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Research article

Does the implementation of economic policies connected to climate change depend on monetary policy mandates and financial stability governance structures?

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ABSTRACT

The objective of the proposed research study is to examine how the economic policy mandates and governance frameworks of central banks affect the implementation of climate-related economic measures. Empirical evidence supports a positive correlation between the adoption of climate-related economic policies and a broader mandate for monetary policy. The existing body of research contradicts the idea that an enhanced framework for governing economic stability will result in higher implementation of financial measures related to climate change. The study, which focuses on China from 2015 to 2023, concludes that enhanced economic stability governance, founded on less integrated arrangements, leads to more successful implementation of climate-related financial measures. For other criteria such as central bank independence, the existence of a democratic government, and membership in the Sustainable Banking Network, a positive and statistically significant influence is seen across all specifications. Physical risks associated with climate change, such as heat waves, droughts, floods, and storms, as well as transition risks represented by variables like per-person CO2 emissions, policies aimed at mitigating climate change, and the financial capacity to carry out climate adaptation plans, must also manifest. Even after accounting for a new dependent variable and several alternative model parameters, the findings hold up well. We employ a fixed-effects panel regression approach to control for unobserved heterogeneity and isolate the impact of time-varying variables on renewable energy production. This methodology ensures robust and consistent estimates, providing clear insights into how monetary policy adjustments influence renewable energy investments.

1. Introduction

Renewable energy is seen as one of the most crucial components of sustainable development since it tackles several pressing worldwide concerns. It is vital to minimize climate change by reducing greenhouse gas emissions and the carbon footprint of the energy industry [1]. Furthermore, it diminishes atmospheric contamination, providing a more salubrious substitute to non-renewable energy sources and enhancing general well-being. Moreover, renewable energy contributes to the improvement of energy security by expanding the range of energy sources and decreasing vulnerability to supply interruptions and geopolitical disputes. From a macroeconomic perspective, the use of renewable energy is also essential. Past studies, for instance, have shown that renewable energy has

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a notably positive effect on economic growth [2]. Research has indicated that the advancement of renewable energy sources not only boosts economic growth but also positively affects employment and exports [3]. Finally, switching from conventional energy sources like fossil fuels to renewable energy sources can help slow the rate of rapidly rising inflation. For this reason, it is critical to understand the factors influencing the growth of renewable energy.

The effect of monetary policy on the generation of renewable energy has gained renewed attention as a result of the recent moves made by central banks to increase interest rates in reaction to significantly increasing inflation. Previous studies have already identified several factors that influence the growth and use of renewable energy sources [3]. There are several ways in which monetary policy might influence the growth of renewable energy. Given the capital-intensive nature of renewable energy technologies, a contracted monetary policy initially impacts the magnitude of the external financing premium. It diminishes the anticipated future viability of green energy companies. In addition, as interest rates rise, borrowing becomes more expensive, making it harder for these companies to finance new projects and expansions. Monetary policy also has an impact on controlling inflation, which can affect how much labor and raw materials are used to produce renewable energy. Ultimately, the monetary policy-shaped economic environment can affect energy demand over business cycles, which in turn might affect the future of renewable energy companies [4].

In the past, the correlation between monetary regulation and the generation of renewable energy has been largely neglected [3]. More research is needed on how renewable energy is developing in relation to business cycles. The results of previous research utilizing low data frequency to examine the correlation between monetary policy and renewable energy sources are supported by reduced-form estimates [5]. indicate that no structural analysis has been done. Using quarterly Chinese fiscal policy data, this research seeks to close this gap and address a number of related issues. We look at some critical questions about the relationship between monetary policy and the production of renewable energy. How does energy output respond to changes in monetary policy, for instance? How much does the macroeconomic shock affect how renewable energy is generated? Do monetary policies that reduce the advantages of an oil price shock also reduce the generation of renewable energy? Comprehending these problems is crucial because it is recommended that central banks consider climate concerns when enacting monetary policy [6]. We have three main reasons for wanting to concentrate on Chinese statistics. China is the largest contributor to carbon dioxide emissions and has the largest economy worldwide. Examining the influence of monetary policy in China on the production of renewable energy and its effects on addressing climate change is a captivating pursuit. With the long-term quarterly statistics on renewable energy production in China, we are able to analyze the impact of economic shocks on business cycles and the varying responses of various kinds of renewable energy production.

Utilizing previous quarterly data, we present evidence of a reduction in renewable energy production caused by restrictive monetary policy. This decline becomes increasingly noticeable as the period lengthens. Among various macroeconomic events, only the real production shock has a notable impact on the generation of renewable energy. Ultimately, solar energy is determined to be the renewable energy source most responsive to changes in monetary policy. Firstly, this is based on innovative research and is widely recognized as the most popular and reliable instrument for identifying monetary policy shocks. This study is the first to utilize a structural model to investigate the correlation between Chinese monetary policy and renewable energy based on current research findings. Expanding on influential research, it is primarily regarded as the most widely used and reliable instrument for identifying monetary policy disturbances [7]. E can understand the indirect effects of fiscal policies on renewable energy generation through structural identification and the ability to conduct policy alternatives [8].

The ongoing increase in carbon emissions will increase the physical climate-related risks associated with event-driven hazards. As a result, there will be significant policy change risks involved in actions connected to climate change [9]. These activities are projected to shift and become more restrictive to facilitate the transition to a more environmentally friendly approach and reduce the impact of climate change. The financial system has previously identified risk elements, such as physical and transition risks, which could have severe consequences for both financial markets and enterprises. Due to the systemic nature of climate change's impact on financial stability, there have been recent efforts to develop frameworks for green macroprudential policies. These frameworks aim to ensure a uniform approach across the whole financial system. Climate-adjusted capital needs can be amended to allocate money specifically to certain sectors of the economy while also accounting for the heightened risk associated with various assets, such as fossil fuels [10].

Various measures have been suggested to mitigate the risks associated with climate change in the financial system, including restrictions on lending, sector-specific leverage ratios, reserve requirements, and liquidity regulations. However, only a small number of low-income nations, primarily in Southeast Asia, have implemented green macroprudential instruments. Conversely, high-income countries seem hesitant to implement the required prudential measures to direct credit towards environmentally-friendly enterprises.

To mitigate the impact of climate change on the economy and ensure the sustainability of the financial system, central banks and financial regulators should take a proactive approach. This involves anticipating the potential disruptions caused by climate change and addressing the risks they represent to monetary policies and economic stability [9]. By doing so, they can help prevent the accumulation of future climate-related shocks and enhance the adaptability of the economic system as a whole. This research aims to improve the evaluation of the effectiveness of economic and macroprudential measures in reducing the impact of climate change and maintaining economic stability. To achieve this, a detailed macro-financial model is developed. This aligns with the crucial need to develop the necessary tools to assess large-scale climate-related risks that pose a threat to financial stability. Implementing a practical macroprudential or economic framework is crucial for maintaining economic stability in accordance with the objectives of the Paris Agreement. These objectives involve decreasing lending to enterprises that are difficult to decarbonize. Considering the potential harm that climate-related risks might cause to the stability of the economy, this becomes particularly significant.

Conversely, the implementation of climate laws and regulations may pose a danger to the financial agreements and performance of fossil fuel and high-carbon companies, known as transition risk. For example, implementing a carbon emissions tax substantially raises the operational expenses for enterprises, hence reducing their profitability [2]. If a firm's performance declines, its capacity to repay debt will be damaged, similar to how physical danger poses a threat. This is because it would become more challenging for the company to turn cash into capital that can be used for new projects.

This article introduces an empirical framework that incorporates endogenous default, nominal limitations, and economic constraints in two sectors. Entrepreneurs can seek external funding from commercial banks through loans or utilize their net worth to finance new initiatives. Entrepreneurs may choose to refrain from repaying lenders if the post-facto return on capital is lower than the total amount of loans they owe the bank, as new ventures involve higher risk and have an uncertain return on capital. Climate-related risks can have both direct and indirect effects on the ex-post rate of return on capital. Physical hazards can significantly impair a company's efficiency and hinder the conversion of raw capital into highly efficient capital. Examples of this phenomenon include weather-related occurrences such as hurricanes and floods, as well as escalating temperatures that result in elevated sea levels. Weather-related occurrences can have a detrimental effect on a business's profitability and the efficiency of its manufacturing. This can result in financial and resource losses, ultimately resulting in an organization's inability to repay loans.

The attention devoted to global warming is increasing. Extensive research in the field of finance has shown both theoretical and empirical evidence that climate change poses a significant financial risk [11]. Most of the research conducted has focused on the correlation between stock market performance and climate change, as well as the assessment of financial markets' valuation of climate issues. The impacts of global warming are becoming progressively more evident. Several research studies are investigating the impact of climate change on financial indicators at the firm level, such as operational income, revenues, and corporate earnings [12]. Furthermore, some scholars specialize in examining the perspectives of entrepreneurs regarding climate change [2]. For instance, it has been stated that institutional investors had to consider climate risks when making investment decisions and that climate change would have a detrimental effect on the value of assets.

As these vulnerabilities become more evident, it is crucial to contemplate their potential influence on the entire economic system. The impact of climate change and economic stability are intricately interconnected. Climate change has a profound impact on the structure of financial and economic systems [13]. International central banks are becoming increasingly concerned about these long-term, structural, and overall problems. The financial sector in China is encountering climatic issues that can be categorized into two primary groups: macro and micro impacts.

In order to broaden the research, we have chosen to concentrate on the G20 and expand the time frame from 2000 to 2018. We employ panel statistical analysis to determine fixed effects. The G20 countries are the focus of attention due to their status as the largest economies in the world and their significant contribution to carbon emissions.

The empirical data supports the positive relationship between the implementation of economic strategies concerning climate change and a more significant mandate for financial policy. The notion that a more focused economic governance model will promote greater adoption of financial approaches aimed at addressing climate change, however, needs more evidence from existing studies. The analysis reveals a correlation between a higher climate-related economic policy index and the existence of a distinct governance structure. Our research has shown that implementing climate-related financial policies is more successful when using intricate financial stability governance that relies on less interconnected arrangements. The results are derived from experiments assessing the strength and reliability of our findings by employing various alternative model parameters and a distinct dependent variable. This further emphasizes the need for increased organizational specialization to address the complex issues posed by climate hazards.

The current body of research on how economic stability frameworks, central bank mandates, and climate-related economic policies intersect has mainly focused on broader macroeconomic impacts and the effectiveness of policies, often sidelining the specific role of central banks in driving climate policy implementation. While a few studies have explored the connection between monetary policy and climate risks, there's been limited investigation into how the governance structures of central banks influence climate-related financial measures. Moreover, the potential impact of democratic governance, sustainability networks, and other institutional factors on the adoption of climate policies within the financial sector has been largely overlooked. This study aims to bridge these gaps by offering a comprehensive analysis of how central bank mandates and governance frameworks shape the execution of climate-related economic policies. In doing so, it seeks to contribute significantly to the ongoing discussions on climate finance and the effectiveness of policy interventions.

The remaining portion of the paper is structured in this manner. Section 2 comprises the examination of existing material and the formulation of hypotheses. Section 3 provides a detailed explanation of the techniques employed and the data used in the study. The empirical data and robustness tests are given and analyzed in Section 4. Section 5 concludes with a summary and conclusion.

2. Literature review

The instability of financial markets will be threatened by extreme climate change as it will cause major natural disasters [14]. People's business practices and production techniques are subject to the complicated and unpredictable impact of climate change [15]. The impact of increasing temperatures, modified precipitation patterns, and a rise in extreme weather events due to greenhouse gas emissions on production operations in general erodes financial stability. For example, if greenhouse gas emissions increase quickly, the polar glaciers may melt, the planet may warm, and a variety of unpredictably occurring natural disasters, such as hurricanes, hailstorms, floods, and sea level rise, may occur, endangering human progress and existence. Natural catastrophes make firms' and people's financial situations worse by lowering solvency, increasing the risk of default, devaluing collateral assets, and raising insurance premiums [16]. The whole financial system could be impacted by these risks, which could also exacerbate financial pressure, undermine economic stability and exacerbate the negative impact on the GDP.

However, our perception of or experience with the effect is merely the tip of the iceberg. Uncertainty surrounding potential climatic changes poses an unquestionable threat to people's future well-being [17]. In addition, China's economy is shifting from being heavily dependent on resources to becoming concentrated and low-carbon [18]. Due to several unknowns, its financial system will be severely strained during this process. People's understanding of the issues related to climate change and environmental change is expanding as the international community actively tackles the threat that climate change poses to human life and advancement.

Since limiting global warming, combating climate change, and enhancing the quality of life on Earth are global concerns, all governments must take urgent action. Nonetheless, further funding is required for carbon reduction and energy conservation. Due to varying energy, industrial, and economic frameworks as well as varying levels of development, achieving the two goals will cost various amounts of money in each country [19]. According to General Secretary Xi Jinping's 2020 speech to the UN General Assembly, China will actively implement stricter control measures, actively enhance its role in conserving energy and reducing emissions, and make a commitment to reach carbon neutrality by 2060 and a peak in carbon dioxide emissions by 2030 [20]. This dedication is undoubtedly exemplary and might make things better overall. China, the world's largest developing country, will have achieved a significant milestone for the sustainable and high-standard development of the international community when it becomes carbon neutral.

Moreover, China is responding to climate change and pursuing economic significance by aiming for carbon neutrality. It presents China's vision for future growth in the world. The government intends to pursue low-carbon and sustainable development while promoting peaceful cohabitation between humans and the environment [21]t. This is predicated on maintaining medium-to fast-paced sustainable economic growth. Historically, fossil fuels have been vital to China's economic development. In that sense, for China to continue its rapid economic expansion, it will need to use more fossil fuels. It, therefore, still has a long way to go before it is carbon neutral.

We must recognize that the differences in development frameworks will cause an unplanned, chaotic, and rapid shift towards a low-carbon economic model, with severe ramifications for the economy and society [22]. There are two distinct ways that these costs manifest. Reorganizing a variety of resources will be the first step in China's transition to a low-carbon economy, coupled with a lot of unknowns and possible hazards. Second, as civilization develops, new, clean energy sources gradually replace people's reliance on antiquated energy sources like coal, oil, and natural gas. When operational costs remain the same, the initial danger will result in a direct decline in economic revenue, a reduction in assets for conventional energy firms, an increase in the leverage ratio, declining solvency, and a higher likelihood of default. The financial system as a whole will share the risk in this way [23]. Once more, it will have an indirect impact on fluctuations in the stock and bond values of energy-associated enterprises.

Consequently, the market values would drop, and financial stability would be threatened if the losses were extended to other components of the financial system. The second risk will directly affect how energy-related enterprises make investment decisions because the clean development path compels corporate executives to increase investment in technology, encourage cost growth, and introduce high uncertainty into the possibilities for growth and future competitiveness of enterprises [24]. Moreover, it may increase concerns about the need for more clarity in upcoming climate policy. One of the two uncertainties could be represented by the stock premium. Put another way, investors want to see a rise in cash flow in the future, which will impact the banking sector. However, it also means putting relevant environmental protection regulations into practice. The advancement and survival of humans are increasingly more at risk from climate change-related risks [25].

Being at the forefront of energy saving, emission reduction, and the fight against climate change is just one more way China demonstrates to the world how seriously it takes its goal of reaching carbon neutrality and achieving the peak of emissions. The government also strengthens important ecological and climatic policies. Some of these actions include stepping up law enforcement, enhancing environmental tax laws, maximizing environmental quality requirements, and monitoring businesses to ensure they meet their energy-saving targets [26]. The expense of foreign account processing, insurance premiums, technical transformation, and corporate criminal responsibility have all increased as a result of this. Moreover, since the industrial structure is what drives the green industry's explosive growth and facilitates the establishment of legitimate enterprises in the survival of the fittest competitive environment, this action also promotes the optimization and adjustment of the energy structure. They are intended to have a cascading effect on the financial industry.

On the one hand, the collapse of the real economy will be a direct result of climate change's immediate impact on the financial system's soundness [27]. On the other hand, it can impact the financial market by requiring a structural change in the energy sector that will result in low-carbon development. The two previously mentioned reasons offer a macro-level explanation for how climate risk indirectly affects financial stability by disrupting the actual economic structure [28]. Climate change may have an impact on China's financial stability since it increases the operational risk for the nation's financial institutions.

One of the primary causes of uncertainty that the Chinese insurance sector must resolve is the climate crisis. Since insurance companies cannot reliably foretell how often and how severe future disasters will be, the most significant risk to human life and progress from climate change is the terror of the unknown [29]. Second, because of climate change and the steps needed to stop it, financial institutions are exposed to significant market risks. The rate at which carbon emissions are increasing will eventually level out in the setting of carbon neutrality. Competing for a restricted allocation of emission space entails striving for future viability and opportunities for growth. Commodities now have a distinct identity since the amount of carbon emissions that one business can use is limited. The expense of carbon emission allowances will rise as a consequence [30].

The fluctuation in energy supply and demand will lead to a decrease in the stock value of enterprises with significant carbon emissions. This will have an immediate effect on the financial stability of asset management firms and banks that possess these assets [31]. The scientific and new energy technologies will have a more significant influence on the stock market's structural transformation. In addition, climate risk will lead to decreased financial revenue, depleting assets, higher borrowing costs, and a reduction in the solvency of businesses with substantial energy use and carbon emissions, as we discussed in our macro talk [32]. As a result, financial institutions will be more likely to suffer losses or not be able to recover their assets or debts. In addition, financial institutions will frequently face penalties and damages for environmental accidents caused by investors' or borrowers' carelessness because of the

Table 1
Summary statistics for the baseline model specification.

Statistic	N	Mean	St. Dev.	Min	Max
CRFPI	420	14.121	20.715	1	82
cb.indep	420	2.761	1.548	2	4
crisis.banksect	420	1.185	1.489	2	4
finopen.index	420	1.5	1.4	1.4	1.20
cb.mand	420	0.784	4.643	0.002	2.122
cb.model	420	0.066	2.672	0.002	2.122
Encons	420	7.118	3.308	0.003	18.121
emissions.pc	420	1.021	1.043	2	2
Sbn	420	68.213	18.847	64.623	88.788
polity	420	10.315	4.533	1.649	18.321
vuln.index	420	1.753	1.165	1.369	1.423

stricter environmental regulation of companies operating in these industries. The danger of lender payback, or credit risk to the financial system, will undoubtedly increase as a result.

Governments, corporations, scholars, and individuals have all come to recognize the financial industry's vital role in fostering a green economy as a result of the growing attention that green finance has received recently [33]. This will strengthen the supervision of ecologically responsible conduct within the financial system. Fund providers for financial institutions, for example, will find that as public awareness of climate risk increases, depositors with environmentally sensitive purchasing patterns will be more inclined to buy environmentally friendly bonds and avoid dirtier bonds. This will impact the progress and standing of financial institutions.

3. Methodology

3.1. Model specification

To determine if the specific structure and mandate of a central bank affect the implementation of climate-related economic policies, we employ a fixed-effects panel regression approach to estimate Equation (1). This method controls for unobserved heterogeneity, ensuring that the unique, time-invariant characteristics of each entity (such as countries or regions) do not bias the results. It is particularly effective in isolating the impact of time-varying variables, like monetary policy changes, on renewable energy production. By focusing on within-entity variations over time, the fixed-effects model addresses potential endogeneity issues and improves the robustness and consistency of the estimates. This approach is crucial for accurately assessing how monetary policy adjustments influence renewable energy investments, providing clearer and more reliable policy insights by holding constant the stable attributes of each entity that could otherwise confound the analysis.

$$CRFPI_{i,t} = \alpha + \beta_1 (cb.model)_{i,t-1} + \beta_2 (cb.mand)_{i,t-1} + \gamma \mathbf{X}_{i,t-1} + \mu_i + \psi_t + \epsilon_{i,t-1}, \tag{1}$$

The country's climate-related monetary policy index at time *b* is determined by the kind of economic governance model (*cb. mUdel*) and the central bank's mandate (*cb. mand*), as stated in Section 3.2. The variables that explain (X-*i*, $t-1$) used in the analysis consist of economic transparency, a dummy variable that accounts for financial crisis, the extent of democracy determined by the democracy index, the central bank's autonomy, participation in the Sustainable Banking Network (SBN), and the percentage of energy produced by fossil fuels. In our analysis, we utilize the vulnerability index as a proxy for the emergence of physical risks associated with climate change. Additionally, we use the consumption of electricity and carbon dioxide (CO2) emissions per person as proxies for transition risks linked to climate change. Our interest lies in examining the impact of these physical and transition risks, as initially suggested by Refs. [32,34], on the implementation of climate-related economic policies.

All of the country and year fixed effects (-*i*. and, -*t*) as well as the random error term ε complete the model. Since all variables have a one-year lag, we anticipate that these factors will function with a temporal lag. Furthermore, this keeps any endogeneity problems at bay. Table 1 provide the summary statistics for the baseline model formulation data sources, while Table 2 displays correlation matrix for baseline model specification.

3.2. Variables and data

3.2.1. Dependent variable

The CRFP index, which stands for the G203's climate-related finance policy, serves as our dependent variable from 2000 to 2018.4. The composite index was created in Ref. [35] to evaluate, measure, and contrast global participation in financial policy connected to climate change. Its underlying theory holds that as the index rises, so does a country's commitment to climate change-related financial policies. The foundation of the CRFP index is a comprehensive examination of adopted financial policies related to climate change. Five policy areas are taken into consideration, in accordance with the body of existing literature: (i) prudential regulations related to climate change; (ii) credit distribution; (iii) green economic principles; (iv) additional disclosure requirements related to climate change targeted at non-financial institutions, such as insurance companies and pension funds; and (v) the issuance and taxation of green bonds.

Table 2
Correlation matrix for baseline model specification.

	cb.indep	emissions.pc	crisis.banksect	cbmand	sbn	polity	Crfpi
cb.indep	2	1					
emissions.pc	0.06	2					
crisis.banksect	−0.32	−0.04	2				
cb.mand	−0.04	0.04	−0.04	2			
sbn	−0.04	−0.02	0.20	−0.20	2		
polity	0.24	0.20	0.04	−0.13	−0.04	2	
crfpi	−0.2	−0.4	0.64	−0.18	0.30	0.18	
encons	0.28	0.24	−0.22	2	0.28	0.20	
vuln.index	−0.43	−0.06	0.38	−0.22	0.42	−0.54	
finopen.index	0.64	−0.28	−0.30	0.32	−0.64	0.52	2

Given the young nature of the debate around the transition of monetary policy towards environmental sustainability and the small number of central banks that have implemented monetary policy activities that are in line with addressing climate change [36], the index solely concentrates on financial policies. This index generation procedure consists of four parts. Literature and taxonomies are utilized to identify financial policies relevant to climate change. Furthermore, a study of relevant policies is carried out using data that is available to the public. Third, the policy's adoption year, jurisdiction, and bindingness that is, whether it is mandatory, optional, or not—are all recorded in a database. The index is computed by adding the weights of the five policy areas that are related to climate change while also determining effectiveness. In particular, the policy indicator is constructed with the policy type and bindingness taken into consideration, and then the index is normalized by means of the min–max approach to ensure that each indication falls within the identical spectrum. A simple additive weighted aggregation method takes each country's unique rescaled indicators and combines them into a single index for each period. Weights are assigned equally among the indicators for the policy domain. Formally speaking, the index looks like this:

$$CRFPI_{i,t} = \sum_{p=0}^{P} \omega SC_{p,t}, \tag{2}$$

According to this suggestion, an indicator is determined by adding up all of the rescaled indicators *S*, -. For every policy *P* throughout every time *t* for every nation *i*. Afterward, every factor is given an exogenously determined weight. Equation (2) thus represents the composite index that integrates the weighted rescaled indicators into a single measure of climate-related financial policy.

[37] create four indices using different configurations and weighting systems. Since our study focuses on the fundamental characteristics of central banks, we utilize the index CRFPI4 to examine the factors that impact the implementation of financial policies related to climate change. The field of preventative policy is defined by five separate policy instruments: credit risk management, financial disclosure regulations, ICAAP, and differential reserve requirements. It builds a thorough sub-index for prudential policy by utilizing these tools. The prudential policy areas detailed policy indicator denoted as *I-i*, *-PP* is examined. Equation (3) provides the computation of the prudential policy indicator.

$$I_{i,t}^{PP} = \left(I_{i,t}^{\alpha} + I_{i,t}^{\beta} + I_{i,t}^{\gamma} + I_{i,t}^{\delta} + I_{i,t}^{\eta} \right) \tag{3}$$

Where the symbols *I-i*, *t*-symbolize the country's instrument, *-i-* at time *t*. These exponents denote the distinct policy categories as follows: α represents credit risk management, β represents stress testing connected to climate change, γ represents bank transparency necessities, δ represents ICAAP, and η represents differential required reserves.

3.2.2. Independent variables

In order to analyze the governance framework of central banks in relation to their supervisory and economic regulatory responsibilities, we utilize two specially designed indices that effectively capture these linkages. We used a three-step process (CB Mandate) to build an index for the mandate-related independent variable. Firstly, we used the IMF Central Banks Legislation Database (CBLD) to gather data regarding the framework of the reference countries' monetary authority missions. In the second stage, we cross-referenced the data with officially available public acts, legislation, and central bank rules that we obtained in the first step to confirm the accuracy of the information. The evolution of the G20 countries' mandates from 2000 to 2018 is consistent with the body of existing literature, which indicates that several countries had established a clear structure wherein the conventional duties of the central bank for attaining financial stability were deferred to its independence and accountability for accomplishing monetary policy goals. The crisis proved that prioritizing price stability and general macroeconomic stability was not enough to ensure economic stability despite these being the primary objectives of monetary policy until then. With the emergence of the need for financial stability after the Great Financial Crisis (GFC), the monetary authorities resumed their role as financial regulators. This revealed that in addition to creating or enhancing their micro-prudential policy regimes, countries have been strengthening their frameworks for macro-prudential regulations targeted at systemic risks. It also led to a significant and dramatic change, though, as several countries moved to place accountable supervision under the jurisdiction of central banks.

Table 3
Influence of governance frameworks and mandates on implementation of climate-related financial policies: Initial findings and validation tests.

Variables	Dependent variable: indexCRFP4					
	Baseline	Robustness checks				
	(1)	(2)	(3)	(4)	(5)	(6)
lag(cb.mand, 1)	10.468*** (1.36)	18.444*** (4.54)	9.456*** (4.78)	10.943*** (3.99)	8.058** (1.49)	8.421* (4.55)
lag(cb.model, 1)	18.534*** (2.56)	8.619*** (2.64)	20.824*** (2.68)	18.507*** (4.34)	28.258*** (2.558)	18.463*** (2.45)
lag(finopen.index, 1)	2.021** (1.94)	2.861** (2.74)	2.298** (2.34)	2.228*** (1.34)	1.539** (1.58)	2.155 (1.87)
lag(cb.indep, 1)	8.098 (19.40)	8.479 (4.91)	18.221 (5.04)	6.323 (4.48)	−4.845 (8.65)	28.321*** (8.75)
lag(sbn, 1)	−8.231 (4.31)	−8.05* (2.56)	−6.931 (4.40)	−5.59 (4.82)	−6.386 (4.74)	−2.948 (4.82)
lag(crisis.banksect, 1)	8.481** (4.95)	8.502** (3.84)	6.492** (4.08)	6.045** (3.64)	4.872 (3.28)	9.423*** (3.46)
lag(energy.consum, 1)	20.892*** (4.40)	18.891*** (4.25)	20.043*** (4.84)	28.450*** (4.27)	20.231*** (4.63)	30.865*** (4.417)
lag(polity, 1)	−2.543*** (1.72)	−2.694*** (1.23)	−5.632*** (1.23)	−2.621*** (1.51)	−2.264*** (2.23)	−2.241** (2.29)
lag(extr.weather, 1)	−8.692*** (2.25)	−8.685*** (2.31)	−8.742*** (2.27)	−7.686*** (2.21)	−8.392*** (2.81)	
lag(energy.import, 1)	−6.611*** (1.31)	−8.934*** (1.30)	−8.141*** (2.56)	−8.124*** (1.19)	−10.612*** (2.70)	−4.218*** (2.12)
lag(emissions.pc, 1)		−2.410* (2.21)				
lag(readiness, 1)				18.833*** (4.28)		
lag(fiscal.clima.mitig, 1)					434.954*** (34.74)	
Country-FE	Yes	Yes	Yes	Yes	Yes	Yes
Countries	20	20	20	20	20	20
Observations	423	423	423	423	423	423
R^2	1.285	2.365	4.295	1.455	2.755	1.554
Adjusted R^2	1.764	2.824	2.745	2.914	2.285	2.843
F Statistic	35.841***	28.455***	30.518***	52.423***	32.882***	20.578***

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

3.2.3. *Control variables*

Our empirical study is grounded in data collected for China that differ significantly in terms of their institutional frameworks for financial services, political and economic development phases, and susceptibility to climate threats. To account for such heterogeneity, we have included factors that represent these differences in various areas of development, including political, economic, fiscal, and ecological. Following in the footsteps of earlier research on concerns pertaining to political economics in central banking and supervision, we account for the economy's dependence on fossil fuels, its energy composition, the effects of financial crises, the degree of democracy as determined by the Polity Index, and the effects of financial openness.

A binary variable signifying inclusion in the Sustainability Banking Network is one of the additional variables that are unique to each nation. The Central Bank Independence Index, which gauges how successfully central banks are able to control monetary instruments, was also included. Because this trait has historically been relevant in the literature, this index has been taken into consideration in relation to the index's selection. The initial condition is that a bank is perceived as being more autonomous if the governor is selected by the central bank board instead of the government, is not susceptible to dismissal, and has a long-term position. When creating the index, these four characteristics were taken into account. Second, the method used to decide on policies is more independent in a nation with greater independence. Third, the independence of a central bank is increased if its charter states that price stability is the exclusive or primary goal of monetary policy. Fourth, independence will rise if the government's capacity to obtain funds from the central bank is limited because it takes into consideration the central bank's intrinsic conservatism—that is, the more weight the central bank law places on price stability, the higher the index's score—we think this measure is the best alternative to central bank independence.

The statistical description additionally incorporates factors pertaining to climate change, such as the vulnerability index and per capita CO2 emissions. The vulnerability index, from which it is derived, evaluates the likelihood that human civilizations may be negatively impacted by climate change. When determining a country's susceptibility, six life-supporting areas are considered: infrastructure, food, water, health, ecological services, and human habitat. Each sector is represented by six indicators that capture three intersecting elements: the sector's susceptibility to risks associated with or amplified by climate change, its responsiveness to those risks' effects, and its ability to cope with or adjust to those effects.

For the robustness checks, we employ the number of severe weather occurrences (such as heat waves, droughts, floods, and storms) documented at the country level, as compiled by Ref. [38], as a substitute indicator for the occurrence of physical hazards. We obtained information from a number of sources regarding the transition hazards. We looked at the following: (i) the percentage of energy use that is attributed to energy imports; (ii) the amount of energy used per person in kilograms of oil equivalent; (iii) the implementation of fiscal policies like feed-in tariffs and carbon taxes to mitigate the effects of climate change; and (iv) readiness, which is the capacity to use investments for adaptation actions in a way that is safe and effective for business.

4. Empirical results

The results of the six-panel regressions are shown in Table 4. The specifications for the alternative model, which includes several

Table 4
Impact of governance structures and mandates on adoption of climate-related financial policies: Alternative dependent variable and robustness checks.

Variables	Dependent variable: indexCRFP1					
	Baseline	Robustness checks				
	(1)	(2)	(3)	(4)	(5)	(6)
lag(cb.mand, 1)	9.345*** (2.16)	8.454*** (2.63)	6.824*** (2.62)	7.734** (1.83)	4.876* (2.68)	4.346* (2.28)
lag(cb.model, 1)	18.531*** (2.23)	18.676*** (2.43)	18.731*** (2.36)	18.636*** (0.04)	20.021*** (2.75)	18.612*** (1.21)
lag(finopen.index, 1)	2.752** (1.704)	2.631** (1.70)	1.696** (1.75)	1.009** (1.65)	1.358* (1.25)	1.235 (1.29)
lag(cb.indep, 1)	10.251 (9.658)	10.344 (6.18)	20.449 (6.76)	18.664 (6.21)	2.482 (7.48)	43.432*** (6.81)
lag(polity, 1)	−4.521 (2.294)	−6.347 (4.76)	−6.381 (4.394)	−5.852 (4.41)	−3.862 (1.06)	−2.174 (2.51)
lag(crisis.banksect, 1)	4.286 (1.441)	5.721 (1.94)	4.061 (1.83)	2.983* (1.23)	2.094 (1.52)	5.188*** (1.44)
lag(energy.consum, 1)	34.123*** (1.586)	34.112*** (4.58)	22.233*** (2.20)	20.751*** (4.52)	20.396*** (2.87)	28.651*** (3.65)
lag(sbn, 1)	−2.121** (1.81)	−1.401*** (1.28)	−1.273** (1.34)	−1.021*** (1.70)	−1.042** (1.242)	−1.052 (1.40)
lag(extr.weather, 1)	−8.275*** (2.31)	−6.04*** (2.36)	−8.295*** (2.25)	−8.22*** (1.23)	−3.521*** (2.013)	
lag(energy.import, 1)	−5.522*** (2.19)	−6.221*** (2.24)	−8.788*** (0.47)	−7.493*** (2.914)	−8.381*** (2.203)	−4.495*** (1.81)
lag(emissions.pc, 1)		−2.241 (1.24)				
lag(readiness, 1)				8.174** (4.121)		
lag(fiscal.clima.mitig, 1)					121.452*** (8.43)	
Country-FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes	Yes	Yes
# countries	20	20	20	20	20	20
Observations	423	423	423	423	423	423
R^2	1.275	1.295	1.275	1.405	1.635	1.524
Adjusted R^2	1.754	1.754	1.734	1.874	1.125	1.424
F Statistic	28.269***	20.852***	32.154***	28.863***	30.133***	20.411***

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

proxies for both physical and transition hazards, are shown in columns (2) through (6). Column (1) represents the baseline specification found in Equation (1). All requirements have a positive and statistically significant central bank mandate coefficient at the 1 % level. The central bank model's positive and statistically significant coefficients pertaining to the different kinds of governance structures for the fundamental criteria and requirements, at the 5 % level for specification, and the 10 % level for specification, in this regard. These findings challenge conventional wisdom on the necessity of a fully integrated governance framework for managing climate-related financial risks from the standpoint of financial stability. The updated text suggests that in policy frameworks aiming for low-carbon shift or zero emissions, it is preferable to have more intricate and widely distributed administrations and delegation. This is because such frameworks require a significant level of technological proficiency and collaborative duties among multiple financial and supervisory entities.

The central bank's level of autonomy, the level of democratic government in the country, and the bank's affiliation with the Sustainability Banking Network all exhibit significant and beneficial parameters, suggesting that these variables are equally crucial in enhancing the economic policy index pertaining to climate change. However, financial transparency only holds significance in the model's formulation. The fundamental and resilience checks presented in columns (2) through (6) illustrate the importance of both physical and transitional risks. The two variables selected to represent physical risk are the measure of vulnerability and the count of adverse weather conditions documented at the national level. Their two coefficients have opposing signs, and both have a significance threshold of 1 %. The presence of extreme weather conditions is positively associated with the climate-related economic policy measure, indicating that as the frequency of these events increases, the index also increases.

Conversely, the measure of vulnerability is negatively associated with the utilization of climate-related economic strategies, indicating that vulnerability decreases as the implementation of these policies increases. The disparity arises due to the fact that they highlight two distinct yet interrelated elements of physical hazards. The vulnerability measure is a metric that predicts the likelihood of human societies being negatively affected by climate risks in the future. It is calculated using a composite index. The occurrence of unpredictable weather is directly associated with the manifestation of actual risk, as it documents the verified occurrences of floods, droughts, heat waves, and storms reported across the entire country.

All of the chosen proxies aside from energy use have significant coefficients for transition risks reported at the 1 % level. Reduced utilization of fossil fuels for energy production, oil energy imports, and overall higher emissions per capita are all associated with a lower climate-related financial policy index, according to the negative coefficients of carbon emissions per capita, consumption of fossil fuel energy, and imports of oil energy, and oil energy imports. The findings presented by Ref. [39] are in line with these results. The presence of positive and statistically significant coefficients at the 1 % level indicates a strong relationship between the implementation of economic measures targeting climate change mitigation and the ability to effectively utilize funding for climatic adaptation in a secure and effective business environment. This suggests a higher level of commitment towards both mitigating climate change and being financially prepared for climate adaptation.

To further ensure the reliability of our results, we recalibrated the Equation using an alternative dependent variable, taking into consideration the CRFPI1 measure as specified by Ref. [40]. This index, like our dependent variable CRFPI4, is determined using an additive model that has the same weights for each policy area, with the exception of the realistic metrics for evaluating policies in the financial policy domain. The calculated coefficients and significance values for each of these various estimations are shown in Table 4. Our findings hold up well under different interpretations of the CRFP index, as seen by the reported significance levels and coefficient signs matching those in Table 3.

5. Conclusions

This study fills a knowledge vacuum on the impact of economic stability administration frameworks and central banks' requirements on the implementation of economic strategies related to climate change. It contributes to the corpus of recent literature in two ways. Initially, our research confirms an empirical relationship between the implementation of economic policies linked to climate change, a unique framework for governing financial stability, and a more expansive mandate for monetary policy. Furthermore, it demonstrates that implementing climate-related economic initiatives is more successful when utilizing a sophisticated economic governance structure that relies on less interconnected arrangements. This implies that a higher level of knowledge and skill is required to effectively deal with the intricate problems that arise from climate-related risks to economic stability. This is justified by the fact that when the mandate for macro-prudential policy is split into several institutions, each with specialized high-level technical knowledge, decision-making over the deployment of new climate-related instruments becomes more specialized and streamlined. That being said, the central bank's strong involvement in the separate committee governance framework ensures cooperation with monetary policy. To adequately address the challenges posed by climate change in a complicated macro-financial system, it is necessary to reassess current strategies and considerations regarding the pros and cons of economic governance frameworks in relation to climate-related economic policymaking. The concepts discussed in this paper open up new avenues for research and policy development concerning supervisory supervision and, on a broader scale, climate-related economic viability. By expanding the policy perimeter to include central bank governance models, empirical research can expand the reach of policy beyond the nations under investigation. Collaboration amongst several policy branches such as fiscal policy and foreign cooperation is taken into account by these models. We also leave this analysis to future studies to investigate which governance model for financial stability, when data becomes available, leads to better climate-related policy.

5.1. Limitations

While this study provides valuable insights into the relationship between economic stability frameworks, central bank mandates, and the implementation of climate-related economic policies, several limitations warrant consideration. Firstly, the focus on a specific time frame and geographical region, namely China from 2015 to 2023, may limit the generalizability of the findings to other contexts. Additionally, the reliance on panel regression analysis, while robust, may not fully capture the complex dynamics at play in shaping climate-related policy implementation, particularly considering the multifaceted nature of climate change challenges. Moreover, the study primarily focuses on the role of central banks and economic governance frameworks, potentially overlooking other influential factors such as political dynamics, public opinion, and international agreements. Finally, while efforts were made to control for various variables, the presence of unobserved factors or omitted variable bias could affect the accuracy of the results. Future research could address these limitations by incorporating broader datasets, considering diverse geographical contexts, and employing more nuanced methodological approaches to provide a comprehensive understanding of the factors influencing climate-related policy implementation.

5.2. Implications of the study

This study has significant implications for policymakers, central banks, and financial regulators around the globe. Firstly, it highlights how crucial the structure and responsibilities of central banks are in influencing the adoption of financial policies related to climate change. By showing that a strong central bank mandate correlates with the implementation of such policies, the study emphasizes the importance of integrating climate considerations into central bank frameworks. Moreover, it suggests that promoting transparency, accountability, and collaboration among governmental and non-governmental bodies is essential for effective climate action within the financial sector. These insights offer valuable guidance for policymakers in shaping institutional frameworks to better tackle the challenges of climate change.

Secondly, the research delves into the intricate relationship between various risks—both physical and transitional—and the adoption of climate-related financial policies. By uncovering how adverse weather conditions and vulnerability measures affect policy implementation differently, the study underscores the necessity of thorough risk assessment and management in formulating climate policies. Furthermore, the study highlights the urgency of transitioning to sustainable energy sources and reducing reliance on fossil fuels, given their negative association with the adoption of climate policies. These findings provide policymakers and financial institutions with important insights for mitigating climate risks and seizing opportunities linked to the shift towards a low-carbon economy. Ultimately, the study underscores the need for proactive and coordinated efforts across sectors to enhance resilience, foster sustainability, and achieve climate-related policy goals.

Consent for publication

All of the authors consented to publish this manuscript.

Data availability

All relevant data in form of results have been included in this paper. Corresponding author (13505563337@163.com) may be contacted for any further query regarding data availability.

CRediT authorship contribution statement

Liu Cheng: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Formal analysis, Conceptualization. **Chang Wu:** Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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