Climate Economics and Finance

Homepage: https://www.anserpress.org/journal/cef

Climate Economics and Finance: A Literature Review

Hao Dong [a, *], Tao Li [b]

[a] *Lingnan College, Sun Yat-Sen University, Guangzhou, China*
[b] *School of Social and Political Science, University of Melbourne, Melbourne, Australia*

ABSTRACT

"Climate Economics and Finance" has risen to prominence as a crucial field, encompassing three primary dimensions: Climate Economics, Climate Finance, and the Intersection of Climate Change and Financial Markets. The adverse externalities arising from climate change, exemplifying a classic instance of "market failure" within market economic frameworks, have garnered global attention. Subsequently, we delve into the literature across three dimensions: the interplay between climate change and macroeconomics, the nexus of climate change and financial markets, and economic or financial resilience. In conclusion, we outline various promising avenues for prospective research in the realm of climate economics and finance.

KEYWORDS

Climate Change; Macro-Economics; Financial markets; Resilience; Literature Review

* Corresponding author: Hao Dong
E-mail address: dongh26@mail.sysu.edu.cn

ISSN
doi: 10.58567/cef01010003

Received 14 August 2023; Accepted 25 September 2023; Available online 3 November 2023

1. Introduction

"Climate Economics and Finance" has emerged as a significant and imperative field. It encompasses three primary facets: Climate Economics, Climate Finance, and the Convergence of Climate Change with Financial Markets. Specifically, "Climate Economics" pertains to economic activities and business prospects intertwined with climate change. It spans a multitude of industries and sectors involved in both mitigating climate change and adapting to its repercussions. (1) The primary objective of Climate Economics is to drive sustainable development, curtail greenhouse gas emissions, and bolster resilience against climate change. This encompasses diverse commercial prospects connected to clean energy, energy efficiency, energy consumption, pollutant emissions, carbon markets, green finance, renewable energy, climate adaptation technologies, and sustainable transportation. (2) Within the realm of Climate Economics, numerous companies and organizations are dedicated to reducing carbon footprints and transitioning toward low-carbon economic models. This transition may encompass the integration of clean energy technologies like solar and wind power, enhancement of energy efficiency, advocacy for sustainable agriculture and forest management, promotion of sustainable urban planning, and innovation in low-carbon products and services. (3) Climate Economics also facilitates the expansion of green finance, encompassing initiatives such as green bonds and sustainable investments, aimed at supporting low-carbon and climate-resilient projects. This economic approach necessitates policy formulation and regulatory actions to incentivize and assist businesses and individuals in pursuing sustainable practices. Above all, Climate Economics endeavors to confront the challenges posed by climate change by fostering sustainable development and cultivating environmentally responsible business prospects. In doing so, it aims to yield enduring ecological and economic advantages.

"Climate Finance" pertains to financial activities and investments intertwined with climate change and sustainable development. Its core focus lies in directing capital toward projects and enterprises that promote the shift towards a low-carbon economy, climate adaptation, and the reduction of carbon emissions. (1) The overarching objective of Climate Finance is to expedite climate action and stimulate economic transformation in response to climate change through the provision of funding and financial instruments. This encompasses investments in the advancement of renewable energy, enhancement of energy efficiency, establishment of carbon markets and pricing mechanisms, climate adaptation, and effective risk management. (2) Within the sphere of Climate Finance, several pivotal financial instruments and mechanisms are extensively employed, including: (a) Green Bonds: These bonds are issued to raise capital for environmentally-friendly and low-carbon projects. Investors can contribute to sustainable development and climate initiatives by investing in these bonds. (b) Sustainable Investment Funds: Designed to invest specifically in entities and projects adhering to environmental, social, and governance (ESG) criteria, these funds aim to drive sustainable development and a low-carbon economy. (c) Carbon Markets and Carbon Trading: Carbon markets incentivize companies to curtail carbon emissions by instituting mechanisms for carbon emission trading. This framework promotes carbon reduction projects through the allocation and trading of carbon quotas. (d) Climate Risk Assessment and Insurance: Employed to evaluate climate-related risks linked to companies and investment portfolios, these tools offer insurance coverage to address losses and disasters induced by climate change. (e) Sustainable Development Goals (SDGs) Bonds: These bonds are issued to support the attainment of the United Nations' Sustainable Development Goals, encompassing domains such as poverty alleviation, healthcare, education, and environmental sustainability. (3) The evolution of Climate Finance has the potential to facilitate the inflow of funds into low-carbon and sustainable economic sectors, stimulating innovation and technological progress. Additionally, it plays a pivotal role in diminishing climate-related risks and yielding lasting environmental and economic advantages.

"The Convergence of Climate Change with Financial Markets", including the stock market, is a complex interplay involving risk assessment, industry evolution, investor inclinations, ESG considerations, and the impact of policies and regulations. (1) Climate change-related physical and transitional risks can significantly influence companies'

profitability and market prospects, thereby influencing their stock prices. For instance, extreme weather events can trigger business disruptions and financial losses, consequently affecting the financial health and market valuation of companies. Investors tend to assign higher valuations to companies that exhibit robust climate change risk management strategies and sustainable development approaches. The impetus towards climate change propels the shift towards energy transition and sustainable development, fundamentally reshaping various industries and sectors. Sectors heavily reliant on high carbon emissions, such as fossil fuels and automotive manufacturing, may confront challenges posed by diminishing demand and heightened market competition. Conversely, sectors focused on low-carbon technologies, such as renewable energy and clean technologies, may thrive due to policy backing and surging market demand. This transformative shift within industries and sectors directly influences the performance and stock prices of pertinent companies. (2) Investor preferences and ESG considerations: An escalating number of investors are now integrating environmental, social, and governance (ESG) criteria into their investment decisions. Climate change assumes a pivotal role within ESG assessments. The attention investors direct towards climate risks is expanding, and they tend to invest in companies that exhibit adept climate risk management while divesting from high-carbon sectors. This shift in investor preferences can also have repercussions on stock market performance. (3) Governmental and regulatory measures addressing climate change stimulate emission reduction endeavors and policies fostering sustainable development. Such policy and regulatory shifts directly shape the operational landscape for industries and corporations, consequently impacting the stock market. For example, the implementation of carbon pricing mechanisms, mandates for renewable energy, and the promotion of green finance standards can influence the profitability and valuation of pertinent companies. These outcomes have prompted financial institutions and investors to increasingly recognize the gravity of climate risks, prompting them to adopt strategies to manage and mitigate these risks, all while pursuing sustainable investment prospects. The financial sector is progressively acknowledging the importance of climate-related factors and enhancing transparency in risk management, investment choices, and asset allocation by disclosing pertinent climate change information. Financial entities must acknowledge these risks and take suitable actions to bolster market resilience while harnessing the opportunities borne out of climate change to steer the transition toward sustainable development and a green economy.

The adverse consequences arising from climate change, representing a quintessential example of "market failure" within market economic contexts, have garnered extensive global attention. China, being a vast nation marked by diverse climate change patterns and situated within the East Asian monsoon region, stands as one of the countries profoundly impacted by extreme weather and climate events. As indicated by the "China Climate Change Blue Book (2022)," China has witnessed a notable escalation in extreme heavy rainfall occurrences from 1961 to 2021, coupled with a significant surge in extreme high-temperature events since the mid-1990s. This is corroborated by an upward trajectory in China's climate risk index. The recurrent instances of extreme climatic events not only present formidable challenges to natural ecosystems, public health, and economic advancement, but also channel adverse risk repercussions into the financial sector. This phenomenon poses a tangible threat to financial system stability, thereby emerging as a significant wellspring of systemic financial risks. The "Outline for High-Quality Meteorological Development (2022-2035)" in China underscores the imperative to enhance society's collective capacity to counter meteorological disasters while bolstering the construction of mechanisms aimed at mitigating and preventing meteorological catastrophes. In 2021, the People's Bank of China successfully concluded the inaugural phase of climate risk stress testing. The forthcoming phase seeks to refine climate stress testing methodologies by concentrating on stress scenarios and transmission routes, broadening the scope to encompass various industries, and conducting macro-level stress assessments.

The global community has initiated the exploration of integrating climate change within risk management frameworks. In 2019, Bain & Company published a report forecasting that the impacts of global climate change

could result in financial market losses surpassing $1 trillion. The study also highlighted that financial institutions and investors face escalated risks due to extreme weather events and climate change-induced disasters, which will exert substantial influence on the stability and sustainable growth of financial markets. In 2021, U.S. financial regulatory bodies designated climate change as a significant threat, asserting that recurrent severe weather events might erode asset valuations. The Financial Stability Oversight Council (FSOC), spearheaded by the U.S. Department of the Treasury, noted in its 2021 report that heightened occurrences of severe weather events and the tangible risks tied to high-carbon industries could weaken asset values and the resilience of institutions. The most recent World Economic Forum Global Risks Report for 2023 underscores that climate and environmental risks occupy a central position in global risk perception for the forthcoming decade, representing the least prepared risks. The Basel Committee on Banking Supervision (BCBS) has delved into comprehensive research on the driving forces behind climate risk and the mechanisms through which these risks transmit to the financial system. This has led to the formulation of measurement techniques for climate-related financial risks. The Network for Greening the Financial System (NGFS), a consortium comprising central banks and regulatory bodies, has merged climate models with macroeconomic models, considering factors like climate warming goals and policy shifts, to establish a more holistic collection of climate scenarios. These serve as a pivotal foundation for executing climate scenario analysis and stress testing on an international scale. Central banks of prominent economies, including the European Union, Japan, and the United Kingdom, are actively exploring climate risk stress testing. Furthermore, numerous significant global banks have already conducted their independent tests or participated in testing initiatives coordinated by regulatory authorities.

The subsequent sections of this paper are structured as follows: Section 2 provides an account of the existing literature concerning the intricate interplay between climate change and macroeconomics. Section 3 presents an overview of the literature that delves into the nexus between climate change and financial markets. Section 4 offers an exposition of the literature addressing economic or financial resilience in the context of climate change impacts. The final section (Section 5) delves into a discussion of prospective and promising avenues for valuable research topics in the domain of climate economics and finance.

2. Climate change and macro-economics

Amidst the backdrop of escalating global warming concerns, the relationship between climate change and the macroeconomy has emerged as a focal point of scholarly inquiry (Dibley et al., 2021). Existing research has meticulously explored the multifaceted impact of climate change across various echelons, spanning businesses, industries, and overall economic development, while adopting diverse research perspectives. Within the business realm, attention has gravitated towards comprehending the implications of climate change-induced extreme events, such as flood risks, heat stress, hurricanes, and rising sea levels, on firm management. Jia et al. (2022) delved into the repercussions of flood risks on firm entry, employment, and their broader ramifications for the aggregate economy. The study scrutinizes the influence of future flood event expectations on firms' decisions to venture into new markets and engage in workforce expansion. In terms of industry-level analysis, initial scholarly endeavors centered on investigating the influence of climate change on agriculture (Mendelsohn et al., 1994; Schlenker et al., 2005; Schlenker and Roberts, 2009; Zhang et al., 2017). As research progressed, the focus organically shifted from agriculture towards encompassing other sectors like manufacturing and real estate (Chen and Yang, 2019; Hauer et al., 2016; Zhang et al., 2018; Dong et al., 2022; Li et al., 2023; Ma and Kirilenko, 2020). Choquette-Levy et al. (2021) explored the effects of amplified climate stress on the adaptive strategies employed by smallholder farmers. Employing an agent-based model, they discovered that in a South Asian agricultural community undergoing a projected 1.5-degree temperature increase by 2050, climate impacts are likely to yield an average 28% reduction in household income by 2050. This correlates with fewer households opting for economic migration and cash crops,

relative to a scenario with a stable climate. Furthermore, climate change introduces intricate challenges for economic adaptation. Semieniuk et al. (2022) scrutinized the distribution of climate change-related risks linked to stranded fossil-fuel assets. Their intriguing findings unveiled that a substantial portion of market risk rests on private investors, predominantly within OECD countries, often manifesting through pension funds and financial markets. Krusell and Smith (2022) examined the nuanced temporal and spatial variations in the economic consequences of climate change. They ascertained that the effects of climate change exhibit marked spatial disparities, with regions experiencing divergent outcomes. Additionally, while global average effects are negative, their quantitative magnitude is overshadowed by spatial differences. Scholars have also explored the interplay of climate change with mitigation costs (Köberle et al., 2022; Sognnaes et al., 2021). Barnett (2023) underscored the potentially profound influence of climate model uncertainties on macroeconomic dynamics and asset pricing outcomes.

Climate change presents a dual threat to financial sectors, encompassing both physical risks and transition risks (Stern, 2008; Hong et al., 2020; Grijalvo and García-Wang, 2023; Murfin and Spiegel, 2020). Physical risks entail heightened occurrences of extreme weather events, such as floods and forest fires, as well as long-term climate alterations, including shifts in precipitation patterns and rising sea levels. These events contribute to business disruptions, scarcities of local resources, the diversion of resources from productive activities towards post-disaster reconstruction and relocation, and surging commodity prices (Stroebel and Wurgler, 2021). As highlighted by Dietz et al. (2016), the perils arising from extreme weather events can precipitate depreciation of household and corporate mortgage portfolios, interruptions in business operations, reduced profitability, and decreased cash flow. These risks exacerbate the financial condition of households and businesses, amplifying the likelihood of loan defaults and elevating banking sector vulnerabilities. Incorporating both physical and macroeconomic dimensions, Drouet et al. (2021) scrutinized the impact of climate change, including temperature overshooting, on various aspects. Their findings underscored how overshooting temperature targets can amplify the likelihood of critical physical impacts, particularly those linked to heat extremes. The reduction of overshooting mitigates risks in the tail-end of the distribution, particularly for lower-temperature objectives, where substantial overshoots are adopted to curtail short-term mitigation expenses. Examining physical risks, Mandel et al. (2021) designed a basic model to trace the propagation of climate-induced shocks through financial networks, primarily focusing on flood-related scenarios. They demonstrated that global risks' magnitude hinges on the interaction between countries' susceptibility to climate-driven natural hazards and their financial leverage. Notably, high-income nations face heightened exposure to financial shocks. Lamperti et al. (2021) employed a macro-financial agent-based model to investigate the interplay of climate change with credit and economic dynamics, and to assess the impact of policy interventions. Their study illuminated that credit provisions could simultaneously enhance firms' productivity and escalate their financial vulnerability, with such a trade-off exacerbated by climate change ramifications. Moreover, extreme events also impact household asset allocations. Gallagher et al. (2023) delved into the influence of exposure to natural disasters on higher education investments. They observed that individuals of college age residing in areas affected by floods in Houston were 7% less inclined to hold student loans after the Harvey disaster, particularly pronounced in locales with higher numbers of potential first-generation students.

Transition risks encompass the financial hazards emanating from the process of transitioning towards a low-carbon economy, aligned with the objectives of the Paris Agreement. These risks are spurred by factors like the abrupt implementation of low-carbon transition policies, swift shifts in consumer preferences, the emergence of novel technologies, and the pace and efficacy of the transition itself. These dynamics yield diverse impacts on financial stability (Agenor and Pereira, 2019; Cahen-Fourot et al., 2020; Giglio et al., 2021; Vermeulen et al., 2021). Dunz et al. (2021) incorporated banks' climate sentiment into a Stock-Flow Consistent (SFC) model, conducting scenario analyses on economic development and financial stability under varied policy combinations of green

support factors and carbon taxes. Their findings underscored the potential effectiveness of carbon taxes in fostering fresh green bank loans and corporate investments compared to green support factors. However, contingent on policy implementation, these measures may impart short-term adverse impacts on GDP growth and financial stability. In assessing whether ambitious climate policies can lead to macroeconomic instability, Carattini et al. (2021) established that transition risk, induced by climate change, can be mitigated through macroprudential policies such as taxes or subsidies on banks' assets. Semieniuk et al. (2022) formulated a coherent theoretical framework outlining the drivers, transmission channels, and consequences of phasing out carbon-intensive industries for the financial system. They also explored the reciprocal influences of the financial system on the broader economy. Analyzing the interactions between climate transition risk and market conditions, Roncoroni et al. (2021) extended the climate stress-test framework for the financial system by incorporating an ex-ante network valuation of financial assets. Their findings indicated that, during a tumultuous low-carbon transition, favorable market conditions could enable the realization of more ambitious climate policies without proportionate increases in financial risk. Stern et al. (2022) deliberated upon the analytical underpinnings of an alternative approach capable of offering insights into optimal management strategies during the transition to net-zero emissions. Acharya et al. (2023) explored the design of climate stress tests to evaluate and manage macroprudential risks arising from climate change within the financial sector. They discussed the relative merits of employing market-based climate stress tests that leverage publicly available data to complement pre-existing stress testing frameworks.

3. Climate change and financial markets

The impact of climate change on financial markets is primarily manifested through two fundamental elements: returns and risks. Regarding returns, climate change exerts significant effects on cross-border securities investments, giving rise to phenomena such as the "carbon premium" in the stock market (Faccini et al., 2023; Barnett et al., 2020; Campiglio et al., 2023), the "green credit premium" in the banking sector (Degryse et al., 2023; Nguyen et al., 2022), and the "green bond premium" in the bond market (Painter, 2020; Bouri et al., 2023). These dynamics wield substantial influences on multinational securities investment decisions. While the physical risks of climate change have not markedly impacted asset pricing, such as stocks and real estate (Hong et al., 2020), the transition-related risks find their reflection in asset valuations, corporate worth, cost of capital, and option prices. The concept of the "carbon premium" refers to the additional returns that high carbon-emitting companies need to offer in the stock market to compensate investors for the associated risks (Hsu et al., 2023; Reboredo and Ugolini, 2022). Bolton and Kacperczyk (2021a) undertook the first global analysis of this "carbon premium," revealing regional disparities where it prevails in Asian, European, and North American countries. Notably, even China and the United States, with distinct economic and financial market landscapes, exhibit similar carbon premiums. Utilizing data from 31 countries/regions with listed food companies, Hong et al. (2019) ranked these entities annually based on long-term drought trends. Their findings indicated that the predictability of returns is inconsistently aligned with the response of food stock prices to climate change risks. In a study by Baldauf et al. (2020), the link between housing prices and people's beliefs about climate change was explored. Their model demonstrated that in a housing choice equilibrium, prices display varying elasticities to climate risk due to agents deriving utility from proximity to similar peers. The "green fund premium" is closely tied to the "carbon premium," signifying that green funds, investing primarily in renewable energy-related stocks, tend to underperform regular funds, and investors in these green funds are willing to pay a premium for their environmental convictions. Existing research indicates that the "green fund premium" is observable in the U.S. market (Chang et al., 2012), European market (Marti-Ballester, 2019), and 27 emerging market economies (Naqvi et al., 2021). The "green bond premium" refers to a significantly negative yield differential for green bonds compared to conventional bonds. Ehlers and

Packer (2017) found this premium to be existent solely in the primary market, suggesting lower financing costs for issuers. Debate surrounds its existence in the secondary market (Baker et al., 2018). Zerbib (2019) conducted a comparative study on global green bonds and found a small, marginally significant, negative green bond premium overall, restricted to U.S. dollar and euro-denominated sub-samples. Huynh and Xia (2021) estimated the covariance between bonds and a climate change news index, revealing that bonds with higher climate change news beta yielded lower future returns, consistent with the impact of demand for bonds capable of hedging climate risks on asset pricing. Pástor et al. (2022) contended that amid the proliferation of "green" assets, German green bonds surpassed higher-yielding non-green bonds, and with escalating climate concerns, the performance of U.S. green stocks surpassed brown bonds. Moreover, Gong et al. (2022) explored the combined influence of policy uncertainty and climate risks on stock market returns.

From a risk perspective, novel asset categories like green bonds not only empower multinational security portfolios to manage the impact of climate change risks but also offer innovative risk management tools. This is primarily accomplished through risk diversification, risk hedging, and safe-haven strategies (Venturini, 2022; Huang et al., 2022; Wang et al., 2023). Bolton and Kacperczyk (2021b) underlined that the carbon premium can't be elucidated by variations in unforeseen profitability or other recognized risk factors, implying that climate change constitutes a novel risk factor. When it comes to risk diversification, Reboredo (2018) discerned that the green bond market displays a strong correlation with fixed-income markets such as corporate and government bonds, while showing weaker connections to the stock market and energy commodity market. This indicates that investments in the former two markets yield superior risk diversification outcomes. Kocaarslan (2021) further revealed that the U.S. dollar's trajectory significantly influences these price interdependencies. During periods of U.S. dollar appreciation, these assets demonstrate heightened risk diversification effects. This can be attributed to the U.S. dollar's significant role as a major reserve currency in the global financial landscape. Risk hedging strategies were proposed by Saeed et al. (2020), suggesting that holding clean energy assets could effectively manage the risk inherent in investing in polluting energy sources. Jin et al. (2020) found the green bond index to be the most effective tool among four market indices for hedging price fluctuations in the carbon futures market, thereby adeptly mitigating climate change-related risks. Adopting a safe-haven perspective, Kuang (2021) highlighted that green bonds substantially diminish the risk of international stock portfolios, whereas clean energy stocks lack this safe-haven effect. Yousaf et al. (2022) discovered that akin to gold, green bonds exhibit a robust safe-haven effect. During the COVID-19 pandemic, they even served as the exclusive safe-haven assets. Investigating the influence of climate and other environmental regulatory risks on corporate bond risk assessment and pricing, Seltzer et al. (2022) utilized the Paris Agreement as a basis to gauge the anticipated impact of climate risk regulations. Their findings established that climate regulatory risks causally impact bond credit ratings and yield spreads. Pankratz et al. (2023) linked records of firm performance, equity analyst forecast errors, and stock returns around companies' earnings announcements to firm-specific measures of heat exposure. Their study revealed that heightened exposure to extremely high temperatures reduces firms' revenues and operating income, with a noteworthy impact on financial metrics. Nguyen et al. (2023) delved into whether a firm's climate risk affects its default and distress risks. Their investigation indicated that climate risk exerts a negative influence on firms' distance to default, particularly concerning the disclosure of transition risk in annual filings.

Furthermore, scholars have also delved into the interplay between climate change and financial market efficiency, with an emphasis on the role of high-quality information on firms' climate risk exposures in shaping market efficiency. Ilhan et al. (2023) systematically provided evidence demonstrating the significance of institutional investors valuing and seeking climate risk disclosures. The findings underscored strong investor demand for climate risk disclosures, with many actively engaging their portfolio firms to enhance these disclosures. Sautner et al. (2023a) focused on assessing the exposure of individual firms to climate change risks and its

ramifications for firm value. Their analysis revealed that firms operating in industries more susceptible to climate change risks, such as energy, utilities, and manufacturing, tend to experience diminished stock returns and a decline in market value. Furthermore, this study unveiled that firms with pronounced exposure to climate change risks encounter heightened financing costs and lower credit ratings, indicative of increased financial vulnerability. Expanding on this theme, Sautner et al. (2023b) estimated the risk premium associated with firm-level climate change exposure among S&P 500 stocks, examining its time-series evolution from 2005 to 2020. They determined that forward-looking expected return proxies yield an unconditionally positive risk premium, peaking between 0.5% to 1% p.a. during 2011 to 2014, contingent on the proxy employed. The risk premium exhibited a decline since 2015, particularly when the expected return proxy explicitly accounts for the enhanced opportunities and decreased crash risks characteristic of high-exposure stocks. Moreover, investors appear to incorporate climate considerations into their decision-making processes. van Benthem et al. (2022) explored the influence of climate risk concerns on investors' capital allocation and oversight of firms, and how this investor response impacts companies operating in the energy sector. This underlines the broader trend of investors integrating climate-related factors into their investment strategies and engagement with companies.

4. Economic or finance resilience

Since the incorporation of the concept of resilience from ecological research into economic studies, the exploration of economic resilience has gained substantial traction, yielding valuable insights that enhance our comprehension of financial resilience. The realm of economic resilience has been subject to comprehensive and profound research, particularly elucidating its multifaceted dimensions. The existing body of work on economic resilience encompasses a spectrum of aspects, ranging from the precise definition of economic resilience to the intricate array of factors that exert influence upon it.

Academic research on the essence of economic resilience primarily revolves around two dimensions: conceptualization and its subsequent elaboration, as well as the formulation of analytical frameworks. Initially, Hill et al. (2008) posited that economic resilience denotes an economy's capacity to withstand the impacts of market dynamics, competition, and environmental factors on its trajectory of development and growth. Furthermore, economic resilience involves the capability to effectively recuperate from these influences, ensuring the economy remains aligned with its growth trajectory and averting potential deviations. Building on this foundation, the scope of economic resilience has been expanded. Boschma (2015) introduced the concept of regional resilience, which not only reframed economic resilience in terms of a region's aptitude to withstand shocks but also broadened it to encompass a region's long-term capability to forge new paths of growth. Moreover, Martin and Sunley (2015) proposed a more comprehensive definition of economic resilience, which encompasses not only the capacity to endure shocks but also the ability to adapt to shifts in economic structure, social systems, and other dimensions. This involves effectively harnessing physical, human, and environmental resources to restore the development trajectory post-shock or transition into a new path of sustainable growth.

Drawing upon existing research, various factors significantly shape economic resilience, with notable contributors encompassing diversification, network connectivity, technological innovation, and unforeseen events (Cottafava et al., 2022; Walmsley et al., 2023). In terms of diversification, Boschma (2015) delved into the correlation between diversity in industrial structure and economic resilience. This research contends that diversification stands as an optimal condition for industrial structure, balancing regional adaptability and versatility. A diversified industrial landscape fosters substantial interconnectivity within each sector, thereby facilitating the effective exchange of technology among industries. This, in turn, encourages the amalgamation of diverse technological advancements, propelling the emergence of novel avenues for development. Examining the nexus

between digital finance (DF) and regional economic resilience, Yu et al. (2023) unveiled that DF exerts a positive impact on regional economic resilience, albeit not uniformly across subsystems. Additionally, DF exhibits positive spatial externalities, implying that it not only bolsters the local Regional Economic Resilience (RER), but also engenders favorable effects on neighboring areas. Furthermore, Du et al. (2023) delved into the intricate mechanism underlying the influence of digital inclusive finance on economic resilience. Their findings indicated that the efficacy of digital inclusion finance in fostering economic resilience is amplified in environments marked by favorable financial market conditions and conducive business landscapes.

In the context of network connectivity, Raco and Street (2012) directed their focus towards scrutinizing the network linkages between Hong Kong and external regions. They posited that robust economic connections between Hong Kong and neighboring regions, particularly the Pearl River Delta in mainland China, offer a strategic advantage for Hong Kong's sustained and resilient growth. By strategically tapping into regional economic networks and fostering collaborations with mainland Chinese provinces and cities, Hong Kong can bolster its economic resilience, positioning itself favorably within the global market competition landscape. Wang and Ge (2023) embarked on an exploration of the spatial correlations underlying economic resilience, examining the phenomenon from multiple perspectives—overall, group, and individual—and shedding light on its determinants. Their study illuminated that geographical proximity and variations in human capital levels act as drivers for the formation of spatial association networks, while disparities in external openness and physical capital hinder the network formation process. Additionally, the work of Lu and Yang (2023) delved into the heterogeneous impact of economic networks on the economic resilience capacity of urban areas across distinct network characteristics. This approach introduced a novel research perspective and theoretical framework concerning the economic resilience capacity within urban clusters. The study findings underscored the pivotal role of urban economic network linkages in augmenting urban economic resilience capacity. Moreover, they highlighted the influence of the polycentric configuration of urban clusters, which exhibited a driving effect on the positive impact of urban economic network interconnections on economic resilience capacity.

Regarding technological innovation, the work of Balland et al. (2015) underscores the vital role of technological interdependencies across industries (domains) in buffering an economic system against crises, thereby significantly bolstering economic resilience. This perspective highlights the potential of interconnected technologies to act as a safeguard, enabling an economic system to navigate challenges more effectively. The research by Bristow and Healy (2017) delved into the resilience exhibited by the European economy during the tumultuous 2007-2008 economic crisis. Their findings revealed that regions characterized by innovation leadership were better poised for rapid recovery from the crisis. This insight accentuates the role of innovation in fostering resilience, indicating that regions with a robust innovation culture tend to rebound more swiftly from economic disruptions. Furthermore, the study undertaken by Zhong et al. (2022) delved into the impact of firms' innovation on the dynamics of industrial structural transformation. Their investigation unveiled sectoral and regional disparities in the influence of two distinct types of technological innovation—product innovation and process innovation—on industrial structural adjustment.

In the context of major events, Zhou et al. (2020) conducted an analysis focused on the areas most profoundly impacted by the 2008 Wenchuan earthquake. Utilizing data envelopment analysis models and the Malmquist productivity index, they computed the economic resilience index for these regions and assessed the efficiency and effectiveness of post-disaster recovery over annual periods. Their study revealed that the earthquake resulted in a short-term economic decline in the affected regions, with the industrial sector demonstrating lower resilience compared to agriculture and the service industry. Bondonio and Greenbaum (2018) adopted U.S. county-level data to examine the resilience of local economies in the face of rare natural disasters. Their research disclosed that all counties affected by these events experienced short-term economic setbacks. In the long run, counties with less

favorable pre-disaster socioeconomic conditions lagged behind in terms of growth, particularly in the case of low-intensity disasters. Trippl et al. (2023) delved into the intricate and unpredictable repercussions of abrupt shocks such as the ongoing COVID-19 pandemic or the energy crisis accelerated by the Russia-Ukraine conflict. These unforeseen events have renewed the interest in regional economic resilience. Their inquiry aims to identify the essential factors and dynamics that play a pivotal role in augmenting the transformative resilience of regions. Cheng et al. (2022) analyzed how economic resilience responds to significant public health events. They concluded that, in comparison to financial crises, the impact of the COVID-19 pandemic on the economy was far-reaching and encompassing. Weber et al. (2023) explored the ramifications of COVID-19 on marginalized communities and its effects on the provision of public services. Their findings illuminated that the absence of resilient public services amplified the repercussions of COVID-19 and the measures implemented to contain it. This exacerbation further deepened existing structural inequalities within marginalized local communities.

Within the framework of finance serving the real economy, the significance of financial resilience has progressively come into focus. Depending on the specific types of microeconomic entities, financial resilience can be categorized as household financial resilience, government financial resilience, and financial market resilience. Household financial resilience can be perceived as the effective capacity to prosper in the face of adversity. Researchers have predominantly concentrated on identifying the determinants of financial resilience among households. Kleimeier et al. (2023) conducted a study examining the determinants of both objective and subjective financial fragility among 2100 individuals in Australia, France, Germany, and South Africa during the COVID-19 pandemic. Their findings indicated that negative personal experiences during the pandemic correlated with higher levels of objective and subjective financial fragility. However, individuals' cognitive and non-cognitive abilities played a counteracting role in mitigating this heightened financial fragility. Clark and Mitchell (2022) analyzed the financial robustness of Americans amid the Covid-19 pandemic, using an index of financial resilience and a measure of financial fragility. Their conclusion highlighted that higher initial levels of resilience were linked to lower levels of financial fragility one year into the pandemic. Regarding government financial resilience, Lee and Chen (2022) elucidated the association between an organization's financial resilience and its financial, human, and political resources, utilizing the framework of the resource-based view theory (RBV). Their analysis showcased that the impact of government resources on financial resilience varies depending on the specific type of resources available. Financial market resilience stands as a pivotal focal point in scholarly investigations. Tang et al. (2022) delved into the resilience of financial markets against short-term capital flow shocks and subsequently examined how financial development influences this resilience. Empirical findings based on the TVP-VAR model revealed that the resilience of major global financial markets has demonstrated consistent enhancement. However, the resilience of developed and emerging countries exhibits variations across different periods. Wang et al. (2023) explored the effects of monetary policies on the jump risk of the Chinese stock market by employing the EGARCH-ARJI model. Their results indicated that the announcement of an interest rate policy significantly enhances jump risk, whereas the impacts of announcements and implementations of required reserve ratio policies are not statistically significant.

5. Future research

Climate economics and finance have emerged as dynamic and focal domains of advancement. This article serves as a stepping stone to comprehending the evolution of climate economics and finance. It offers insights into ongoing research endeavors and presents compelling directions for future investigations. We first attempt to analyze the development process of climate economy and finance. Secondly, it reviews the research status of climate economics and finance from three perspectives: climate change and macroeconomics, climate change and financial markets, and economic (financial) resilience to climate change. Finally, based on relevant research, three aspects

for further study are proposed. They are as follows:

Explore the mechanisms through which climate change impacts the economy and finance from multiple perspectives, and evaluate its effects from a dynamic viewpoint. On one hand, the impacts of climate change on the real economy, financial systems, or financial markets need to be approached from multiple angles. Different industries within the real economy will experience varying effects from climate change, influenced by factors such as energy consumption, technological investments, and labor utilization. The financial system primarily provides funding support to businesses to cope with climate change impacts. Whether from the perspective of individual enterprises or from the standpoint of industry supply chains, climate change can have significant impacts on operating costs, investment efficiency, operational risks, and supply chain stability. The impacts of climate change on financial markets not only refer to its influence on corporate operations but also relate to investor sentiment and tolerance towards climate change. On the other hand, evaluating the impacts of climate change can be expanded by adopting a resilience perspective. Assessing the impacts of climate change from a resilience viewpoint involves considering both the negative effects of climate change and examining the market's risk management capabilities, adaptive capacity, and learning and reform abilities. Reviewing the relevant research on financial resilience and the relationship between climate change and financial markets reveals that scholars have made initial explorations into the application of resilience in financial markets. Most studies consider climate change as a new risk factor and further examine the risks it brings. However, there is a lack of literature that assesses the impacts of climate change dynamically from a resilience perspective. Furthermore, there is a need to improve climate change assessment methods and models. Enhancing and developing impact assessment models can better quantify and evaluate the impacts of climate change on critical sectors such as agriculture, water resources, energy, and health. This includes improving the accuracy, reliability, and adaptability of the models, considering different climate change scenarios and uncertainties, and simulating the long-term effects of these impacts on systems. Therefore, addressing the impacts of climate change requires not only considering its effects on enterprise operations and extreme events but also examining the market's risk management capabilities, adaptive capacity, and learning and reform abilities.

Build a multi-scale early warning mechanism for climate change impacts. Constructing an early warning mechanism for climate change is a crucial step in protecting society, the economy, and ecosystems from climate-related risks. On one hand, by reviewing the relevant literature on the impacts of climate change on different industries, it is evident that climate change has significant negative effects on agriculture, real estate, manufacturing, and other sectors. However, these studies mainly focus on aspects such as industry-level total factor productivity, while overlooking the industry's own risk management, adaptive capacity, and learning capabilities, as well as the differences among industries. For example, the ability to manage risks and recover from climate change impacts, including extreme weather events, varies considerably between agriculture and manufacturing or real estate sectors. Additionally, the disparities in the learning and adaptation abilities of manufacturing and real estate industries may result in variations in the stability of financial markets before and after climate shocks. Furthermore, the impact mechanisms of climate change differ significantly across industries or different periods. Due to variations in carbon emission intensity, climate change impacts have a greater influence on the input structure and resource utilization in the manufacturing industry. Therefore, the manufacturing industry may experience more significant impacts from climate change, which can also propagate to the financial system and financial markets. On the other hand, integrating climate change-related data and knowledge, including expertise from climate science, socio-economics, environmental science, and other disciplines, is essential. By employing interdisciplinary research methods, a deeper understanding of the complexity and mechanisms of climate change can be achieved, providing comprehensive information support for the early warning mechanism. Hence, constructing an early warning mechanism for climate change requires considering the characteristics of different industries and incorporating the impact mechanisms of climate change to develop specific warning models, among other approaches. Through

continuous improvement and optimization of the early warning mechanism, we can better predict and respond to the impacts of climate change, safeguarding sustainable development for humanity and the environment.

Construct a multidimensional analytical framework to mitigate the impacts of climate change. Strengthen research on measures to prevent climate change while constructing an early warning mechanism. On one hand, identify preventive factors against climate change impacts. As climate change has increasingly significant effects on the economy and society, it is crucial to find effective strategies and response measures. These include policy and regulatory measures, technological innovation and transformation, adaptive capacities of businesses and financial institutions, as well as cross-sector and international cooperation. This involves the development and implementation of relevant policies, regulations, and standards to promote emissions reduction and sustainable development. Simultaneously, regulatory agencies need to enhance monitoring and assessment of climate-related risks to provide guidance and regulations for businesses and financial institutions. Renewable energy, energy storage, carbon capture and utilization, among others, should be promoted. Furthermore, efforts should be made to facilitate industrial transformation and upgrading, encourage low-carbon and sustainable production methods, and reduce reliance on high-carbon energy and resources. Attention should be given to the climate adaptation and risk management capacities of businesses and financial institutions. Research is needed on how to improve businesses' ability to identify and assess climate risks, as well as establish effective risk management and disaster reduction mechanisms. Additionally, financial institutions can further explore pricing methods for climate-related risks and asset allocation to enhance portfolio resilience and risk resistance. Research should focus on strengthening international cooperation mechanisms to facilitate information sharing, technology transfer, and experience exchange, thereby accelerating global climate action and mitigating the impacts of climate change. Moreover, with the development of digital technology and the digital economy, digital technology is gradually diversifying in its approach to addressing climate change impacts. On the other hand, addressing climate change impacts requires both preventing the initial shocks of climate change and creating conditions for the recovery of the real economy, financial system, or financial markets. Existing literature has established a two-dimensional analytical framework, with risk prevention before the shock, response and recovery during the shock, and learning and reflection after the shock as the horizontal axis, and financial stability, financial functionality, and financial reform as the vertical axis. However, this framework does not consider the differences in risk prevention, response, and learning across different industries in the market. Additionally, the role of digital technology and policy interventions by the market or government in preventing and mitigating the impacts of climate change remains unclear. By constructing a multidimensional analytical framework to prevent climate change, decision-makers and researchers can comprehensively understand and evaluate the impacts of climate change shocks, and formulate corresponding response strategies.

Funding Statement

This research was funded by National Natural Science Foundation of China, grand number 72301302, China Postdoctoral Science Foundation, grant number 2022M723680 and Guangdong Basic and Applied Basic Research Foundation, grant number 2022A1515110551.

Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

Author contributions

Conceptualization: Hao Dong, Tao Li; Investigation: Hao Dong, Tao Li; Methodology: Hao Dong; Formal

analysis: Hao Dong, Tao Li; Writing – original draft: Hao Dong, Tao Li; Writing – review & editing: Hao Dong, Tao Li.

References

Acharya, V. V., Berner, R., Engle III, R. F., Jung, H., Stroebel, J., Zeng, X., and Zhao, Y. (2023). Climate Stress Testing. *National Bureau of Economic Research*, working paper, No. w31097. https://www.nber.org/ papers/w31097.

Agénor, P. R., and Pereira da Silva, L. A. (2019). Global Banking, Financial Spillovers, and Macroprudential Policy Coordination. *BIS Working Paper*, 764. https://ssrn.com/abstract=3331409.

Baker, M., Bergstresser, D., Serafeim, G., and Wurgler, J. (2018). Financing the Response to Climate Change: The Pricing and Ownership of U.S. Green Bonds. *NBER Working Paper*, w25194. https://www.nber.org/papers/w25194.

Baldauf, M., Garlappi, L., and Yannelis, C. (2020). Does Climate Change Affect Real Estate Prices? Only If You Believe in It. *Review of Financial Studies*, 33(3), 1256-1295. https://doi.org/10.1093/rfs/hhz073.

Balland, A., Rigby, D., and Boschma, R. (2015). The Technological Resilience of U.S. Cities. *Cambridge Journal of Regions, Economy and Society*, 8(2), 167-184. https://doi.org/10.1093/cjres/rsv007.

Barbera, C., Guarini, E., and Steccolini, I. (2020). How Do Governments Cope with Austerity? The Roles of Accounting in Shaping Governmental Financial Resilience. *Accounting Auditing & Accountability Journal*, 33(3), 529-558.https://doi.org/10.1108/AAAJ-11-2018-3739.

Barnett, M. (2023). Climate change and uncertainty: An asset pricing perspective. *Management Science*, forthcoming. https://doi.org/10.1287/mnsc.2022.4635.

Barnett, M., Brock, W., and Hansen, L. P. (2020). Pricing Uncertainty Induced by Climate Change. *Review of Financial Studies*, 33(3), 1024-1066. https://doi.org/10.1093/rfs/hhz144.

Bolton, P., and Kacperczyk, M. (2021a). Global Pricing of Carbon-Transition Risk. NBER Working Paper, w28510. https://www.nber.org/papers/w28510.

Bolton, P., and Kacperczyk, M. (2021b). Do Investors Care about Carbon Risk?. *Journal of Financial Economics*, 142(2), 517-549. https://doi.org/10.1016/j.jfineco.2021.05.008.

Bondonio, D., and Greenbaum, R. T. (2018). Natural Disasters and Relief Assistance: Empirical Evidence on the Resilience of U.S. Countries Using Dynamic Propensity Score Matching. *Journal of Reginal Science*, 58(2), 659-680. https://doi.org/10.1111/jors.12379.

Boschma, P. (2015). Towards an Evolutionary Perspective on Regional Resilience. *Regional Studies*, 49(5), 733-751. https://doi.org/10.1080/00343404.2014.959481.

Bouri, E., Rognone, L., Sokhanvar, A., and Wang, Z. (2023). From Climate Risk to the Returns and Volatility of Energy Assets and Green Bonds: A Predictability Analysis under Various Conditions. *Technological Forecasting and Social Change*, 194, 122682. https://doi.org/10.1016/j.techfore.2023.122682.

Bristow, G., and Healy, A. (2017). Innovation and Regional Economic Resilience: An Exploratory Analysis. *Annals of Regional Science*, 60(5), 1-20. https://doi.org/10.1007/s00168-017-0841-6.

Cahen-Fourot, L., Campiglio, E., Dawkins, E., Godin, A., and Kemp-Benedict, E. (2020). Looking for the Inverted Pyramid: An Application Using Input-output Networks. *Ecological Economics*, 169, 106554. https://doi.org/10.1016/j.ecolecon.2019.106554.

Campiglio, E., Daumas, L., Monnin, P., and von Jagow, A. (2023). Climate-related Risks in Financial Assets. *Journal of Economic Surveys*, 37(3), 950-992. https://doi.org/10.1111/joes.12525.

Carattini, S., Heutel, G., and Melkadze, G. (2021). Climate policy, financial frictions, and transition risk. *National Bureau of Economic Research*, working paper, No. w28525. https://www.nber.org/papers/ w28525.

Chabot, M., Bertrand, J. L., and Thorez, E. (2019). Resilience of United Kingdom Financial Institutions to Major Uncertainty: A Network Analysis Related to the Credit Default Swaps Market. *Journal of Business Research*, 101, 70-82. https://doi.org/10.1016/j.jbusres.2019.04.003.

Chang, C. E., Nelson, W. A., and Doug Witte, H. (2012). Do Green Mutual Funds Perform Well?. *Management Research Review*, 35(8), 693-708. https://doi.org/ 10.1108/01409171211247695.

Chen, X., and Yang, L. (2019). Temperature and Industrial Output: Firm-level Evidence from China. *Journal of Environmental Economics and Management*, 95, 257-274. DOI: https://doi.org/10.1016/j.jeem.2017.07.009.

Cheng, T., Zhao, Y., and Zhao, C. (2022). Exploring the Spatio-temporal Evolution of Economic Resilience in Chinese Cities During The COVID-19 Crisis. *Sustainable Cities and Society*, 84, 103997. https://doi.org/10.1016/j.scs.2022.103997.

Choquette-Levy, N., Wildemeersch, M., Oppenheimer, M., and Levin, S. A. (2021). Risk Transfer Policies and Climate-Induced Immobility among Smallholder Farmers. *Nature Climate Change*, 11(12), 1046-1054. https://doi.org/10.1038/s41558-021-01205-4.

Clark, R. L., and Mitchell, O. S. (2022). Americans' Financial Resilience during the Pandemic. *Financial Planning Review*, 5(2-3), e1140. https://doi.org/10.1002/cfp2.1140.

Cottafava, D., Gastaldo, M., Quatraro, F., and Santhiá, C. (2022). Modeling Economic Losses and Greenhouse Gas Emissions Reduction During the COVID-19 Pandemic: Past, Present, and Future Scenarios for Italy. *Economic Modelling*, 110, 105807. https://doi.org/10.1016/j.econmod.2022.105807.

Degryse, H., Goncharenko, R., Theunisz, C., and Vadasz, T. (2023). When Green Meets Green. *Journal of Corporate Finance*, 78, 102355. https://doi.org/10.1016/j.jcorpfin.2023.102355.

Dibley, A., Wetzer, T., and Hepburn, C. (2021). National COVID Debts: Climate Change Imperils Countries' Ability to Repay. *Nature*, 592(7853), 184-187. https://doi.org/10.1038/d41586-021-00871-w.

Dietz, S., Brown, A., Dixon, C., and Gradwell, P. (2016). Climate Value at Risk of Global Assets. *Nature Climate Change*, 6(7), 676-679. https://doi.org/10.1038/NCLIMATE2972.

Dong, M., Liu, W., Yang, Y., Xie, M., Yuan, H., and Ni, C. (2022). Load and Release of Gambogic Acid via Dual-target Ellipsoidal-Fe3O4@SiO2@mSiO2-C18@ Dopamine Hydrochloride-graphene Quantum Dots-folic Acid and Its Inhibition to VX2 Tumor Cells. *Nanotechnology*, 34(10), 105101. https://doi.org/10.1088/1361-6528/aca76f.

Drouet, L., Bosetti, V., Padoan, S. A., Aleluia Reis, L., Bertram, C., Dalla Longa, F., ... and Tavoni, M. (2021). Net Zero-emission Pathways Reduce the Physical and Economic Risks of Climate Change. *Nature Climate Change*, 11(12), 1070-1076. https://doi.org/10.1038/s41558-021-01218-z.

Du, Y., Wang, Q., and Zhou, J. (2023). How Does Digital Inclusive Finance Affect Economic Resilience: Evidence From 285 Cities in China. *International Review of Financial Analysis*, 102709. https://doi.org/10.1016/j.irfa.2023.102709.

Dunz, N., Naqvi, A., and Monasterolo, L. (2021). Climate Sentiments, Transition Risk, and Financial Stability in a Stock-Flow Consistent Model. *Journal of Financial Stability*, 54, 100872. https://doi.org/10.1016/j.jfs.2021.100872.

Ehlers, T., and Packer, F. (2017). Green Bond Finance and Certification. BIS Quarterly Review, September. https://ssrn.com/abstract=3042378.

Faccini, R., Matin, R., and Skiadopoulos, G. (2023). Dissecting Climate Risks: Are They Reflected in Stock Prices?. *Journal of Banking & Finance*, 106948. https://doi.org/10.1016/j.jbankfin.2023.106948.

Gallagher, E. A., Billings, S. B., and Ricketts, L. R. (2023). Human Capital Investment After the Storm. *Review of Financial Studies*, 36(7), 2651-2684. https://doi.org/10.1093/rfs/hhad003.

Giglio, S., Kelly, B., and Stroebel, J. (2021). Climate Finance. *Annual Review of Financial Economics*, 13, 15-36. https://doi.org/10.1146/annurev-financial-102620-103311.

Gong, X., Fu, C., Huang, Q., and Lin, M. (2022). International Political Uncertainty and Climate Risk in the Stock Market. *Journal of International Financial Markets, Institutions and Money*, 81, 101683. https://doi.org/10.1016/j.intfin.2022.101683.

Grijalvo, M., and García-Wang, C. (2023). Sustainable Business Model for Climate Finance. Key Drivers for ehe Commercial Banking Sector. *Journal of Business Research*, 155, 113446. https://doi.org/10.1016/j.jbusres.2022.113446

Hauer, M. E., Evans, J. M., and Mishra, D. R. (2016). Millions Projected to be at Risk from Sea-level Rise in the Continental United States. *Nature Climate Change*, 6(7), 691-695. https://doi.org/10.1038/NCLIMATE2961.

Hill, E., Wial, H., and Wolman, H. (2008). Exploring Regional Economic Resilience. Working Paper, Institute of Urban and Regional Development, University of California. https://www.econstor.eu/handle/10419/59420.

Hong, H., Karolyi, G. A., and Scheinkman, J. A. (2020). Climate Finance. *Review of Financial Studies*, 33(3): 1011-1023. https://doi.org/10.1093/rfs/hhz146.

Hong, H., Li, F. W., and Xu, J. (2019). Climate Risks and Market Efficiency. *Journal of Econometrics*, 208(1), 265-281. https://doi.org/10.1016/j.jeconom.2018.09.015.

Hsu, P. H., Li, K., and Tsou, C. Y. (2023). The Pollution Premium. *Journal of Finance*, 78(3), 1343-1392. https://doi.org/10.1111/jofi.13217.

Huang, Z., Dong, H., and Jia, S. (2022). Equilibrium Pricing for Carbon Emission in Response to the Target of Carbon Emission Peaking. *Energy Economics*, 112, 106160. https://doi.org/10.1016/j.eneco.2022.106160.

Huynh, T. D., and Xia, Y. (2021). Climate Change News Risk and Corporate Bond Returns. *Journal of Financial and Quantitative Analysis*, 56(6), 1985-2009. https://doi.org/10.1017/S0022109020000757.

Ilhan, E., Krueger, P., Sautner, Z., and Starks, L. T. (2023). Climate Risk Disclosure and Institutional Investors. *Review of Financial Studies*, 36(7), 2617-2650. https://doi.org/10.1093/rfs/hhad002.

Jia, R., Ma, X., and Xie, V. W. (2022). Expecting Floods: Firm Entry, Employment, and Aggregate Implications. NBER working paper, No. w30250. https://www.nber.org/papers/w30250.

Jin, J., Han, L., Wu, L., and Zeng, H. (2020). The Hedging Effect of Green Bonds on Carbon Market Risk. *International Review of Financial Analysis,* 71, 101509. https://doi.org/10.1016/j.irfa.2020.101509.

Kleimeier, S., Hoffmann, A. O., Broihanne, M. H., Plotkina, D., and Göritz, A. S. (2023). Determinants of Individuals' Objective and Subjective Financial Fragility during the COVID-19 Pandemic. *Journal of Banking & Finance*, 153, 106881. https://doi.org/10.1016/j.jbankfin.2023.106881.

Köberle, A. C., Vandyck, T., Guivarch, C., Macaluso, N., Bosetti, V., Gambhir, A., ... and Rogelj, J. (2022). Publisher Correction: The Cost of Mitigation Revisited. *Nature Climate Change*, 12(3), 298-298. https://doi.org/10.1038/s41558-021-01203-6.

Kocaarslan, B. (2021). How Does The Reserve Currency (U.S. Dollar) Affect The Diversification Capacity of Green Bond Investments?. *Journal of Cleaner Production*, 307, 127275. https://doi.org/ 10.1016/j.jclepro.2021.127275.

Krusell, P., and Smith Jr, A. A. (2022). Climate Change Around the World. NBER working paper, No. w30338. https://www.nber.org/papers/w30338.

Kuang, W. (2021). Are Clean Energy Assets a Safe Haven for International Equity Markets?. *Journal of Cleaner Production*, 302, 127006. https://doi.org/10.1016/j.jclepro.2021.127006.

Lamperti, F., Bosetti, V., Roventini, A., Tavoni, M., and Treibich, T. (2021). Three Green Financial Policies to Address Climate Risks. *Journal of Financial Stability*, 54, 100875. https://doi.org/10.1016/j.jfs.2021.100875.

Lee, S., and Chen, G. (2022). Understanding Financial Resilience from a Resource-Based View: Evidence from US State Governments. *Public Management Review*, 24(12), 1980-2003. https://doi.org/ 10.1080/14719037.2021.1955951.

Li, X., Ma, S. D., and Wu, M. (2023). What Makes Social Media Branding More Effective in Shaping Pre-visit Image: Information Quality or Source Credibility?. *Tourism Management Perspectives*, 46, 101084. https://doi.org/10.1016/j.tmp.2023.101084.

Lu, R., and Yang, Z. (2023). Analysis on the Structure and Economic Resilience Capacity of China's Regional Economic Network. *Applied Economics*, 1-19. https://doi.org/10.1080/00036846.2023.2208852

Ma, S., and Kirilenko, A. P. (2020). Climate Change and Tourism in English-language Newspaper Publications. *Journal of Travel Research*, 59(2)m 352-366. https://doi.org/10.1177/0047287519839157.

Mandel, A., Tiggeloven, T., Lincke, D., Koks, E., Ward, P., and Hinkel, J. (2021). Risks on Global Financial Stability Induced by Climate Change: The Case of Flood Risks. *Climatic Change*, 166(1-2), 4. https://doi.org/10.1007/s10584-021-03092-2.

Martí-Ballester, C. P. (2019). Do European Renewable Energy Mutual Funds Foster the Transition to a Low-Carbon Economy?. *Renewable Energy*, 143, 1299-1309. https://doi.org/10.1016/j.renene.2019.05.095.

Martin, R., and Sunley, P. (2015). On the Notion of Regional Economic Resilience: Conceptualization and Explanation. *Journal of Economic Geography*, 15(1), 1-42. https://doi.org/10.1093/jeg/lbu015.

Mendelsohn, R., Nordhaus, W. D., and Shaw, D. (1994). The Impact of Global Warming on Agriculture: A Ricardian Analysis. *American Economic Review*, 89(4), 753-771. https://www.jstor.org/stable/2118029.

Murfin, J., and Spiegel, M. (2020). Is The Risk of Sea Level Rise Capitalized in Residential Real Estate?. *Review of Financial Studies*, 33(3), 1217-1255. https://doi.org/10.1093/rfs/hhz134.

Naqvi, B., Mirza, N., Rizvi, S. K. A., Porada-Rochoń, M., and Itani, R. (2021). Is There A Green Fund Premium? Evidence from Twenty Seven Emerging Markets. *Global Finance Journal*, 50, 100656. https://doi.org/ 10.1016/j.gfj.2021.100656.

Nguyen, D. D., Ongena, S., Qi, S., and Sila, V. (2022). Climate Change Risk and the Cost of Mortgage Credit. *Review of Finance*, 26(6), 1509-1549. https://doi.org/10.1093/rof/rfac013.

Nguyen, Q., Diaz-Rainey, I., and Kuruppuarachchi, D. (2023). In Search of Climate Distress Risk. *International Review of Financial Analysis*, 85, 102444. https://doi.org/10.1016/j.irfa.2022.102444.

Painter, M. (2020). An Inconvenient Cost: The Effects of Climate Change on Municipal Bonds. *Journal of Financial Economics*, 135(2), 468-482. https://doi.org/10.1016/j.jfineco.2019.06.006.

Pankratz, N., Bauer, R., and Derwall, J. (2023). Climate Change, Firm Performance, and Investor Surprises. *Management Science*, forthcoming. https://doi.org/10.1287/mnsc.2023.4685.

Pástor, Ľ., Stambaugh, R. F., and Taylor, L. A. (2022). Dissecting Green Returns. *Journal of Financial Economics*, 146(2), 403-424. https://doi.org/10.1016/j.jfineco.2022.07.007.

Raco, M., and Street, E. (2012). Resilience Planning, Economic Change and the Politics of Post-recession Development in London and Hong Kong. *Urban Studies*, 49(5), 1065-1087. https://doi.org/ 10.1177/0042098011415716.

Reboredo, J. C. (2018). Green Bond and Financial Markets: Co-Movement, Diversification and Price Spillover Effects. *Energy Economics*, 74, 38-50. https://doi.org/10.1016/j.eneco.2018.05.030.

Reboredo, J. C., and Ugolini, A. (2022). Climate Transition Risk, Profitability and Stock Prices. *International Review of Financial Analysis*, 83, 102271. https://doi.org/10.1016/j.irfa.2022.102271.

Roncoroni, A., Battiston, S., Escobar-Farfán, L. O., and Martinez-Jaramillo, S. (2021). Climate Risk and Financial Stability in the Network of Banks and Investment Funds. *Journal of Financial Stability*, 54, 100870. https://doi.org/10.1016/j.jfs.2021.100870.

Saeed, T., Bouri, E., and Tran, D. K. (2020). Hedging Strategies of Green Assets Against Dirty Energy Assets. *Energies,* 13(12), 3141. https://doi.org/10.3390/en13123141.

Sautner, Z., Van Lent, L., Vilkov, G., and Zhang, R. (2023a). Firm-level Climate Change Exposure. *Journal of Finance*, 78(3), 1449-1498. https://doi.org/10.1111/jofi.13219.

Sautner, Z., Van Lent, L., Vilkov, G., and Zhang, R. (2023b). Pricing Climate Change Exposure. *Management Science*, forthcoming. https://doi.org/10.1287/mnsc.2023.4686.

Schlenker, W., and Roberts, M. J. (2009). Nonlinear Temperature Effects Indicate Severe Damages to U.S. Crop Yields under Climate Change. *Proceedings of the National Academy of Sciences*, 106(37), 15594-15598. https://doi.org/10.1073/pnas.0906865106.

Schlenker, W., Hanemann, W. M., and Fisher, A. C. (2005). Will U.S. Agriculture Really Benefit from Global Warming? Accounting for Irrigation in the Hedonic Approach. *American Economic Review*, 95(1), 395-406. https://doi.org/10.1257/0002828053828455.

Seltzer, L. H., Starks, L., and Zhu, Q. (2022). Climate Regulatory Risk and Corporate Bonds. NBER working paper, No. w29994. http://www.nber.org/papers/w29994.

Semieniuk, G., Campiglio, E., Mercure, J. F., Volz, U., and Edwards, N. R. (2021). Low-carbon Transition Risks for Finance. *Wiley Interdisciplinary Reviews: Climate Change*, 12(1), e678. https://doi.org/10.1002/wcc.678.

Semieniuk, G., Holden, P. B., Mercure, J. F., Salas, P., Pollitt, H., Jobson, K., ... and Viñuales, J. E. (2022). Stranded Fossil-Fuel Assets Translate to Major Losses for Investors in Advanced Economies. *Nature Climate Change*, 12(6), 532-538. https://doi.org/10.1038/s41558-022-01356-y.

Sognnaes, I., Gambhir, A., van de Ven, D. J., Nikas, A., Anger-Kraavi, A., Bui, H., ... and Peters, G. P. (2021). A Multi-model Analysis of Long-term Emissions and Warming Implications of Current Mitigation Efforts. *Nature Climate Change*, 11(12), 1055-1062. https://doi.org/10.1038/s41558-021-01206-3.

Stern, N. (2008). The Economics of Climate Change. *American Economic Review*, 98(2), 1-37. https://doi.org/10.1257/aer.98.2.1.

Stern, N., Stiglitz, J., and Taylor, C. (2022). The Economics of Immense Risk, Urgent Action and Radical Change: Towards New Approaches to the Economics of Climate Change. *Journal of Economic Methodology*, 29(3), 181-216. https://doi.org/10.1080/1350178X.2022.2040740.

Stevenson. C., Costa, S., Wakefield, J. R. H., Kellezi, B., and Stack, R. J. (2020). Family Identification Facilitates Coping with Financial Stress: A Social Identity Approach to Family Financial Resilience. *Journal of Economic Psychology*, 78, 102271. https://doi.org/10.1016/j.joep.2020.102271.

Stroebel, J., and Wurgler, J. (2021). What do You Think About Climate Finance?. *Journal of Financial Economics*, 142(2), 487-498. https://doi.org/10.1016/j.jfineco.2021.08.004.

Tang, C., Liu, X., and Zhou, D. (2022). Financial Market Resilience and Financial Development: A Global Perspective. *Journal of International Financial Markets, Institutions and Money*, 80, 101650. https://doi.org/10.1016/j.intfin.2022.101650.

Triggs, A., Kacaribu, F., and Wang, J. (2019). Risks, Resilience, and Reforms: Indonesia's Financial System in 2019. *Bulletin of Indonesian Economic Studies*, 55(1), 1-27. https://doi.org/10.1080/00074918.2019.1592644.

Trippl, M., Fastenrath, S., and Isaksen, A. (2023). Rethinking Regional Economic Resilience: Preconditions and Processes Shaping Transformative Resilience. *European Urban and Regional Studies*, 09697764231172326. https://doi.org/10.1177/09697764231172326.

van Benthem, A. A., Crooks, E., Giglio, S., Schwob, E., and Stroebel, J. (2022). The Effect of Climate Risks on the Interactions Between Financial Markets and Energy Companies. *Nature Energy*, 7(8), 690-697. https://doi.org/10.1038/s41560-022-01070-1.

Venturini, A. (2022). Climate Change, Risk Factors and Stock Returns: A Review of the Literature. *International Review of Financial Analysis*, 79, 101934. https://doi.org/10.1016/j.irfa.2021.101934.

Vermeulen, R., Schets, E., Lohuis, M., Kölbl, B., Jansen, D. J., and Heeringa, W. (2021). The Heat is on: A Framework for Measuring Financial Stress under Disruptive Energy Transition Scenarios. *Ecological Economics*, 190, 107205. https://doi.org/10.1016/j.ecolecon.2021.107205.

Walmsley, T., Rose, A., John, R., Wei, D., Hlávka, J. P., Machado, J., and Byrd, K. (2023). Macroeconomic consequences of the COVID-19 pandemic. *Economic Modelling*, 120, 106147. https://doi.org/10.1016/j.econmod.2022.106147.

Wang, H., and Ge, Q. (2023). Spatial Association Network of Economic Resilience and its Influencing Factors: Evidence from 31 Chinese Provinces. *Humanities and Social Sciences Communications*, 10(1), 1-14. https://doi.org/10.1057/s41599-023-01783-y.

Wang, J., Chen, P., Wang, J., Guo, X., and Wang, X. (2023). Monetary Policy, Investor Sentiment, and the Asymmetric Jump Risk of Chinese Stock Market. *IEEE Transactions on Computational Social Systems*, forthcoming. https://doi.org/10.1109/TCSS.2023.3234430.

Wang, Z., Dong, H., and Huang, Z. (2023). Carbon Spot Prices in Equilibrium Frameworks Associated with Climate Change. *Journal of Industrial and Management Optimization*, 19(2), 961-983. https://doi.org/ 10.3934/jimo.2021214.

Weber, G., Cabras, I., Peredo, A. M., Yanguas-Parra, P., and Prime, K. (2023). Exploring Resilience in Public Services within Marginalised Communities During COVID-19: The Case of Coal Mining Regions in Colombia. *Journal of Cleaner Production*, 137880. https://doi.org/10.1016/j.jclepro.2023.137880.

Yan, X., Liu, W., Wen, S., Wang, L., Zhu, L., Wang, J., ... and Wang, J. (2023). Effect of Sulfamethazine on the Horizontal Transfer of Plasmid-Mediated Antibiotic Resistance Genes and Its Mechanism of Action. *Journal of Environmental Sciences,* 127, 399-409. https://doi.org/10.1016/j.jes.2022.06.014.

Yousaf, I., Suleman, M. T., and Demirer, R. (2022). Green Investments: A Luxury Good or A Financial Necessity?. *Energy Economics,* 105, 105745. https://doi.org/10.1016/j.eneco.2021.105745.

Yu, Z., Li, Y., and Dai, L. (2023). Digital Finance and Regional Economic Resilience: Theoretical Framework and Empirical Test. *Finance Research Letters*, 55, 103920. https://doi.org/10.1016/j.frl.2023.103920.

Zerbib, O. D. (2019). The Effect of Pro-Environmental Preferences on Bond Prices: Evidence from Green Bonds. *Journal of Banking & Finance*, 98, 39-60. https://doi.org/10.1016/j.jbankfin.2018.10.012.

Zhang, P., Deschênes, O., Meng, K., and Zhang, J. (2018). Temperature Effects on Productivity and Factor Reallocation: Evidence from a Half Million Chinese Manufacturing Plants. *Journal of Environmental Economics and Management*, 88, 1-17. https://doi.org/10.1016/j.jeem.2017.11.001.

Zhang, P., Zhang, J., and Chen, M. (2017). Economic Impacts of Climate Change on Agriculture: The Importance of Additional Climatic Variables other than Temperature and Precipitation. *Journal of Environmental Economics and Management*, 83, 8-31. https://doi.org/10.1016/j.jeem.2016.12.001.

Zhang, R. (2022). Language Commonality and Sell-side Information Production. *Management Science*, 68(6), 4435-4453. https://doi.org/10.1287/mnsc.2021.4059.

Zhong, Z., Chen, Z., and He, L. (2022). Technological Innovation, Industrial Structural Change and Carbon Emission Transferring Via Trade-------An Agent-based Modeling Approach. *Technovation*, 110, 102350. https://doi.org/10.1016/j.technovation.2021.102350.

Zhou, K., Lin, B., and Fan, J. (2020). Post-Earthquake Economic Resilience and Recovery Efficiency in the Border Areas Affected by the Wenchuan Ms 8.0 Earthquake in Sichuan, China in 2008. *Journal of Geographical Sciences*, 30(8), 1363-1381. https://doi.org/10.1007/s11442-020-1786-8.