements that have not been implemented or are only in the research stage in the current domestic macro-prudential framework. In the future, we will further improve the central and local coordination mechanism, improve the risk monitoring model, enrich differentiated prudential tools, promote the deep integration of climate risks and macro prudential policies, improve the resilience of the financial system to cope with climate risks, improve the effectiveness and adaptability of macro prudential policies, and build a strong financial stability defence line.

5. CONCLUSION AND PROSPECT

This article systematically analyses the transmission path of physical risks and transformation risks in climate financial risks, and reveals "Extreme Weather/ Weather Changes - Damage to Physical Departments - Deterioration of Financial Assets - Systemic Financial Risks" and "Carbon Neutralisation/Environmental Protection Policy and Technological Change - Impact of High-energy-consuming Industries - Exposure of Financial Risks" The cross-market and cross-departmental chain transmission logic clarifies the macro-prudential policy framework of climate financial risk with risk monitoring, prudential restraint and policy coordination as the core. The study found that at present, China's framework still faces application challenges such as cross-departmental coordination barriers, insufficient risk identification accuracy, limited tool adaptability and weak cross-border governance. Based on this, this paper puts forward three targeted improvement suggestions: first, accelerate the construction of an independent climate transition risk macro-prudential subframework and promote its legalisation and normalisation; second, pilot the implementation of the internal climate risk rating method of financial institutions to improve the level of risk measurement; third, establish a macro-prudential linkage of cross-border transformation risks. Mechanism to prevent external risk transmission. The above proposals not only fit the characteristics of China's financial system, but also can effectively make up for the shortcomings of the existing framework and provide a feasible path for coordinating financial stability and green transformation.

Future research can be further deepened from three aspects. To begin with, quantitative verification can introduce Dynamic Stochastic General Equilibrium (DSGE) to empirically test the policy effect of the climate risk subframework and internal rating method proposed in this paper, and quantify the inhibitory effect of different tool combinations on risk transmission. Next, refine the scenario, focus on the transformation of high-carbon industries, physical risks in coastal areas and other subdivision scenarios, explore the adaptability of differentiated prudential tools, and improve the accuracy of policy implementation. Third, international coordination can further study the specific model of cross-border climate risk supervision and coordination of countries along the Belt and Road Initiative, and provide more operational solutions for China's participation in global climate financial governance and the construction of regional risk prevention and control networks.

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