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Climate change, environmental sustainability, and financial risks: are we close to an understanding?

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Climate change and other threats to environmental sustainability will have an increasingly material impact on financial actors. However, transmission channels and possible spillover effects remain understudied. This review paper summarizes recent works published on these intersections and portraits venues for further research. In this respect, late advances on the control of the impact of climate change-related risks on financial risks have been relevant. New climate scenario analyses, stress testing techniques, and disclosure requirements have been recently introduced. Existing risk management frameworks are being updated to integrate climate change-related risks. Yet, as the development of new practices continues, the need for assessing their effectiveness and limitations, from a risk management as well as a financial stability perspective, remains. In this vein, sufficient attention needs also to be paid to emerging market failures linked to climate change. These include noninsurability of risks and credit rationing or mispricing, potentially hampering adaptation and mitigation investments in some areas. Last, while focus has been put thus far mainly on climate change, time has come to accelerate the debate on the financial implications of other threats to the environment. This is notably the case of loss of biodiversity, by also taking stock of the work of the Conference of the Parties (COP).

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Introduction

The nexus between sustainability and financial risks is an emerging field of research laying in the intersection between natural sciences and social sciences. It has to be encompassed in the general discourse on the relationship linking nowadays sustainability and finance, and for which an increasing volume of research is being made available focussing on the investigation of the role of finance in shaping a more sustainable society (e.g. [40,51,67]). Frameworks such as sustainable finance, green finance, and impact investing, among others, are at the heart of this effort (e.g. [44]). This body of literature has been incentivized by an unprecedented political commitment toward sustainability, mainly built around the Paris Agreement and the Sustainable Development Goals (SDGs), and the consequent engagement of policymakers and regulators to deliver on the transition objectives.

This review paper aims to provide a concise overview of the recent works published on the relation between environmental sustainability and financial risks, with a focus on the implications for banks and insurance companies. In this respect, it acknowledges the prominent role given thus far by researchers and public institutions to the investigation of the impact of climate change on financial risks, *vis-à-vis* other possible threats to environmental sustainability. These latter include loss of biodiversity, depletion of nonrenewable natural resources, pollution (in its different forms), deforestation, soil degradation, and overuse or misuse of waters, to name some. The recognition of this imbalance in literature represents a first useful outcome of this paper, and calls for new venues of research.

Climate change as an emerging source of financial risks

Evidence of global warming caused by human activities and its impact on climate change is now consolidated [35,36]. However, the understanding of how the effects of climate change relate to the risks in the remit of financial intermediaries, in particular banks and insurance companies, is still at a relatively early stage of development. Seminal, awareness-rising contributions have either described the mismatch between the long-term occurrence of climate change-related risks and the typical short-term risk-taking strategies of financial

intermediaries as the ‘*tragedy of the horizon*’ [20], or assessed the likely nonlinearity and fat-tailed distributions featuring climate change-related risks, coupled with the lack of data on their economic impacts and of adapted risk management frameworks, as the ideal conditions for a ‘*green swan*’ [13]. In this respect, physical risk, transition risk, and liability risks have been identified as the main drivers of the diffusion of climate change-related risks to financial intermediaries, primarily through the client they serve, which may be directly concerned (e.g. [4,9]). This is mainly the case of businesses but it also refers to households and public administrations, notwithstanding the at least theoretical possibility of direct impacts of climate change-related events on financial intermediaries. Some relevant attempts have been recently produced as concerns the identification of the features and the functioning of the specific transmission channels and of possible spillover effects [9,45]. Yet, very limited empirical evidence still features the field.

The increasing consideration of the materiality of climate change-related risks at firm as well as financial intermediary level has eventually raised the question of the possible implications in terms of financial stability (e.g. [6,10]). Similarly, it has paved the way to international initiatives in support of climate-related financial disclosure [27,60,61] and the development of sustainability accounting standards [37].

The climate change argument for financial risks hence mainly converges toward the need of assessing the implications of climate change-related risks on the risks under management by financial intermediaries, in particular credit risk, market risk, liquidity risk, liability risk, reputational risk, and even operational risk [9,43]. Figure 1 gives a general overview of the dynamics under discussion.

An increasingly warning evidence on the impact of climate change on financial risks

Recent axes of development of literature

Academic researchers have lately contributed to this assessment either indirectly by investigating the existence and the magnitude of transition risk and physical risk for specific economic sectors or geographical areas (e.g. [25,32,56]), or more directly by trying to observe the sensitiveness of various financial risks or returns to climate change-associated variables (in particular carbon emissions) for large samples of banks or stocks (e.g. [12,63,64]). On the other hand, regulators and financial intermediaries, having in mind respectively the need to preserve financial stability and integrate climate change-related risks in existing risk management frameworks, have prompted the development of forward-looking computational modeling (notably scenario analysis) and stress testing, taking as a reference the asset and liability composition at a single financial intermediary level (e.g. [3,49,8]).

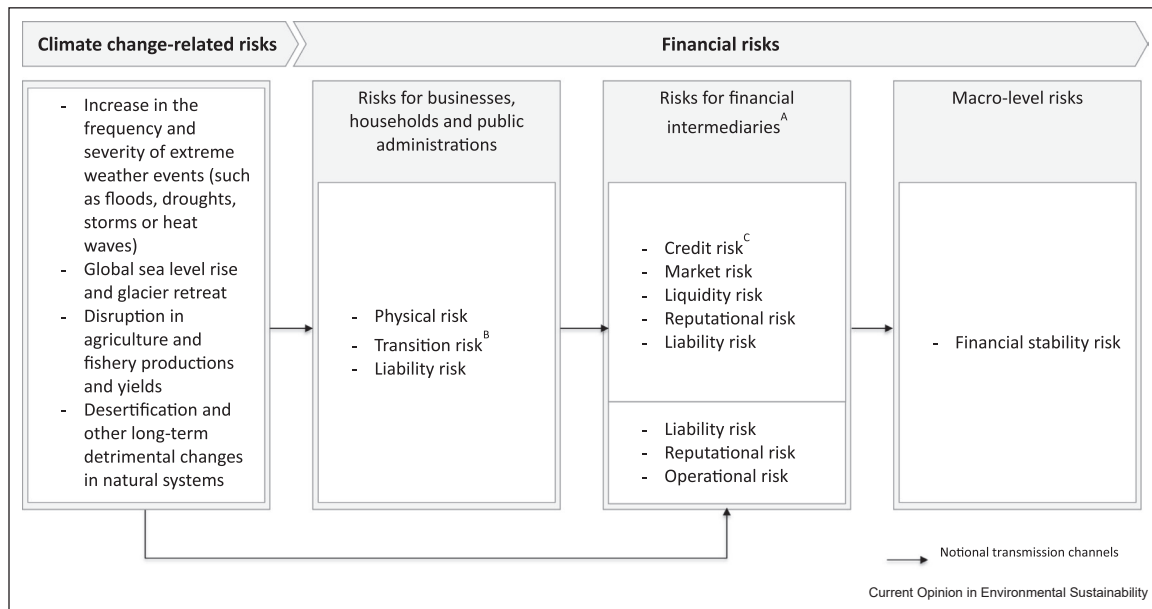
Climate change-related risks and financial intermediaries

Recent literature focussing on transition and physical risks provides warning evidence. Results have been produced supporting the thesis that climate change should be already today considered a significant source of risk on the firm value [18,63]. To this extent, investors are starting demanding compensation to businesses responsible for carbon emissions [11••,19], and to those more exposed to temperature rise, as perceived significantly riskier [64]. The introduction of carbon taxes and other policies aiming at supporting the achievement of the objectives of the Paris Agreement is recognized as the main source of transition risk for firms, by triggering stranded assets [17,23,42]. However, accurate quantification of both transition and physical risk still remains a substantial challenge for the industry, as well as puzzles policymakers [53]. In addition, these risks can also be exacerbated for firms by a rising number of successful climate litigations [55,57].

These trends are generally confirmed by literature leading the observation from the financial intermediation perspective, even though conclusions remain in this case more nuanced. Studies show that banks’ exposure to climate change-related risks, especially if acquired via the lending channel, mostly lowers banks’ stability and increases tail risks [10,25,66]. However, the impact on banks may differ based on the type of climate change-related risks, the banks’ size and business model, and even their location [15,39]. In this line, recent evidence suggests that incremental credit risk for banks stemming from the introduction of an even heavy carbon tax may result to be mild [1••]. This also highlights the relevance of the risk management layer in shielding banks from the transmission of climate change-related shocks. On the other side, the transition to a low-carbon economy may generate a significant shift in the banks’ profitability dependence on specific sectors, with emerging clean sectors taking an unprecedented prominent role [65]. This would reinforce the need for banks to consider climate change as a topic of strategic relevance and ensure its integration in the governance processes, including at board level [16•]. As concerns more specifically insurers, although less explored, late literature similarly advocates that the exposure of insurance companies to natural disasters and other climate change-related risks may decrease profitability and risk-sharing capacity [66].

To investigate the level of preparedness of market actors to manage climate change-related risks, financial regulators have recently run a series of climate stress tests [5,28]. The main aim was to assess the robustness of the climate scenarios recently developed by financial intermediaries, as well as the level of integration in the existing risk management frameworks (e.g. [3,5]). In this respect, climate scenarios considered both transition and

Figure 1



A (very) simplified risk chain linking climate change-related risks and financial risks. Note: A — In this figure, financial intermediaries include banks and insurance companies. B — Transition risk impacts mainly businesses. It may stem from policy and technology shifts linked to the combat to climate change, which can inter alia trigger stranded assets. Transition risk could also follow market-driven more stringent financing conditions for polluting sectors and, more generally, a permanent change in market preferences toward more sustainable products or companies. C — Credit risk concerns banks only.
 Source: Author's elaboration.

physical risk: in the former case by typically taking into account ‘orderly’ and ‘disorderly’ transition pathways (e.g. [7,28]), in the latter by anticipating different temperature rise and climate change patterns. As of today, climate scenario analysis can be considered still in its early days, with notable data gaps making projections of climate change-related losses (in particular as concerns credit and market portfolios) remaining uncertain [5]. Yet, some relevant developments in methodologies can also be observed, including the adaptation of Value at Risk techniques to integrate climate change-related risks [24]. Looking forward, the principle that the design of the measurement methodologies should be conducted according to nature, size, and significance of the concerned financial institutions would need to guide both industry and regulatory efforts.

Climate change-related risks and financial stability

The issue of the implications of climate change in terms of financial stability is also increasingly discussed in literature. Recent evidence has confirmed that physical risks and transition risks can exacerbate financial systemic risks, even though limited to the occurrence of the most adverse climate scenarios [22,41,54]. At the same time, except for the (relevant) efforts for the integration of climate change-related risks into existing risk

management frameworks and for better disclosure, the debate on how to mitigate systemic risk linked to climate change remains open. In this respect, the micro-prudential framework and related banking regulation have thus far not evolved significantly. Capital buffers and measures limiting exposure concentration have been proposed only recently [34]. In this respect, in framing the most effective regulatory approach, key elements such as the size of the financial institution and the intensity of the climate change-related risks at a single-institution level need to be taken into account. This debate overlaps with the one on the potential role of both prudential regulation and monetary policy in speeding up the transition, with key trade-offs still to be disentangled (e.g. [6,58,31]). This can be the case of a supporting (punishing) factor consisting in lowering (increasing) capital requirements for banks detaining green (polluting) assets, that could contribute to incentivize new investments in clean industries but also elicit uncertainties in terms of both its macroeconomic and financial stability feedback [26]. Similarly, the opportunity of taking into account any environmental consideration or the economic impact of climate change in the formulation of the monetary policy remains questioned, as it could interfere with the main objective of central banks of maintaining price stability [14,48].

The need of considering other environmental sustainability threats and further research

Biodiversity loss as an emerging cause of financial risks

When it comes to their impact on financial risks, the different environmental sustainability threats have been thus far addressed by policymakers and researchers in a substantially separated manner [38•], with significant advances referable to date only to climate change. In particular, thanks to the encouraging output of COP15, hazards to biodiversity and actions to reduce biodiversity loss have recently received revamped attention [21]. In this respect, recent literature has already hinted that biodiversity loss can be at a larger extent considered another cause of stranded assets [17], be potentially material for banks [59,62], and that its materiality should be better assessed focusing on the local level due to the nature of biodiversity impacts and their dependencies [46]. To widen knowledge on the entire spectrum of environmental sustainability-related risks, while the policy and research patterns developed to address the financial implications of climate change can be broadly replicated, a standardized approach should not be used. In this respect, neglecting possible interactions between the different environmental sustainability-related risks (e.g. between climate change and biodiversity loss) as well as their idiosyncratic characteristics (e.g. the time horizon of their expected materiality) may lead to inaccurate conclusions. This could undermine both progress on climate policies and the emerging work on biodiversity loss-related financial risks [38•].

Further areas of research and new market failures

Yet, to reach a fair understanding on the relationship featuring environmental sustainability and financial risks, at least two additional areas of research would need to be further developed in the next years. The first refers to the effectiveness of the financial and management practices adopted by financial intermediaries and businesses to mitigate the impact of climate change and other environmental sustainability-related risks on their financial risks. This assessment should include the observation of the results of the progressive integration of environmental sustainability-related risks in existing risk management frameworks and in the overall governance structure [8]. These aspects could integrate the wider literature already addressing the link between ESG (environmental, social, and governance) performances and financial performances of firms (e.g. [2,30,47,29]). Outputs of such analyses could also inform the policy and industry debate on the structuring or refining of the sustainable finance frameworks currently present in the market. In this vein, an analysis on whether the issuance of securities such as green or sustainability-linked bonds contributes to reduce the inherent risk for firms linked to climate change and other environmental sustainability threats is also pertinent.

Finally, a relevant area of further research concerns the possibility of the emergence of new market failures directly caused by climate change or other environmental sustainability threats. Non-negligible market failures may stem from the increasing awareness by financial intermediaries of the materiality of these threats and the likely increase over time of the frequency and magnitude of tail events [35]. An argument can be made according to the idea that conditions for noninsurability of risks (e.g. in areas increasingly subject to extreme weather events) and credit limitations or mispricing (e.g. for companies in polluting industries) can emerge in the near future in specific geographies or economic sectors. This may follow a progressive increase in the cost of accessing financial services for businesses and households subject to physical or transition risks, which literature has in turn started to point out [33,50••,52••]. The social implications of this possible outcome, including in terms of financing mitigation and adaptation initiatives, should be further assessed and effective policy and industry responses proposed.

Data Availability

No data were used for the research described in the article.

Declaration of Competing Interest

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

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
- of outstanding interest

1. Aiello MA, Angelico C: **Climate change and credit risk: the effect of carbon tax on Italian banks' business loan default rates.** *J Policy Model* 2023, **45**:187-201.

The authors studied the effect of a carbon tax on the banks' credit risk. They provided evidence that credit risks stemming from the introduction of a carbon tax are modest for a sample of Italian banks and for periods of low default rates. More specifically, they found that on average, over a one-year horizon, the default rates of firms increase but remain below their historical averages. The effect is heterogeneous across different sectors and rises with the tax value. As concerns the methodology, they estimate the potential impact of different carbon taxes (€50, €100, €200, and €800 per ton of CO₂) at the sector level, by using a counterfactual analysis and focusing on the period 2006–2019. Although the study is of high relevance both in terms of the methodology used and policy implications, it should be supplemented by analyses covering other countries in order to have more robust conclusions.

2. Atz U, Van Holt T, Liu ZZ, Bruno CC: **Does sustainability generate better financial performance? Review, meta-analysis, and propositions.** *J Sustain Financ Invest* 2023, **13**:802-825.
3. Autorité de contrôle prudentiel et de résolution (ACPR): **Scenarios and Main Assumptions of the 2023 Climate Stress Test Exercise.** Paris; 2023.

4. Autorité de contrôle prudentiel et de résolution (ACPR): A First Assessment of Financial Risks Stemming from Climate Change: the Main Results of the 2020 Climate Pilot Exercise. Paris; 2021.
5. Bank of England (BoE) : Results of the 2021 Climate Biennial Exploratory Scenario (CBES). London; 2022.
6. Bank of England (BoE): Bank of England Report on Climate-related Risks and The Regulatory Capital Frameworks. London; 2023.
7. Banque de France: Long-term Growth Impact of Climate Change and Policies: The Advanced Climate Change Long-term (ACCL) Scenario Building Model, Working Paper Series No 759. Paris; 2020.
8. Basel Committee on Banking Supervision (BCBS). Principles for the Effective Management and Supervision of Climate-related Financial Risks. Basel; 2022.
9. Basel Committee on Banking Supervision (BCBS): Climate-related Risk Drivers and Their Transmission Channels. Basel; 2021.
10. Battiston S, Dafermos Y, Monasterolo I: **Climate risks and financial stability**. *J Financ Stab* 2021, **54**:100867.
11. Bolton P, Kacperczyk M: **Do investors care about carbon risk?** *J Financ Econ* 2021, **142**:517-549.
The authors investigated the impact of carbon emissions on stocks' returns. They found that a carbon premium exists in the returns of US stocks, concluding that investors are demanding compensation for their exposure to carbon emission risk. They used a cross-section of US stock returns and observed that stocks of firms with higher total carbon dioxide emissions (and changes in emissions) earn higher returns, controlling for size, book-to-market, and other return predictors. The study can lead the way to the identification of a permanent presence of a market-based carbon premium, which would strengthen policy action for climate change mitigation. Further relevant research from the same authors on the topic is Bolton and Kacperczyk (2023).
12. Bolton P, Kacperczyk M: **Global pricing of carbon-transition risk**. *J Financ* 2023, **78**:3677-3754.
13. Bolton P, Despres M, Da Silva LAP, Samama F, Svartzman R: **The Green Swan. Central Banking and Financial Stability in the Age of Climate Change**. BIS Books; 2020.
14. Boneva L, Ferrucci G, Mongelli FP: **Climate change and central banks: what role for monetary policy?** *Clim Policy* 2022, **22**:770-787.
15. Bounou W, Urom C: **Climate change-related risks and bank stock returns**. *Econ Lett* 2023, **224**:111011.
16. Caby J, Ziane Y, Lamarque E: **The impact of climate change management on banks profitability**. *J Bus Res* 2022, **142**:412-422.
The study is one of the few attempts to examine the impact of climate change management on the profitability of the banks. Results show that banks seem to be aware of the consequences of climate change on their business, to the point of making it a strategic topic worthy of the board of directors. However, banks remain vague in terms of operational implementation, leading to a positive but only limited impact on profitability. The authors used panel data from a sample of 137 banks from 36 emerging and developed countries during the period 2011–2019, applying GMM estimators.
17. Caldecott B, Clark A, Koskelo K, Mulholland E, Hickey C: **Stranded assets: environmental drivers, societal challenges, and supervisory responses**. *Annu Rev Environ Resour* 2021, **46**:417-447.
18. Campiglio E, Dumas L, Monnin P, von Jagow A: **Climate-related risks in financial assets**. *J Econ Surv* 2023, **37**:950-992.
19. Capasso G, Gianfrate G, Spinelli M: **Climate change and credit risk**. *J Clean Prod* 2020, **266**:121634.
20. Carney M: Breaking the tragedy of the horizon – climate change and stability. *Speech Given by Mark Carney Governor of the Bank of England*, September 2015; 2015.
21. Conference of the Parties to the Convention on Biological Diversity (COP): Decision adopted by the convention of the parties to the convention on biological diversity — 15/4. *Kunming-Montreal Global Biodiversity Framework*. Montreal; 2022.
22. Curcio D, Gianfrancesco I, Vioto D: **Climate change and financial systemic risk: evidence from US banks and insurers**. *J Financ Stab* 2023, **66**:101132.
23. Delis DD, de Greiff K, Ongena S: Being stranded with fossil fuel reserves? Climate policy risk and the pricing of bank loans. *EBRD Working Paper 231*; 2019.
24. Dietz S, Bowen A, Dixon C, Gradwell P: **Climate value at risk of global financial assets**. *Nat Clim Change* 2016, **6**:676-679.
25. Do QA, Phan V, Nguyen DT: **How do local banks respond to natural disasters?** *Eur J Financ* 2023, **29**:754-779.
26. Dunz N, Naqvi A, Monasterolo I: **Climate sentiments, transition risk, and financial stability in a stock-flow consistent model**. *J Financ Stab* 2021, **54**:100872.
27. European Commission (EC) : Commission Delegated Regulation Supplementing Directive 2013/34/EU as Regards Sustainability Reporting Standards, C(2023) 5303 Final. Brussels; 2023.
28. European Central Bank (ECB): Climate Risk Stress Test. SSM Stress Test 2022. Frankfurt; 2021.
29. Friede G, Busch T, Bassen A: **ESG and financial performance: aggregated evidence from more than 2000 empirical studies**. *J Sustain Financ Invest* 2015, **5**:210-233.
30. Gonçalves TC, Barros V, Avelar JV: **Environmental, social and governance scores in Europe: what drives financial performance for larger firms?** *Econ Bus Lett* 2023, **12**:121-131.
31. Grünewald S: **Climate change as a systemic risk in finance: are macroprudential authorities up to the task?** In *Sustainable Finance in Europe. EBI Studies in Banking and Capital Markets Law*. Edited by Busch D, Ferrarini G, Grünewald S. Palgrave Macmillan; 2021.
32. Hansen TA: **Stranded assets and reduced profits: analyzing the economic underpinnings of the fossil fuel industry's resistance to climate stabilization**. *Renew Sustain Energy Rev* 2022, **158**:112144.
33. Huang HH, Kerstein J, Wang C, Wu F: **Firm climate risk, risk management, and bank loan financing**. *Strateg Manag J* 2022, **43**:2849-2880.
34. Hiebert P, Monnin P: Climate-related systemic risks and macroprudential policy. *The INSPIRE Central Banking Toolbox, Policy Briefing Paper 14*; 2023.
35. Intergovernmental Panel on Climate Change (IPCC): Climate change 2023. *Sixth Assessment Report*; 2023.
36. Intergovernmental Panel on Climate Change (IPCC): Special report. *Global Warning of 1.5°C*; 2018.
37. International Sustainability Standards Board (ISSB): SASB Standards. London; 2023.
38. Kedward K, Ryan-Collins J, Chenet H: **Biodiversity loss and climate change interactions: financial stability implications for central banks and financial supervisors**. *Clim Policy* 2022, **23**:1-19.
The study focuses on reviewing existing literature and policy documentation on the financial risks related to climate change and biodiversity loss. By using a qualitative methodology for the analyses, the authors have the merit of pointing out important elements to feed the discussions on the most effective ways to address these risks. Notably, the authors underline how financial risks related to climate change and biodiversity loss are currently being addressed in a largely 'siloeed' manner, and claim that policymakers should focus on the broader concept of systemic environmental-financial risks to better account for interactions and trade-offs.
39. Koetter M, Noth F, Rehbein O: **Borrowers under water! Rare disasters, regional banks, and recovery lending**. *J Financ Intermed* 2020, **43**:100811.
40. Kumar S, Sharma D, Rao S, Lim WM, Mangla SK: **Past, Present, and Future of Sustainable Finance: Insights from Big Data Analytics through Machine Learning of Scholarly Research**. *Annals of Operations Research*; 2022.

41. Mandel A, Tiggeloven T, Lincke D, Koks E, Ward P, Hinkel J: **Risks on global financial stability induced by climate change: the case of flood risks.** *Clim Change* 2021, **166**:4.
The study is an important reference in the assessment of the impact of floods on financial stability. The authors show that the magnitude of the risk is determined by the interplay between the exposure of countries to this kind of climate-related natural hazards and their level of financial leverage. In adverse climate scenarios, this could lead to the emergence of systemic risk. In terms of methodology, the authors developed a model for the propagation of shocks through the financial network, including using Monte Carlo simulation.
42. Mercure J-F, Salas P, Vercoulen P, Semieniuk G, Lam A, Pollitt H, Holden PB, Vakilifard N, Chewpreecha U, Edwards ER, Viñuales JE: **Reframing incentives for climate policy action.** *Nat Energy* 2021, **6**:1133-1143.
43. Migliorelli M: **The sustainability-financial risks nexus.** In *Sustainability and Financial Risks. The iMPact Of Climate Change, Environmental Degradation And Social Inequality On Financial Markets*. Edited by Migliorelli M, Dessertine P. Palgrave Macmillan; 2020.
44. Migliorelli M: **What do we mean by sustainable finance? Assessing existing frameworks and policy risks.** *Sustainability* 2021, **13**:975.
45. Monasterolo I: **Climate change and the financial system.** *Annu Rev Resour Econ* 2020, **12**:299-320.
46. Nedopil C: **Integrating biodiversity into financial decision-making: challenges and four principles.** *Bus Strategy Environ* 2022, **32**:1619-1633.
47. Neitzert F, Petras M: **Corporate social responsibility and bank risk.** *J Bus Econ* 2022, **92**:397-428.
48. Network of Central Banks and Supervisors for Greening the Financial System (NGFS): **Monetary Policy and Climate Change: Key Takeaways from the Membership Survey and Areas for Further Analysis.** Paris; 2023.
49. Network of Central Banks and Supervisors for Greening the Financial System (NGFS): **NGFS Climate Scenarios for Central Banks and Supervisors.** Paris; 2022.
50. Nguyen DD, Ongena S, Qi S, Silaand V: **Climate change risk and the cost of mortgage credit.** *Rev Financ* 2022, **26**:1509-1549.
The authors studied the interrelation between the cost of mortgages and sea level rise. They found that lenders already charge higher interest rates for mortgages on properties exposed to a greater risk of sea level rise. They observed that this premium is not present in short-term loans and is not related to borrowers' short-term realized default or creditworthiness. The premium is smaller when the consequences of climate change are less important and in areas with more 'climate change deniers'. In terms of methodology, the study focuses on coastal states in the US and runs a series of regression specifications. It uses the difference between the interest rate on mortgages in a specific year and zip code and the 10-year US treasury bond as the response variable, and the proportion of the property's zip code that will be underwater if the global sea level rises by 6 ft as an independent variable.
51. Rasoulizhad E, Taghizadeh-Hesary F: **Role of green finance in improving energy efficiency and renewable energy development.** *Energy Effic* 2022, **15**:14.
52. Reghezza A, Altunbas Y, Marques-Ibanez D, Rodriguez d'Acri C, Spaggiari M: **Do banks fuel climate change?** *J Financ Stab* 2022, **62**:101049.
The authors analyzed the effect of the policies following the Paris Agreement on the capital allocation of banks. They found that, after the Agreement, European banks reallocated credit away from polluting firms in relative terms. More specifically, euro area banks' loan share to more polluting firms decreased by about 3% compared to less polluting (or 'green') firms, and such a result is stronger for banks that are well capitalized, have lower credit quality, and are less profitable. The authors used a difference-in-differences method matching loan-level data to firm-level greenhouse gas emissions.
53. Rising J, Tedesco M, Piontek F, Stainforth DA: **The missing risks of climate change.** *Nature* 2022, **610**:643-651.
54. Roncoroni A, Battiston S, Escobar-Farfán LOL, Martinez-Jaramillo S: **Climate risk and financial stability in the network of banks and investment funds.** *J Financ Stab* 2021, **54**:100870.
The authors analysed the effects on financial stability of the interaction between climate transition risk and market conditions. They found that in the event of a disorderly low-carbon transition, stronger market conditions (in terms of recovery rate and asset price volatility) would allow them to reach more ambitious climate policies at the same level of financial risk. In terms of methodology, they boosted a framework for a climate stress-test of the financial system by including an *ex-ante* network valuation of financial assets that takes into account asset price volatility, and endogenous recovery rate on interbank assets, as well as considers indirect contagion of banks and investment funds. They ran analytical results and applied the model to a supervisory dataset in a range of climate policy scenarios and market conditions.
55. Sato M, Gostlow G, Higham C, Setzer J, Venmans F.: **Impacts of climate litigation on firm value.** *Centre for Climate Change Economics and Policy Working Paper No.41 – Grantham Research Institute on Climate Change and the Environment Working Paper No. 397*; 2023.
56. Semieniuk G, Holden PB, Mercure JF, Salas P, Pollitt H, Jobson K, Vercoulen P, Chewpreecha U, Edwards NR, Viñuales JE: **Stranded fossil-fuel assets translate to major losses for investors in advanced economies.** *Nat Clim Change* 2022, **12**:532-538.
57. Setzer J, Higham C.: **Global trends in climate change litigation: 2022 snapshot.** Grantham Research Institute on Climate Change and the Environment; 2022.
58. Smoleńska A, van 't Klooster J: **A risky bet: climate change and the EU's microprudential framework for banks.** *J Financ Regul* 2022, **8**:51-74.
59. Svartzman R, Espagne E, Gauthey J, Hadji-Lazaro P, Salin M, Allen T, Berger J, Calas J, Godin A, Vallier A: **A 'silent spring' for the financial system? Exploring Biodiversity-related Financial Risks in France.** Banque de France, Paris; 2021.
60. Task Force on Climate-related Financial Disclosures (TCFD): **Task Force on Climate-related Financial Disclosures. 2022 Status Report,** Basel; 2022.
61. Task Force on Climate-related Financial Disclosures (TCFD): **Recommendations of the Task Force on Climate-related Financial Disclosures,** Basel; 2017.
62. Van Toor J, Piljic D, Schellekens G: **Indebted to Nature Exploring Biodiversity Risks for the Dutch Financial Sector.** De Nederlandsche Bank; 2020.
63. Venturini A: **Climate change, risk factors and stock returns: a review of the literature.** *Int Rev Financ Anal* 2022, **79**:101934.
64. Yan Y, Xiong X, Li S, Lu L: **Will temperature change reduce stock returns? Evidence from China.** *Int Rev Financ Anal* 2022, **81**:102112.
65. Zhang X, Zhang S, Lu L: **The banking instability and climate change: evidence from China.** *Energy Econ* 2022, **106**:105787.
66. Zhou F, Endendijk T, Botzen WJW: **A review of the financial sector impacts of risks associated with climate change.** *Annu Rev Resour Econ* 2023, **15**:1.
67. Ziolo M, Bak I, Cheba K: **The role of sustainable finance in achieving sustainable development goals: does it work?** *Technol Econ Dev Econ* 2021, **27**:45-70.