“Climate change challenges in central banking: A systematic review with bibliometric and content analysis”

AUTHORS	Ahmad Kaab Omeir Deimante Vasiliauskaite

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Ahmad Kaab Omeir (Lithuania), **Deimante Vasiliauskaite** (Lithuania)

CLIMATE CHANGE CHALLENGES IN CENTRAL BANKING: A SYSTEMATIC REVIEW WITH BIBLIOMETRIC AND CONTENT ANALYSIS

Abstract

Solving climate change issues has become the most essential topic in all areas of business and activity. Even central banks take action to enhance climate risk management. Central banks are taking action to regulate the financial system and manage foreign reserves by implementing green investments in their own and monetary portfolios, thereby utilizing their direct functions. This paper aims to identify the primary areas of focus for central banks in climate risk management by systematically reviewing and consolidating existing scientific papers, identifying research gaps, and highlighting areas that require further investigation. Using bibliometric and content analysis, the study examines the primary areas in which central banks can contribute to addressing climate change challenges. Using Web of Science data in this research, 503 English-language articles on "climate risk" were analyzed, and the scope was then narrowed by analyzing articles using the keywords "climate risk banks," which limited the research area to 320 articles. The analysis reveals that central banks are increasingly integrating climate risk management into their policy frameworks, employing stress tests and disclosure guidelines to enhance the resilience of financial institutions. The findings reveal a significant gap in scientific research on the role of central banks in climate risk mitigation through foreign reserve management, despite their primary responsibility for managing climate risks within the banking system. This study underscores the necessity for enhanced risk assessment methodologies and collaborative regulatory efforts, thereby advancing the scientific discourse and informing the development of practical policies.

Keywords central banks, climate risk, foreign reserves, monetary policy, financial stability

JEL Classification E58, G21, Q540

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Ahmad Kaab Omeir, Ph.D. Student, Junior Assistant Professor, Finance Department, Faculty of Economics and Business Administration, Vilnius University, Lithuania.

Deimante Vasiliauskaite, Ph.D., Professor, Business School, Vilnius University, Lithuania. (Corresponding author)

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INTRODUCTION

Climate change's complex, long-term nature poses a unique challenge, especially in economic decision-making. Current understanding of the potential financial risks posed by climate change, affecting companies, investors, and the broader financial system, remains in its early stages of development. Financial systems are not immune, as climate risks can induce systemic financial risks, affecting markets and increasing connectedness across financial systems.

Climate change has recently become the primary focus in the banking sector. It is worth noting that climate change presents new risks for banks and offers a crucial path to new opportunities. Climate change issues must be implemented in banking and regulatory activities. Banks must revise their strategies, policies, and risk management. Financial regulators are creating a climate risk management system in the financial sector. As a result, they require more climate risk assessment activity from the commercial banking sector. At the same time,

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central banks themselves face climate risk management challenges in their management of foreign reserves, monetary policy, and financial stability decisions.

Climate risk in the banking sector is typically associated with financial losses and various disruptions resulting from climate-related issues and the transition to a green economy. It can strongly affect the banking sector's financial and operational risks. Due to climate change, market risk can also increase as a result of volatility in asset values and the repricing of financial instruments. Finally, liquidity risk can increase because of a lack of reliable and comparable information on climate-sensitive exposures.

The topic is both highly relevant and relatively new, so many financial institutions are sharing best practices in climate risk management within the banking sector. The Eurosystem has taken numerous initiatives to consider the impact of climate change on the banking sector at both practical and business levels. At the same time, differing views and understandings of the issue highlight a significant need to research this field and add value to science and practice.

The article addresses the scientific problem of understanding the role of central banks in mitigating climate risks and the gaps in scientific research on their contributions, especially in managing foreign reserves, which remains underexplored. The study examines how central banks incorporate climate risk considerations into their frameworks to maintain financial stability and facilitate the transition to a sustainable economy.

1. LITERATURE REVIEW AND HYPOTHESES

The research begins with understanding climate risk and its role in the risk classification system. Understanding climate risk in the broad risk management framework differs significantly among researchers. For example, some research analyzes climate risk as a non-financial risk (Wee et al., 2021), while there are more views that climate risk is under the financial risks umbrella (Rudebusch, 2021; Breitenstein et al., 2019).

The current analysis of climate risk taxonomy also requires scientific discussion. The Network for Greening the Financial System (NGFS) uses the term "environmental risks "and refers to environmental and climate-related risks. Although it can be used interchangeably in NGFS documentation, it is worth noting that climate risk is a subset of environmental risks. According to the latter, environmental risks include air pollution, water pollution, freshwater scarcity, land contamination, reduced biodiversity, and deforestation. At the same time, climate risk is closely tied to climate change, including damage caused by extreme weather events or a decline in asset value in carbon-intensive sectors. As the understanding of environmental risks differs significantly in the global financial community, there is a space for scientific discussion and research. Scientific discussion can be even more interesting because there is no precise classification of different types of risks. The impact of climate change refers to different risks (Ozkan et al., 2021; Simpson et al., 2021; Saliya & Wickrama, 2021).

Many scientists focus only on two types of climate risks: physical and transition. Rudebusch (2021) takes a broad approach, identifying that climate change creates both physical and transition financial risks. This is a standard climate risk classification, and this research also adopts the same perspective. Physical risk is associated with rising temperatures, higher sea levels, and more destructive storms, floods, and wildfires. Transition risk encompasses changes in climate policy, technological innovations, and shifts in consumer preferences.

Ramakrishna (2024) classifies climate risk by adding liability risks together with physical and transmission risks. Climate risk in the banking sector is a multifaceted challenge that encompasses both physical and transition risks, impacting financial stability and asset valuation.

On the whole, physical and transition risks are interrelated (especially in the long-term) but have impacts and the short- as well as on the long-term

– for example, policies might be ambitious and expose economic agents to transition risks in the short-term while simultaneously reducing the exposure to future physical events (or vice versa).

The next step in this study is to examine how climate risk impacts the financial system, with a focus on the banking sector. Climate change will have a direct impact on the global ecological system. Still, its repercussions extend to the economic and financial realm through various channels, posing heightened systemic and structural risks to the financial system (Liang et al., 2023). Specifically, climate change will disrupt financial stability and macroeconomic factors by altering supply and demand dynamics, thereby disturbing the adjustment and transmission mechanisms of monetary policy and weakening the effectiveness of macroeconomic control (Fried et al., 2021). Consequently, macroeconomic fundamentals assume critical importance as a foundation for central banks to formulate policies and exercise macroeconomic control, a need exacerbated by the significant influence of climate change on these vital variables (Batten et al., 2020; Liang et al., 2023). On the one hand, inflation, a well-recognized metric closely linked to people's well-being, plays a pivotal role. On the other hand, the intricacies of climate change and its associated secondary disasters introduce substantial uncertainty into monetary policy decisions, resulting in highly uncertain inflation expectations (Gavriilidis, 2021; Liang et al., 2021; Shen et al., 2023).

In recent years, policymakers, regulators, academics, and central banks have increasingly acknowledged the impact of climate change on the financial sector. Climate change creates new risks for banks and is a crucial path to new opportunities. Climate change issues must be implemented in banking and regulatory activities. Banks must revise their strategies, policies, and risk management. This awareness has sparked discussions on its implications for financial stability and strategies to bolster the banking industry's resilience to climate-related risks. Dikau and Volz (2021) describe "green central banking" as an approach in which central banks consider environmental and climate risks that could significantly impact both short-term and long-term financial stability and the macroeconomy. Various studies examine the potential impact of climate change on global financial assets, emphasizing the need for central banks to address climate-related risks. Climate risks can destabilize the financial system, disrupting the transmission of monetary policy and price stability. Pfister and Valla (2021) examine how to integrate sustainability goals into monetary policy and financial stability frameworks, noting that it is more feasible to incorporate sustainability into the financial stability framework than to make monetary policy environmentally sustainable due to inherent challenges.

Conversely, Apergis (2023) analyzed the impact of weather-related disasters on financial stability, finding that such disasters negatively affect the deposit-to-loans ratio and increase non-performing loans, thereby contributing to financial instability in the U.S. banking sector. In Europe, Chabot et al. (2023) employed network analysis and panel regressions to investigate the impact of climate-related hazards on financial stability, aiming to identify financially vulnerable significant institutions within the climate context and pinpoint risk concentrations. In another study, D'Orazio et al. (2023) introduced a novel approach: a macro-financial agent-based integrated assessment model. This model meticulously examines the propagation of climate risks toward financial instability, with a primary focus on the dynamics of interbank markets and their potential to trigger liquidity crises. Simulations using this model highlighted the possibility of substantial funding and market liquidity shortages in the financial system due to climate-induced liquidity crises. Climate-related risks can also act as shocks to the financial system or amplify the effects of other shocks. (Brunetti et al., 2021).

Various factors contribute to the current situation, including the lack of company disclosure, the absence of a standardized green taxonomy, and limited experience in quantifying climate risks and opportunities, which are among the most urgent. Dikau and Volz (2021) shift focus to central banks' mandates and objectives concerning sustainability and green Finance, advocating that even central banks without explicit sustainability objectives should embed climate-related risks into their core policy frameworks to safeguard macro-financial stability. Given the current understanding, cen-

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tral banks appear to be reassessing their past risk models to incorporate proactive evaluations of climate-related risks. Regulatory bodies employ stress tests to assess the resilience of banking institutions under adverse macroeconomic and financial conditions.

Dealing with the financial risks arising from the physical effects of climate change and society's responses presents numerous new analytical and governance complexities (Campiglio et al., 2018). These studies underscore the importance of understanding and addressing climate risks within the financial sector, particularly for central banks. They highlight the potential impact of climate change on global financial assets and stress the need for regulatory frameworks and risk management systems to incorporate climate-related risks. However, the literature on central banking and climate change is fragmented, with uneven approaches to the functions and roles of central banks. Some studies focus on monetary policy as a means to address climate change. In contrast, others address the calibration of prudential supervision strategies to include new climate risks alongside traditional financial risks or the regulatory process aimed at strengthening financial stability by incorporating the potential impact of climate change (Campiglio et al., 2018).

Climate risk issues can be analyzed at different levels in central banking: the monetary policy level and prudential level (micro-prudential and macro-prudential levels) (Dikau & Volz, 2021; Chenet et al., 2021; Feridun & Güngör, 2020; Gelzinis, 2021). Climate risk management issues in central banking are significant in the field of foreign reserves management (Torinelli & Silva, 2021).

The most cited authors analyzing climate risk issues in the banking sector were D'Orazio and Popoyan (2019). Their paper adopted a unique perspective and sought to explore the potential impacts of financial regulations on the transition towards a sustainable, environmentally friendly economy. The second most cited article by Chenet et al. (2021) also focuses on climate risk topics in the central banking area. The authors posit that financial risks associated with climate change, particularly those concerning short-term to medium-term transition and long-term physical risks, are characterised by profound uncertainty. The authors, based on their research, have suggested implementing a precautionary financial policy strategy to address the financial stability risks associated with climate change.

Dunz et al. (2021) developed a Stock-Flow Consistent model for a high-income country, incorporating an adaptive forecasting function for banks' climate sentiments. Subsequently, the research evaluated the effects of a carbon tax and green supporting factors on the shift towards a greener economy and banking sector. The study's findings indicated that the green supporting factor has a short-term impact on boosting green investments but also introduces potential trade-offs related to banks' financial stability.

This paper aims to identify the primary areas of focus for central banks in climate risk management by systematically reviewing and consolidating existing scientific papers and identifying gaps in the research that point to areas requiring further investigation.

The following hypotheses were formulated based on a comprehensive review of the literature and the identification of gaps in climate risk management by central banks.

H1: Integrating climate risk considerations into central bank policies significantly enhances the financial stability of banking systems.

H2: There is a significant gap in scientific research on the role of foreign reserves management in mitigating climate risks by central banks.

H3: Enhanced climate risk disclosure practices in the financial sector contribute to better alignment with sustainability objectives and reduce systemic financial risks.

The first hypothesis stems from the growing recognition in existing research that central banks play a crucial role in promoting financial stability through climate-aware monetary and prudential policies. However, the extent of their effectiveness remains an open question. The second hypothesis stems from the study's findings that foreign reserve management, a critical function of central banks,

is underrepresented in climate risk research, underscoring an area for further exploration. Lastly, the third hypothesis is informed by evidence suggesting that robust climate risk disclosure practices enhance the resilience of financial institutions and support their sustainability objectives; however, the mechanisms and outcomes of these practices require further empirical validation. These hypotheses aim to bridge the scientific and practical knowledge gaps in central banks' climate risk strategies.

2. METHODS

Bibliometric analysis is a quantitative approach employed to examine and assess academic publications, encompassing scientific articles, conference papers, books, and other scholarly works. This method entails utilizing statistical and mathematical methods on bibliographic data to glean valuable insights into diverse facets of academic research. Such analyses help researchers, institutions, and policymakers understand patterns in scientific literature, assess the impact of research endeavors, and comprehend the composition of academic networks. Bibliometric analysis as a tool is used in various scientific research covering different areas of science (Vorontsova et al., 2025; Nam & Thi, 2024; Ho et al., 2025).

For a detailed bibliometric analysis, the research follows the methodology of Donthu et al. (2021), as illustrated in Table 1. The VOSviewer software was chosen for visualization.

Bibliometric analysis helps to scan large amounts of information and uncover meaningful insights by building clusters with homogeneous features.

The study conducted a bibliometric analysis of the literature. It employed a systematic literature review method, also known as a hybrid review, to gain insights into best practices in scientific knowledge, particularly within the realm of climate risk management. This comprehensive approach allows us to track the development of scientific knowledge in this field using quantitative bibliometric tools while delving into the subject matter in-depth through qualitative systematic review techniques. In this paper, quantitative and qualitative analysis methods were used to examine the literature concerning climate risk and management in the banking sector. Data from the Web of Science and Scopus were utilized.

Table 1. Research design

Source: Donthu et al. (2021), Singh et al. (2024).

Identification	
Records identified from: Web of Science Databases. Search Keywords used: "climate risk" (number of records: 4171) and "climate risk banks" (number of records: 1217)	
Screening	
Limited to: Articles (3643 for "climate risk"; 1068 "climate risk banks"), English language (3596 for "climate risk"; 1200 "climate risk banks"), Subject areas limited to Business, Economics, and Management (503 for "climate risk") / Subject areas limited to Business, Business Finance, Economics, and Management (320 for "climate risk banks")	
Included	
The number of articles from the Web of Science Core Collection: "climate risk" – 503; "climate risk banks" – 320	
Bibliometric analysis	
Aspect	
Focus	Quantitative patterns in publication metadata
Data Type	Metadata (e.g., citations, authors, journals)
Methodology	Quantitative and computational approach
Tools	VOSviewer
Purpose	Analyzing research output and trends
Output	Citation networks, trend graphs, and author analysis
Content analysis	
Aspect	
Focus	Content and meaning within communication
Data Type	Textual, visual, or auditory data
Methodology	Qualitative or mixed-methods approach
Purpose	Understanding themes and interpretations
Output	Themes, codes, narratives, or content patterns

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Different data can be used to analyze the scientific literature. The data can be analyzed by publication year, growth, research area, country, document type, authors, Web of Science category, affiliation, language, and other factors. For bibliometric network analysis, the software VOSviewer was used, following the methodological ideas of Steiner et al. (2024), Mong and Thanh (2024), Voronenko et al. (2024), Viet and Thanh (2024), and Sang (2024).

Content analysis is a versatile research method that systematically examines and interprets the content of communication, including texts, images, and audiovisual materials. It aims to identify patterns, themes, or underlying meanings within the data by categorizing and coding the information based on predefined or emergent criteria. This method can be qualitative, focusing on in-depth interpretation and the contextual meaning of content, or quantitative, where numerical data are generated to assess the frequency and distribution of themes or keywords. Content analysis is widely applied in media studies, social sciences, and health research to explore how certain topics are represented, the prevalence of specific ideas, or shifts in discourse over time. Its strength lies in its flexibility, allowing researchers to analyze manifest content (explicit information) and latent content (underlying meanings), making it a powerful tool for uncovering insights in complex datasets. Content analysis is a valuable tool for understanding the challenges of climate change in the banking sector.

3. RESULTS

The bibliometric analysis is started using the Web of Science Core Collection database. The first search was made using the words "climate + risk". The Web of Science database Core Collection gave 4171 search results. In the Web of Science Core Collection database, various types of scientific documents related to climate risk issues were identified. Still, of course, the articles are the most popular form of scientific production. Based on the chosen methodology, the search results by document type were limited to articles, and 3643 articles for the topic "climate + risk" were then selected for further research.

Firstly, data analysis was used to identify the importance of climate risk issues in historical trends. Figure 1 shows that this science topic was first analyzed in 1990, but after the COVID-19 pandemic, an obvious uptrend can be seen. This topic became highly relevant in 2021--2022 and has remained so to date. The reason is quite apparent: lately, everyone has faced numerous signs of climate change, and this topic has become especially relevant among business entities and financial institutions.

The topic of climate risk is relevant in many sciences, including the banking sector. This illustrates how the problem is fundamental to all fields of science. Figure 2 indicates that Economics accounts for approximately 11 percent of all research areas, and Business Finance accounts for about 9 percent. The most popular climate risk issues analysis is in environmental sciences, accounting for about 34 percent of all research.

Analyzing the research spread worldwide by country (Table 2), it is evident that U.S. scientists conduct the most research, accounting for approximately 25 per cent of all articles on climate risk.

Source: Web of Science data.

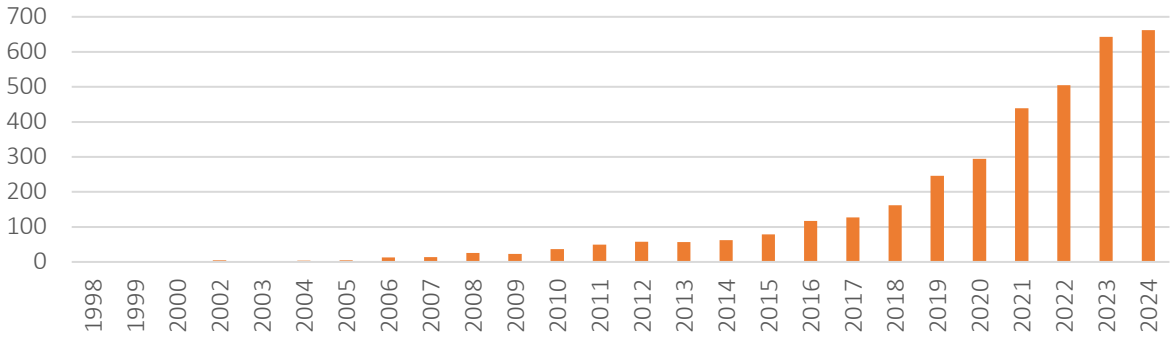

Figure 1. Number of articles by publication year

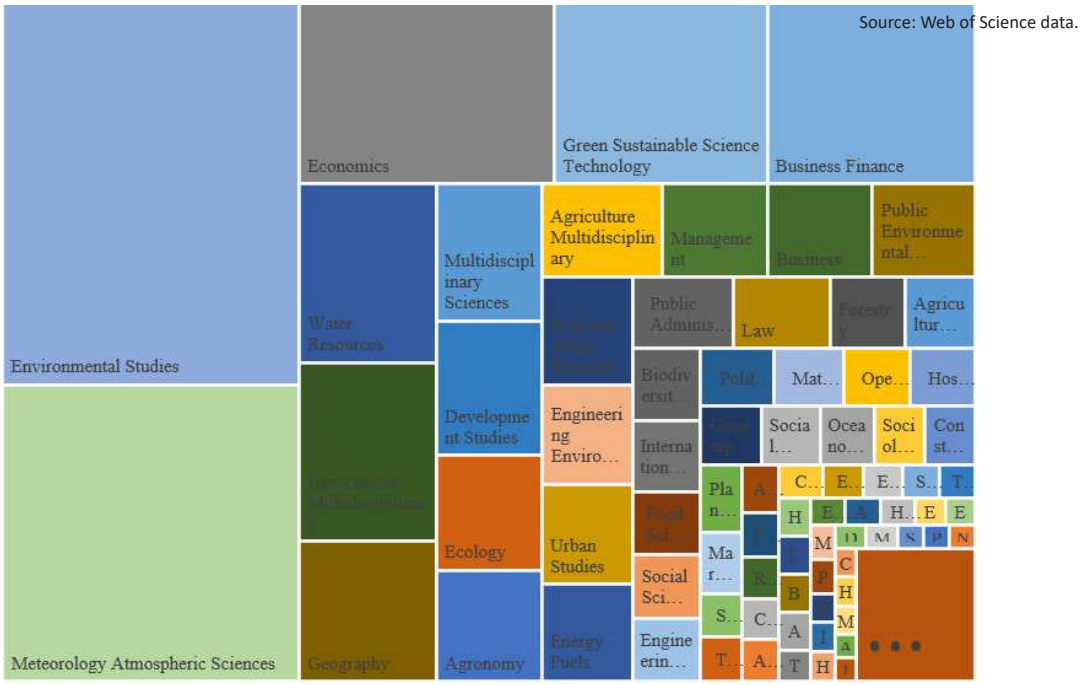

Figure 2. Number of scientific articles by research area

In second place is England (15.8%), and China (14.5%) comes in third position. Among the Baltic states, Latvia has the most favorable research environment. There can be found three scientific articles in Latvia, Lithuania, two articles, and Estonia, the smallest amount of scientific articles (1 article). It cannot be concluded, based on scientific papers, that the problem of climate risk differs across countries. The data above shows how the topic is widely analyzed among different countries.

Table 2. Number of scientific articles by country

Source: Web of Science data.

Country	Number of articles	Percentage of all articles
USA	905	24.842%
England	575	15.784%
People's Republic of China	528	14.494%
Australia	391	10.733%
Germany	327	8.976%
Canada	207	5.682%
Netherlands	206	5.655%
India	182	4.996%
France	177	4.859%
Italy	177	4.859%

The articles can be diversified based on the language using Web of Science data. Based on the search results, it was identified that 3,596 articles were written in English, 15 in Spanish, 11 in Portuguese, and even 1 in Ukrainian. For the bibliometric analysis using VOSViewer, the articles were limited to English and excluded those in other languages. For VOSViewer analysis, the focus was limited to three Web of Science categories: Economics, Business, and Management. After applying this limitation for deeper analysis, only 503 articles remained.

Figure 3 illustrates co-word analysis, which helps identify relevant research fields in the context of climate risk. For co-occurrence analysis, all keywords were used. The minimum number of occurrences of a keyword was limited to 5. Based on this limitation, of 2,357 keywords, only 172 met the threshold. Some words unrelated to the primary research topic, such as country names or irrelevant abbreviations, were excluded.

Figure 3 illustrates the relationship between keywords and climate risk events. The node thickness represents the frequency of occurrences and highlights the significance of these keywords. Each cluster is color-coded to represent different topics. The ten most frequently used keywords include climate risk, climate change, impact, risk, adaptation, uncertainty, performance, management, cost, and policy.

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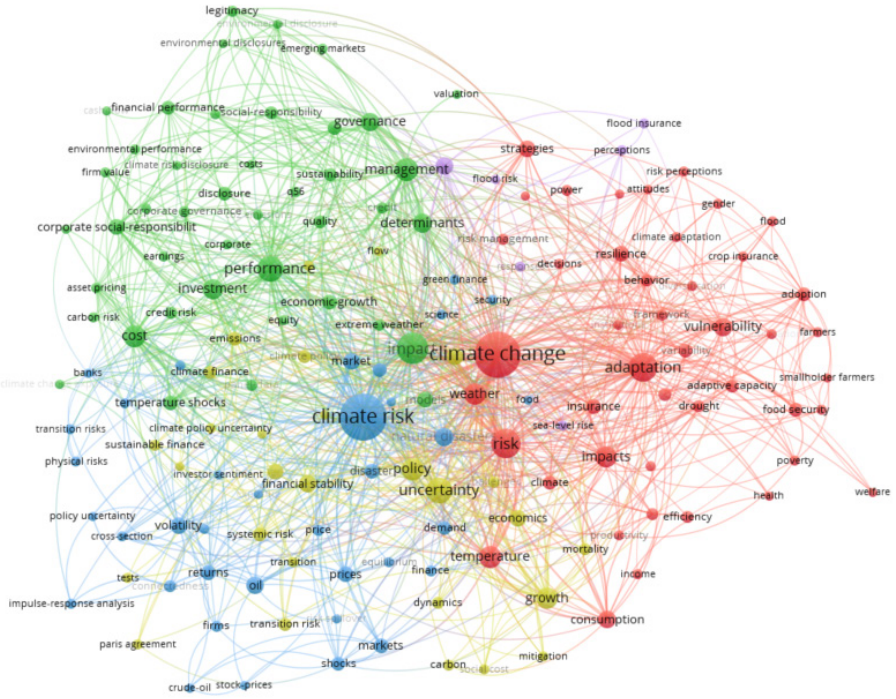

Figure 3. Network visualization: Co-occurrence of keywords based on clusters

To understand the latest challenges of climate risk in broad economics and management, research focuses on the top 10 most cited papers of 2024 (Table 3).

The most cited paper on climate risk by Wang et al. (2024) addresses disclosure issues, emphasizing the necessity for Chinese enterprises to disclose climate risk information. Using data from 2010 to 2020, the study develops indicators that link disclosure to reduced carbon emissions, which are amplified by executive environmental experience, investor attention, and government oversight. It finds that physical disclosure is adequate for short-term reductions, while transformational disclosure is better suited for long-term goals. High-quality disclosures mitigate the negative impacts of carbon emissions on solvency and profitability.

Li et al. (2024) analyze firm-level climate risk exposure through textual analysis of earnings calls, developing dictionaries for physical and transition risks. Firms that are unresponsive to high transition risks face valuation discounts, whereas proactive responses include investments, green innovations, and adjustments to employment practices.

Table 3. Most cited articles in 2024 for climate risk in economics

Author	Area, research level	Citations
Wang et al. (2024)	Climate risk disclosure, company level	24
Li et al. (2024)	Measurements and responses, company level	21
Arfaoui et al. (2024)	Green investment funds, financial market level	21
Naseer et al. (2024)	ESG performance and value, company level	16
Qin et al. (2024)	Climate risk and technological progress	12
Liu et al. (2024)	Climate risk and financial stability, central bank level	11
Hu and Borjigin (2024)	Economic policy uncertainty and energy stock market volatility, financial market level	10
Mohammed et al. (2024)	The effect of green bonds on climate risk, financial market level	10
Banerjee (2024)	Climate risk and global commodity markets, financial market level	10
Berkman et al. (2024)	Climate risk and company valuation, company level	9

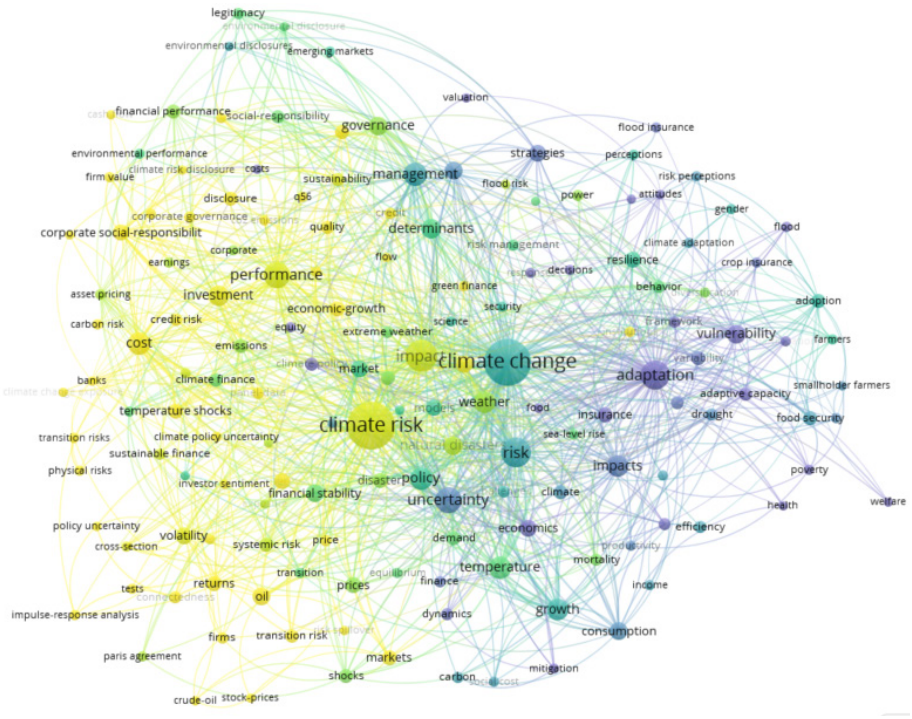

Figure 4. Overlay visualization: Co-occurrence of keywords by publication year

Arfaoui et al. (2024) explore whether green investment funds (GIFs) hedge climate risk. Their analysis, spanning 2009–2022, identifies the diversification benefits of GIFs during extreme events, despite symmetrical co-movement during crises such as COVID-19 and the Russia-Ukraine armed conflict. The study highlights the role of GIFs in mitigating climate risks, offering insights for sustainability-aligned investment strategies.

Figure 4 shows the keywords used to trace the development and trends from the previous year. Based on the information in Figure 5, it is evident that climate risk topics have become increasingly relevant in recent years despite the numerous scientific works on climate change issues published many years ago. Based on time frame analysis, it is evident that climate risk challenges have become increasingly relevant in terms of performance and costs. Also, more attention is paid to volatility in the financial markets.

Source: Web of Science data of 2024-11-09.

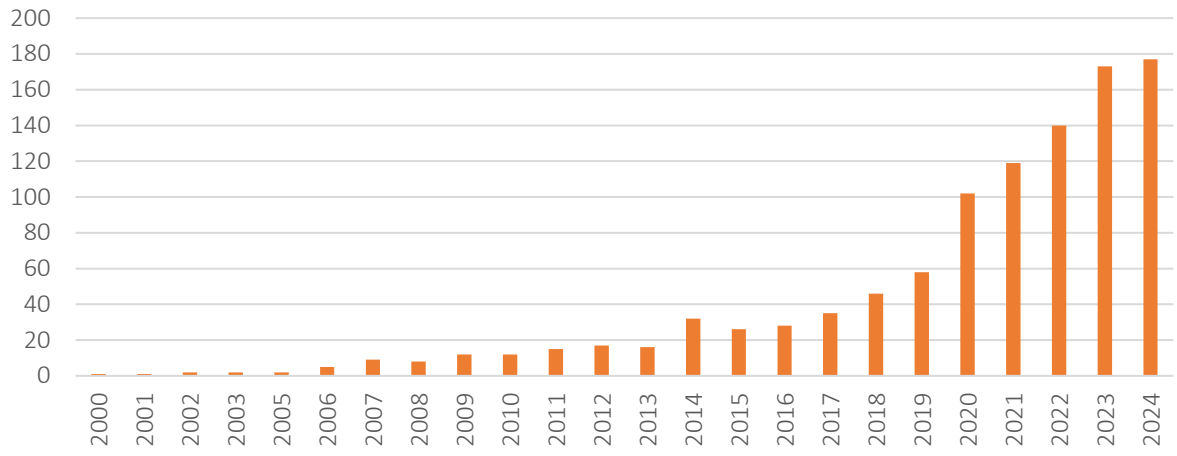

Figure 5. Number of articles by publication year

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Table 4. Most cited articles in banking

Source: Web of Science data of 2024-11-10.

Authors	Research focus	Citations
Dafermos et al. (2018)	Climate change, financial stability, and monetary policy	264
Dikau and Volz (2021)	Central bank mandates, sustainability, and green Finance	194
Geddes et al. (2018)	State investment banks in low-carbon energy finance	164
Javadi and Masum (2021)	The impact of climate change on the cost of bank loans	151
Battiston et al. (2021)	Climate risk and financial stability	143
D'Orazio and Popoyan (2019)	Climate-related financial risks and macroprudential Policies	135
Fatica et al. (2021)	The pricing of green bonds and banks issuing bonds	130
Roncoroni et al. (2021)	Climate risk and financial stability	101
Chenet et al. (2021)	Climate-related financial risks and central banks' policy	98
Lamperti et al. (2021)	The green financial policies: financial sector and economic growth	95

After analyzing a scientific article on climate risk, the research focuses on a narrower topic related to climate risk in the banking sector. After narrowing the search and analysis to the banking topic and making the search based on the words "climate risk banks," the search gave more precise results focused on economic, business finance, business, and management issues. By narrowing the search field, 319 articles were found.

Figure 5 shows that the trend of scientific articles is quite visible, with relevance growing yearly. 2020 was the most active year for writing about climate risk issues in the banking sector, particularly concerning upcoming regulatory aspects. Additionally, historical trends indicate that the relevance of climate risk in the banking sector increased significantly during the COVID-19 period and its aftermath.

In the next step, the research focuses on the most cited articles in the area of banking. Table 4 clearly shows that the most cited articles focus on central banks, financial stability, and policy-creating challenges.

According to the Web of Science database, the most active authors in climate risk and banking are Battiston S., Monasterolo I., Niedziółka P., Allesi L., and Korzeb Z. Alessi and Battiston (2022) developed a top-down method to identify financial portfolio greenness and estimate exposure to climate transition risk, showing that green-focused investors still face significant transition risks. Bressan et al. (2022) examined how greenness combines with financial criteria in corporate bond portfolios under the ECB asset purchase program.

Roncoroni et al. (2021) analyzed the impact of climate risk on financial stability, highlighting how market conditions and transition risks interact. They found that robust markets could support ambitious climate policies without increasing financial risk. Monasterolo et al. (2018) introduced a climate stress-testing approach for energy infrastructure loans, highlighting that coal and oil projects are highly vulnerable to climate shocks, with regional impacts ranging from 4.2% to 22% of loan values.

Battiston et al. (2017) developed a climate stress-testing method using network analysis, revealing significant exposures in equity and loan portfolios to sectors affected by climate policies. Dunz et al. (2021) developed a stock-flow model to assess the impact of green frameworks on economies and banks, highlighting both short-term benefits and potential trade-offs for bank stability. Dunz et al. (2023) extended this work to analyze COVID-19 and climate risks, using the EIRIN model to assess the interplay of lending and policy in economic recovery.

Based on the research of scientific literature, all three hypotheses were accepted.

H1: Integration of climate risk considerations into central bank policies significantly enhances the financial stability of banking systems.

The research demonstrates that central banks are increasingly incorporating climate risk measures, such as stress tests and disclosure guidelines, into their policy frameworks. These measures have been demonstrated to enhance the resilience of financial institutions and mitigate systemic fi-

Table 5. Most active authors in climate risk management in financial systems, with the most focus on banks

Source: Web of Science data of 2024-11-10.

Author / Number of articles about climate risk in banks	WoS H-index	Article	Year	Citation	Co-authors	Research area
Battiston, S. / 8	36	Over with carbon? Investors' reaction to the Paris Agreement and the U.S. withdrawal (Alessi et al., 2024)	2024	1	Alessi, Lucia; Kvedaras, Virmantas	Financial markets level
		Financial stability through the lens of complex systems (Halaj et al., 2024)	2024	0	Halaj, Grzegorz; Martinez-Jaramillo, Serafin	Central bank level
		Two sides of the same coin: Green Taxonomy alignment versus transition risk in financial portfolios (Alessi & Battiston, 2022)	2022	22	Alessi, L.	Financial markets level
		Sustainable investing and climate transition risk: A portfolio rebalancing approach (Bressan et al., 2022)	2022	5	Bressan, G., Monasterolo, I.	Financial markets level
		Climate risk and financial stability in the network of banks and investment funds (Roncoroni et al., 2021)	2021	101	Roncoroni, A., Escobar-Farfán, L.O.L., Martinez-Jaramillo, S.	Central bank level
		Climate risk and financial stability (Battiston et al., 2021)	2021	143	Dafermos, Yannis; Monasterolo, Irene	Central bank level
		Financial networks and stress testing: Challenges and new research avenues for systemic risk analysis and financial stability implications (Battiston & Martinez-Jaramillo, 2018)	2018	72	Martinez-Jaramillo, Serafin	Central bank level
		Climate Transition Risk and Development Finance: A Carbon Risk Assessment of China's Overseas Energy Portfolios (Monasterolo et al., 2018)	2018	30	Monasterolo, Irene; Zheng, Jiani I.	Financial markets level
Monasterolo I. / 6	20	The double materiality of climate physical and transition risks in the euro area (Gourdel et al., 2024)	2024	2	Gourdel, Regis; Dunz, Nepomuk; Mazzocchetti, Andrea; Parisi, Laura	Financial markets level Commercial banking Central bank level
		Compounding COVID-19 and climate risks: The interplay of banks' lending and government's policy in the shock recovery (Dunz et al., 2023)	2023	23	Dunz, N., Hrast Essenfelder, A., Mazzocchetti, A., Raberto, M.	Commercial banking
		Sustainable investing and climate transition risk: A portfolio rebalancing approach (Bressan et al., 2022)	2022	5	Bressan, G., Battiston, S.	Financial markets level
		Climate risk and financial stability (Battiston et al., 2021)	2021	143	Dafermos, Yannis; Battiston, S.	Central bank level
		Climate sentiments, transition risk, and financial stability in a stock-flow consistent model (Dunz et al., 2021)	2021	76	Dunz, N., Naqvi, A., Monasterolo, I.	Financial markets level
		Climate Transition Risk and Development Finance: A Carbon Risk Assessment of China's Overseas Energy Portfolios (Monasterolo et al., 2018)	2018	30	Zheng, J.I., Battiston, S.	Financial markets level

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Table 5 (cont.). Most active authors in climate risk management in financial systems, with the most focus on banks

Author / Number of articles about climate risk in banks	WoS H-index	Article	Year	Citation	Co-authors	Research area
Niedziólka P. / 5	5	Climate risk and capital requirements - findings for the Polish banking sector based on empirical research (Korzeb et al., 2024a)	2024	0	Korzeb, Zbigniew; Gospodarowicz, Marcin; Gallegos, Antonio de la Torre	Central bank level
		ESG and climate-related risks versus traditional risks in commercial banking: A bibliometric and thematic review (Korzeb et al., 2024c)	2024	0	Korzeb, Zbigniew; Szpilko, Danuta; di Pietro, Filippo	Commercial banking
		How do ESG challenges affect default risk? An empirical analysis from the global banking sector perspective (Korzeb et al., 2024 b)	2024	2	Korzeb, Zbigniew; Karkowska, Renata; Matysek-Jedrych, Anna	Commercial banking
		Assessment of the Impact of Commercial Banks' Operating Activities on the Natural Environment by Use of Cluster Analysis (Korzeb et al., 2022)	2022	1	Korzeb, Zbigniew; Zegadlo, Monika	Commercial banking
		Polish Banking Sector Facing Challenges Related to Environmental and Climate Protection (Niedziólka, 2020)	2020	1	-	Commercial banking
Allesi L. / 4	10	Accounting for climate transition risk in banks' capital requirements (Alessi et al., 2024b)	2024	1	Di Girolamo, Erica Francesca; Pagano, Andrea; Giudici, Marco Petracco	Central bank level
		Over with carbon? Investors' reaction to the Paris Agreement and the U.S. withdrawal (Alessi et al., 2024a)	2024	1	Battiston, S. Kvedaras, Virmantas	Financial markets level
		Two sides of the same coin: Green Taxonomy alignment versus transition risk in financial portfolios (Alessi & Battiston, 2022)	2022	22	Battiston, S.	Financial markets level
		What greenium matters in the stock market? The role of greenhouse gas emissions and environmental disclosures (Alessi et al., 2021)	2021	67	Ossola, Elisa; Panzica, Roberto	Financial markets level
Korzeb Z. / 4	5	How do ESG challenges affect default risk? An empirical analysis from the global banking sector perspective (Korzeb et al., 2024b)	2024	2	Karkowska, Renata, Matysek-Jedrych, Anna; Niedziolka, Pawel	Commercial banking
		ESG and climate-related risks versus traditional risks in commercial banking: A bibliometric and thematic review (Korzeb et al., 2024c)	2024	0	Niedziolka, Pawel; Szpilko, Danuta; di Pietro, Filippo	Commercial banking
		Climate risk and capital requirements - findings for the Polish banking sector based on empirical research (Korzeb et al., 2024a)	2024	0	Gospodarowicz, Marcin; Niedziolka, Pawel; Gallegos, Antonio de la Torre	Commercial banking
		Assessment of the Impact of Commercial Banks' Operating Activities on the Natural Environment by Use of Cluster Analysis (Korzeb et al., 2022)	2022	1	Niedziolka, Pawel; Zegadlo, Monika	Commercial banking

nancial risks, thereby improving overall financial stability. The analysis also highlights successful examples of central banks adopting proactive policies to address climate risks, supporting this hypothesis.

H2: There is a significant gap in scientific research on the role of foreign reserves management in mitigating climate risks by central banks.

The study explicitly identifies foreign reserves management as a critical area lacking in-depth research and analysis. While central banks have made strides in other aspects of climate risk management, such as stress testing and regulatory oversight, the integration of climate risk considerations into foreign reserves strategies remains underexplored, confirming this hypothesis.

H3: Enhanced climate risk disclosure practices in the financial sector contribute to better alignment with sustainability objectives and reduce systemic financial risks.

The results support this hypothesis by referencing studies that link high-quality climate risk disclosures to improved corporate practices, reduced carbon emissions, and enhanced financial stability. The role of disclosure practices in fostering alignment with sustainability goals and mitigating systemic risks is highlighted, mainly through regulatory and market-driven efforts, reinforcing the validity of this hypothesis.

4. DISCUSSION

This study highlights the growing role of central banks in mitigating climate risks, reflecting the financial sector's vulnerability to climate change and the need for systemic responses. Through bibliometric and content analyses, it highlights the dual nature of climate risks – physical and transition – and their implications for monetary policy, financial stability, and resilience, underscoring the need for robust integration of climate considerations into operational frameworks.

A key finding is the varied global approaches driven by differences in regulatory environments and national policies. While measures like stress testing and enhanced disclosure are widely adopted, foreign reserve management remains underexplored. This presents opportunities to align reserve strategies with sustainability goals while balancing safety, liquidity, and returns.

The research also reveals a fragmented scientific discourse, with limited studies on the long-term implications of foreign reserves and their interaction with macroprudential stability. Insights from advanced frameworks, such as the Eurosystem, can guide the harmonization of global practices and address these gaps.

This study contributes to the literature by identifying thematic trends and gaps while emphasizing the importance of adaptive strategies. By fostering collaboration among financial institutions, policymakers, and regulatory bodies, the central banking community can address immediate financial stability challenges and prepare for the profound, systemic impacts of climate change. Future studies should aim to develop standardized tools for assessing climate risks in foreign reserves and explore the integration of climate-sensitive metrics into monetary policy frameworks.

The findings of this article align with and expand upon existing research in the field of climate risk management by central banks. For instance, the role of stress tests and enhanced disclosure guidelines identified in this study aligns with Battiston et al. (2021), who emphasized the importance of climate stress tests in assessing financial system resilience and the evolving dynamics of contagion between financial institutions. Similarly, Dikau and Volz (2021) emphasize the integration of sustainability goals into central banking frameworks, corroborating this study's observation of a broader institutional shift toward climate-aware policies.

The article's focus on the gap in foreign reserves management aligns with Torinelli and Silva (2021), who advocate for incorporating environmental risk analysis into strategic asset allocation by central banks. However, this study identifies this area as underexplored, highlighting a specific gap that previous literature has not addressed comprehensively.

Furthermore, the study's findings on the importance of climate risk disclosures are consistent with those of Wang et al. (2024), who demonstrat-

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ed that high-quality climate risk disclosures lead to tangible benefits, including reduced carbon emissions and improved financial stability. This supports the argument that central banks' regulatory efforts in fostering better disclosure practices can have a systemic impact.

In comparison to Campiglio et al. (2018), who discuss the broader challenges central banks face in addressing climate change, this article provides a more focused analysis of specific tools, such as stress tests and foreign reserves management, offering actionable insights that complement the broader theoretical discussions in the literature.

While this study reinforces existing research conclusions, it also identifies unique gaps and practical challenges, particularly in foreign reserves management, that provide a basis for future research and policy development.

CONCLUSION

This paper aims to identify the primary areas of focus for central banks in climate risk management by systematically reviewing and consolidating existing scientific papers and identifying gaps in the research that point to areas requiring further investigation. It highlights that climate risks, including physical and transition risks, pose significant challenges to financial stability and economic resilience. Central banks are increasingly integrating climate considerations into their policy frameworks through measures such as stress tests, risk disclosure guidelines, and macroprudential strategies, thereby strengthening the resilience of the financial system.

Key findings reveal progress in climate risk management but highlight gaps in foreign reserves management, an under-researched area. Future research should focus on aligning reserve management strategies with sustainability objectives while maintaining traditional priorities of safety, liquidity, and return. Standardized models to evaluate the impact of climate risks on reserves, along with insights from leading central banks' best practices, could inform global guidelines. Exploring the interplay between reserve currency portfolios, climate risks, and strategic allocation decisions could further support adaptive strategies for long-term sustainability.

The study also notes diverse institutional approaches reflecting varying regulatory environments, economic structures, and climate policies, emphasizing the need for harmonized methodologies and shared best practices. Central banks must evolve their roles to adopt robust, forward-looking strategies that address both immediate financial stability and the long-term implications of climate change. Collaborative efforts among financial institutions, regulators, and policymakers are vital to developing comprehensive frameworks that support sustainable development and financial resilience. Bridging knowledge gaps in foreign reserves management remains crucial for central banks' proactive engagement in climate risk mitigation.

AUTHOR CONTRIBUTIONS

Conceptualization: Ahmad Kaab Omeir, Deimante Vasiliauskaite.
Data curation: Ahmad Kaab Omeir, Deimante Vasiliauskaite.
Investigation: Ahmad Kaab Omeir, Deimante Vasiliauskaite.
Methodology: Ahmad Kaab Omeir, Deimante Vasiliauskaite.
Software: Ahmad Kaab Omeir.
Supervision: Ahmad Kaab Omeir, Deimante Vasiliauskaite.
Visualization: Ahmad Kaab Omeir.
Writing – original draft: Ahmad Kaab Omeir, Deimante Vasiliauskaite.
Writing – reviewing & editing: Ahmad Kaab Omeir, Deimante Vasiliauskaite.

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