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Climate Change and Financial Stability: A Thematic Analysis of the Literature Using BERTopic[1]

Abstract

This article examines the links between climate change and financial stability in the scientific literature. The BERTopic method was applied to analyse over one thousand abstracts of publications indexed in Scopus, and the results were validated via a dataset from Web of Science. The findings indicate the dominance of topics related to climate policy and transition risk, whose importance increased significantly after 2015. At the same time, issues concerning physical risk, such as climate-related disasters, water resources, and flood risk, are also present, although less prominently represented. A particularly notable gap concerns direct references to macroprudential policy objectives. The comparative analysis also reveals geographical differentiation: in countries pursuing intensive climate policies (e.g., EU member states), research is predominantly focused on transition risk, whereas in regions particularly exposed to extreme weather events (e.g., India), emphasis is placed on physical risk. Analyses of Web of Science abstracts confirmed the conclusions drawn from Scopus publications. The findings highlight the need for further research on the integration of climate-related risks into macroprudential policy.

Keywords: climate change, financial stability, BERTopic, macroprudential policy

JEL Codes: G01, G28, Q54, Q58

Introduction

The stability of the financial system is increasingly analysed in the context of climate change. This development generates both physical risks, which are primarily linked to extreme weather events, and transition risks, which stem from the costs of climate

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policies. The literature highlights that both dimensions of risk can significantly affect banks, capital markets, the insurance sector, and the real economy, thereby shaping systemic risk. Despite the growing number of studies, comprehensive approaches that structure the climate dimension within the financial stability literature remain scarce.

The aim of this study is to examine the extent to which the academic literature identifies and describes the mechanisms linking climate change with financial stability. The analysis is based on a set of more than one thousand abstracts of scientific articles retrieved from the Scopus database. Topic modelling was conducted via the BERTopic method (Grootendorst 2022), which relies on BERT-based language representations and has been widely applied in the literature on topic modelling (e.g., Aristei et al. 2025; Tang et al. 2024). This approach made it possible to identify and interpret the main research themes and their links to categories of climate risk (physical and transition), the goals of macroprudential policy, and the geographical dimension of the studies. To assess the robustness of the findings, an additional comparative analysis (robustness check) was carried out on a set of abstracts from the Web of Science database.

This article makes an important contribution to the literature on the links between climate change and financial stability. First, it structures existing research by systematizing the main topics, which facilitates an understanding of the dominant themes and their interrelations. Second, the analysis reveals research gaps, particularly regarding references to climate risk management within macroprudential policy, highlighting the need for further investigation in this area. Third, the article emphasizes geographical variation in approaches to climate risk – ranging from studies that stress physical threats to those focusing on transition risks associated with climate policy. An examination of author affiliations reveals that different regions assign their research priorities in distinct ways, indirectly reflecting which types of risk are most relevant from the perspective of specific economies.

The article is structured into several sections. Section two provides a literature review, which establishes the theoretical foundations for the subsequent analyses. Section three presents the research methodology, covering the data collection process, the preparation of abstract texts, and the application of the BERTopic model. Section four reports the results, including the structure of the identified topics, their links to categories of climate risk and the objectives of macroprudential policy, as well as the geographical dimension. Section five summarizes the study and outlines directions for further research on the systemic relevance of climate risk.

1. Literature review

The literature review in this article is aligned with the adopted research method and serves as the theoretical foundation for the subsequent analyses. Its structure mirrors the sequence outlined in the research design and is organized in a way that allows for later semantic comparisons between the abstracts and selected definitions and analytical categories. The first part of the review discusses the concept of systemic risk, which provides a reference point not only for considerations of financial stability but also for the appropriate selection of literature for further analysis. The next part presents the objectives of macroprudential policy, which constitute the regulatory framework for managing systemic risk. The following section addresses climate risk, with attention to its two main dimensions – physical and transition – and its potential impact on financial stability. The final part of the review highlights the geographical differentiation of climate risk and its implications for the global financial system. This structure makes it possible to establish a clear link between the theoretical and empirical parts of the article.

The starting point for considerations of financial system stability is the concept of risk, which is among the most fundamental categories in economics and finance. In the context of financial stability, risk is associated with factors that may lead to disruptions in the functioning of the system as a whole. Of particular importance in this regard is the notion of systemic risk. In accordance with the definition provided in the Article 4(15) act of 5 August 2015 on Macroprudential Supervision of the Financial System and Crisis Management, "*systemic risk – it shall mean the risk of disruption in the functioning of the financial system, which, if materialised, interferes with the operation of the financial system and the national economy as a whole, the sources of which might be in particular trends associated with excessive lending or debt growth and the related imbalances in terms of asset prices, unstable funding models, distribution of risk in the financial system, linkages between financial institutions or macroeconomic and sectoral imbalances.*" As noted by Smaga (2020), systemic risk has several features that distinguish it from other types of financial risk. These include the sudden and hardly predictable nature of changes, the disruption of the core functions of the financial system, the significant scale of the phenomenon, the variable character of its sources, the contagion effect arising from strong interconnections between institutions, and the possibility of leading many entities to insolvency at the same time. Importantly, the materialization of systemic risk not only reduces confidence in financial institutions but also generates consequences for the real economy, leading to substantial social and economic costs.

Citing the definition of systemic risk has methodological significance in this context. It serves as a reference point for subsequent analyses of the academic literature on the links between financial stability and climate risk. A clear definition of the systemic risk category enables the precise use of keywords in the process of abstract exploration and thus makes it possible to capture how climate change research relates to issues of financial stability.

The concept of systemic risk is inseparably linked with the need to develop an appropriate framework for its mitigation and management, which is reflected in the evolution of macroprudential policy (IMF 2013; ESRB 2014). According to the approach of the European Systemic Risk Board (ESRB), the primary objective of macroprudential policy is to safeguard the stability of the financial system as a whole by preventing and mitigating systemic risk. Five main areas are distinguished as potential sources of such risk (ESRB, 2014):

1. Excessive credit growth and leverage.
2. Excessive maturity mismatch and market illiquidity.
3. Direct and indirect exposure concentrations.
4. Misaligned incentives and moral hazard.
5. Insufficient resilience of financial infrastructure.

These areas also represent the intermediate objectives of macroprudential policy. Their identification makes it possible to organize and match the relevant instruments of this policy in a way that effectively mitigates systemic risk and strengthens the resilience of the entire financial system. Moreover, in the context of the analysis presented later in this article, a precise specification of these objectives has methodological significance. The identified objectives serve as a reference point for the semantic comparison of the academic literature, which in turn allows for an assessment of the extent to which scholarly research addresses the priorities of macroprudential policy.

A new type of risk that is increasingly classified as systemic risk is climate risk. The literature distinguishes between two categories of climate risk: physical risk and transition risk (NGFS 2019; Kurowski 2024). Physical risk refers to the financial consequences of the effects of climate change. It includes both sudden and extreme weather events, such as floods, hurricanes, and prolonged droughts, as well as chronic processes, such as rising average temperatures, sea-level rise, and ongoing ecosystem degradation. These phenomena may lead to substantial material losses, increasing burdens on the insurance sector, and a decline in the value of assets used as collateral for financial obligations. Lamperti et al. (2019) emphasized that climate change significantly increases the frequency of banking crises – by between 26% and 248%. Rescuing insolvent banks as a result of climate change could impose additional fiscal costs of 5–15% of GDP annually. As a consequence, the ratio of public debt to GDP may double. Approximately one-fifth of these effects stem from the deterioration of bank balance sheets induced by climate change. Macroprudential tools reduce bailout costs but only to a limited extent. The authors stress that ignoring the financial system in integrated climate–economic models leads to an underestimation of the consequences of climate change. As climate change progresses, climate risk has gained importance, particularly due to the increasing frequency and intensity of extreme weather events (IPCC 2021).

The second key type of climate risk is transition risk. This refers to the financial consequences arising from the adjustment of the economy to climate policy requirements and the shift toward a low-emission development path (NGFS 2019; Kurowski 2024). This risk encompasses regulatory changes, such as the introduction of CO_2 emission charges under the EU Emissions Trading System (EU-ETS) (Osorio et al. 2021), the tightening of environmental standards (Wang and Wang 2024), technological progress (Daumas 2024), and shifting consumer preferences (Rai et al. 2019). The economic transition involves the potential depreciation of high-emission assets and the emergence of stranded assets. This phenomenon may substantially reduce the value of investment portfolios and deteriorate the financial standing of companies that remain dependent on fossil fuels (Caldecott et al. 2016; Cahen-Fourot 2024). Battiston et al. (2017) further indicate that sectors particularly exposed to changes in climate regulation account for a significant share of institutional investors' equity portfolios, especially those of investment and pension funds. Moreover, the exposure of banks' loan portfolios to these sectors is comparable to the level of their own funds. Although economic transition entails significant costs for the financial system, it remains less burdensome for the economy than the potential losses from escalating physical risk in the absence of decisive climate policy (EBA 2021).

Climate risk has a clear geographical dimension that differentiates its scale and nature across countries and regions. In the case of physical risk, this variation stems mainly from differing climatic conditions and vulnerabilities to extreme weather events. Tropical and island countries are particularly exposed to cyclones, floods, and sea-level rise (Lal et al. 2002), whereas southern Europe more frequently experiences prolonged heatwaves and droughts (Tripathy and Mishra 2023). This implies that financial institutions operating in different parts of the world face distinct physical risk profiles. In the case of transition risk, geographical variation arises primarily from differences in climate policies and regulations across states (Truffer et al. 2015). The introduction of high carbon prices in some economies may lead to the depreciation of high-emission assets and increased pressure on the financial sector, whereas countries that delay regulatory action may gain short-term competitive advantages in certain industries. This phenomenon is referred to in the literature as the "free-rider effect," where some states benefit from the actions of others without immediately bearing the costs of transition, although in the long term, it involves a greater risk of abrupt and costly adaptation (Roy 2020). Geographical differences in both types of risk mean that the consequences of climate change for financial stability are not uniform. As a result, the global financial system becomes more vulnerable to risk transmission across regions, and the lack of coordinated climate policy increases the likelihood of systemic instability (FSB 2023).

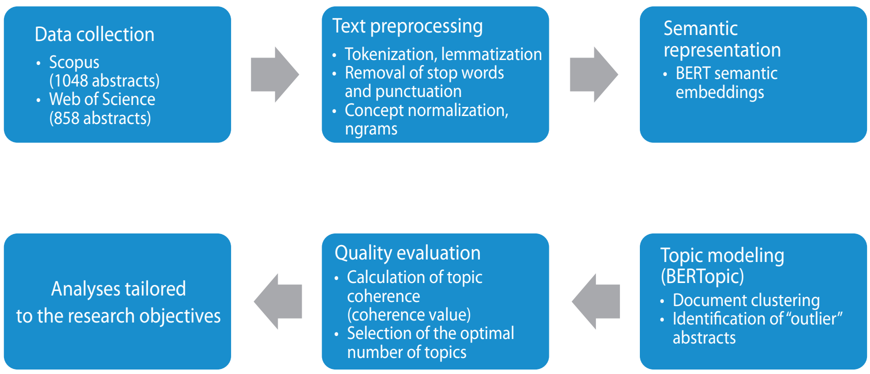
In the following sections, both types of risk (physical and transition) are analysed in bibliometric and semantic terms on the basis of a set of scientific article abstracts. The analysis examines not only how the literature addresses the systemic relevance of physical and transition risks but also the extent to which geographical differences are reflected in studies conducted across different regions of the world.

2. Methodology

In the literature on topic modelling in text collections, the Latent Dirichlet Allocation (LDA) method is widely used. It groups documents on the basis of word co-occurrence within a corpus (Blei et al. 2003). Although LDA remains an important tool, its limitation lies in the fact that it relies mainly on word frequency and co-occurrence analysis, making it more difficult to capture subtle semantic relationships between texts. This study applies the BERTopic method (Grootendorst 2022), which combines the classical vector-based approach with modern BERT language models. This allows for the inclusion of word meaning in context, leading to more accurate topic differentiation and improved interpretability of the results. An additional advantage of BERTopic is its ability to identify documents that do not clearly fit into any topic and are labelled as outliers. In our case, the model classified approximately 19% of the abstracts into this category. This result falls within the acceptable range in studies of highly diverse text corpora and indicates that the vast majority of publications can be assigned to coherent thematic clusters.

The adopted BERTopic procedure consists of several steps: data preparation and preprocessing, creation of semantic representations of abstracts, topic modelling, evaluation of the quality of results, and subsequent analyses (temporal trends, geographical dimensions, and links to macroprudential policy). For clarity, the text analysis procedure is presented schematically in Figure 1.

Figure 1. Methodological Approach to Abstract Analysis



Source: own work.

The first step of the analysis was to collect source material in the form of scientific article abstracts. For this purpose, two leading publication databases were used: Scopus and Web of Science. The Web of Science database was employed as a comparative set to Scopus to assess the robustness of the results. The search criteria included phrases referring both to climate risk (including its physical and transition dimensions) and to financial stability and related regulatory concepts. The query was logically constructed and included terms such as *climate risk, transition risk, physical risk, emissions trading system, EU ETS, CBAM, climate policy, and climate stress test, combined with concepts from the area of financial stability: financial stability, systemic risk, macroprudential, prudential supervision*, and *stranded assets*. As a result, 1,048 abstracts were obtained from Scopus, and 858 abstracts were obtained from Web of Science, providing a representative dataset for further analysis. The appendix presents the results of the preliminary dataset analysis: (1) the annual number of tokens in abstracts from Scopus and Web of Science and (2) the distribution of abstract lengths (number of tokens per document) shown as a histogram with a kernel density estimation (KDE) curve.

In the next step, the abstract texts were prepared for analysis via the BERTopic method. This process involves the tokenization of texts[2], the lemmatization of words to their base forms (e.g., *banks* → *bank*, *emissions* → *emission*), and the canonization of concepts to unify spelling variants (e.g., *heat wave* → *heatwave*). Extensive stop-word lists were applied, covering not only the most common functional words but also technical terms and recurring domain-specific phrases, such as *climate change* or *financial stability*, which did not provide differentiating value, as they appeared in nearly all abstracts. The texts were also normalized, including the removal of punctuation and numerical records. In addition, n-grams (up to bigrams) were incorporated to capture more complex semantic structures, such as *carbon_price* or *renewable_energy*. This produced a normalized text representation suitable for subsequent semantic and topic modelling.

In the third step, each abstract was transformed into a numerical vector representing its semantic meaning. For this purpose, a BERT-based language model from the family of transformer models was applied (Reimers and Gurevych 2019). These models learn the context of words from large text corpora, which enables them to capture not only individual terms but also the relationships between them. As a result, each document receives an embedding – a multidimensional numerical representation that preserves semantic similarities between texts. This means that abstracts addressing similar issues (e.g., those concerning physical climate risk or transition regulations) will have vectors located close to one another in semantic space. Such a representation forms the basis for subsequent topic analysis and makes it possible to group texts according to their content rather than merely shared keywords.

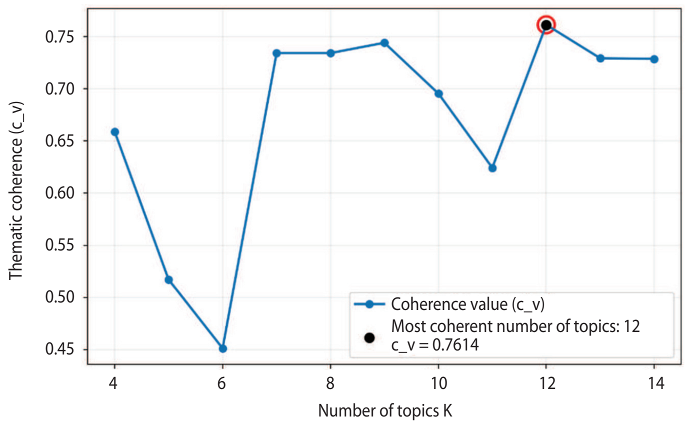
Before the final number of leading topics present in the abstracts was determined, models with different numbers of topics (from 5 to 15) were analysed. Each variant was evaluated via the coherence value (c_v)[3], which measures the semantic consistency of a topic on the basis of the co-occurrence of its keywords within the corpus (i.e., the set of all abstracts used in the study). Figure 2 presents the relationship between the c_v value and the number of topics; the final model was selected as the variant that maximized c_v. This procedure reduces the arbitrariness of choosing the number of topics to be analysed in the literature and ensures that

[2] Tokenization is the process of dividing text into smaller units known as tokens. Most often, a token is a single word, but depending on the tokenization rules it may also be a number, a symbol, or even a combination of words (e.g., bigrams such as *carbon price*). The notion of a "token" is therefore broader than that of a "word," as it encompasses all textual units that are extracted and passed on for further analysis.

[3] The higher the c_v value, the more frequently the words describing a given topic co-occur in documents, which indicates greater topic coherence.

the resulting topics are both linguistically coherent and substantively meaningful. On the basis of the topic coherence measure, the optimal structure was found to be the model with 12 topics.

Figure 2. Semantic coherence (c_v) by number of topics in the BERTopic model (Scopus)



Source: own work.

Each of the 12 topics identified via the BERTopic model was described by a set of top-n keywords that best represent its content. The final outcome of applying the BERTopic model was the assignment of each abstract to one of the extracted topics.

The final step was the assignment of abstracts to risk categories and macroprudential policy objectives. First, with respect to physical and transition risk, we used the definitions from the EBA (2020) report as the semantic reference point: each abstract was compared with these definitions and assigned to the climate risk category with the highest similarity. Next, to classify abstracts into one of the five macroprudential objectives, we applied a hybrid approach: the average of two similarity measures, weighted equally (50/50) – (i) similarity to the regulatory definitions in ESRB/2013/1 and (ii) similarity to representative academic articles selected for each objective (credit growth and leverage: Alessi and Detken 2018; maturity mismatch and liquidity: Bai et al. 2018; concentration of exposures: Giudici et al. 2020; misaligned incentives and moral hazard: Farhi and Tirole 2012; resilience of infrastructure: Vargas-Herrera et al. 2023). If none of the objectives reached the minimum cosine similarity threshold of 0.45[4], the abstract was marked as "no reference to objective." This procedure combines alignment with the regulatory intent of the ESRB with the language and emphasis found in the current literature.

[4] A similar approach, also applying the 0.45 threshold, was adopted by Boutaleb et al. (2024), who justified this choice by the need to capture semantic relationships in cases where the analysed categories are incomplete and general. Similarly, in our study the 0.45 threshold makes it possible to capture content semantically related to the broadly formulated objectives of the ESRB.

Results

The results of the analyses are presented in several complementary steps. First, sets of keywords characteristic of the topics identified in the Scopus abstract collection are shown, which makes it possible to capture their basic semantic profiles. Next, cosine similarity is used to determine the relationships and semantic proximity between topics. The following element is a dynamic analysis that illustrates how the importance of individual topics has changed over time. The study then examines the extent to which the topics can be linked to the categories of physical and transition risk, as well as to the macroprudential policy objectives defined by the European Systemic Risk Board. This approach is complemented by a geographical perspective, which highlights regional differences in the issues addressed. Finally, to assess the robustness of the results, the findings from the Scopus database are compared with those from an analogous analysis conducted on abstracts from Web of Science.

In the first stage of the analysis, the results of topic modelling conducted on the Scopus abstract collection are discussed. Each of the identified topics was described by a set of representative keywords and then assigned a descriptive label reflecting its main content. This approach enabled to capture the main research streams in the literature on the links between financial stability and climate risk. The sets of keywords and the assigned topic labels are presented in Table 1.

Table 1. Research topics addressed in abstracts (Scopus)

Topic number	Representative words based on the BERTopic model	Assigned topic label
1.	'climate policy', 'impact climate', 'macroeconomic', 'climate transition', 'bank sector', 'equity', 'firms', 'regulation', 'sector', 'portfolio'	Climate policy and macroeconomics
2.	'climate policy', 'energy sector', 'fossil_fuel reserves', 'fossil_fuel industry', 'renewable_energy', 'renewable', 'coal power', 'fossil_fuel', 'power generation', 'developing country'	Energy and fossil fuels
3.	'resilience', 'natural disaster', 'disaster management', 'natural hazard', 'resilient', 'infrastructures', 'ecosystem', 'infrastructure', 'disaster', 'climate adaptation'	Climate disasters and resilience
4.	'supply_hydropower generation_environment', 'water availability', 'water resource', 'water management', 'water supply_hydropower', 'water utilities', 'hydropower generation', 'supply_hydropower', 'hydrological', 'water supply'	Water resources and hydropower

Table 1. (cont.)

Topic number	Representative words based on the BERTopic model	Assigned topic label
5.	'china carbon', 'carbon efficiency', 'enterprise emission', 'carbon market', 'environmental regulation', 'carbon neutrality', 'green innovation', 'green development', 'carbon credit', 'inequality renewable_energy'	Carbon markets and China's transition
6.	'bank regulation', 'bank supervision', 'bank stability', 'bank liquidity', 'bank', 'bank capital', 'affected bank', 'supervision central_bank', 'loan', 'bank albania'	Banking regulation and stability of the banking sector
7.	'global institutions', 'global governance', ' international relations', 'global public_policy', 'globalization', 'global challenges', 'emerging powers', 'foreign relations', 'global public', 'governance'	Global climate governance
8.	'tropical cyclone', 'weather', 'monsoon', 'severe cyclone', 'cyclone', 'wind_speed intensity', 'range weather', 'cyclone amphan', 'cyclone track', 'indian ocean'	Extreme weather events – cyclones and monsoons
9.	'natural_resource threats', 'ecosystem services', 'traditional resource', 'reforestation', 'forest_based micro_entrepreneurs', 'grazing', 'forestry', 'forest_based bioeconomy', 'agroforestry', 'conservation'	Ecosystems and natural resources
10.	'insurance policy', 'insurer explicitly', 'insurer margin', 'insurance stability', 'insurer', 'affects insurer', 'insurer profits', 'insurance', 'insurers', 'insurance instability'	Stability of the insurance sector
11.	'crop_insurance', 'area_yield insurance', 'yield insurance', 'index_insurance', 'crop yield', 'insurance subsidy', 'mutual insurance', 'insurance', 'yield variability', 'yield_yield dependence'	Agricultural insurance
12.	'flood households', 'flood hazard', 'flood estimates', 'costs flood', 'flood resilience', 'challenges housing', 'uncertain flood', 'responsibility flood', 'flooded populations', 'flood'	Flood risk and household exposure

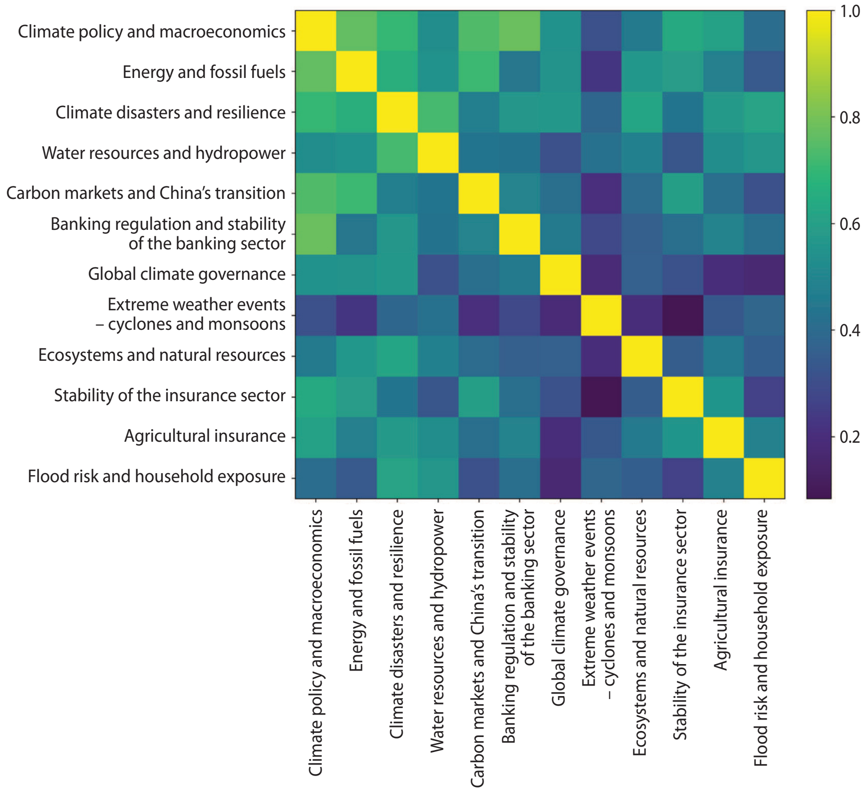
Source: own work.

The analysis of the extracted topics indicates that some of them directly and clearly refer to key issues linking climate change with financial stability. These include, for instance, *climate policy and macroeconomics* (topic 1). This topic highlights regulatory aspects and the impact of climate policy on the financial sector and investor portfolios. Another example is *banking regulation and stability of the banking sector* (topic 6), which focuses on the institutional dimension of financial system resilience. At the same time, some topics reveal less obvious yet highly interesting areas of research on the connections between climate change and financial system stability. Examples include *water resources and hydropower* (topic 4) and *ecosystems and natural resources* (topic 9). The analysis of the *water resources and hydropower* topic revealed important links between hydrological changes, energy security, and potential consequences for financial stability. Projected declines and increasing variability in water flows directly affect the performance of hydropower. In countries highly dependent on this source of energy, this may lead to an increased risk of supply disruptions and greater vulnerability of the economy to energy shocks (Senni et al. 2024). Recognizing that water resources are fundamental to the functioning of many sectors of the economy and thus to the financial health of entities served by financial institutions, both the Network for Greening the Financial System (NGFS 2022) and De Nederlandsche Bank, in their analyses of nature-related risks, emphasize the need to consider hydrological threats in the assessment of financial stability (Tiems et al. 2024).

Another less obvious yet highly important mechanism linking climate change and financial stability is the loss of biodiversity and the degradation of natural resources. This issue was clearly captured by the BERTopic model in the category of ecosystems and natural resources. The analysis of this topic broadens the traditional perspective on financial stability by extending beyond purely regulatory and market considerations to include an ecological dimension. Environmental degradation – such as deforestation or soil quality loss – translates into tangible financial risks, particularly for sectors of the economy that depend on natural capital. Research conducted by De Nederlandsche Bank estimated that investments worth €510 billion, representing 36% of the portfolios of Dutch banks, pension funds, and insurance companies, are critically dependent on ecosystem services (van Toor et al. 2020). Similarly, Ceglar et al. (2024), in a study published in the Economic Bulletin of the European Central Bank, indicate that approximately 75% of all corporate loans in the euro area were granted to firms reliant on at least one ecosystem service. The authors emphasize that *"the risks arising from nature degradation and biodiversity loss pose potentially significant challenges to the ESCB's Treaty-based objective of maintaining price and financial stability*" (Ceglar et al. 2024).

The analysis of the cosine similarity matrix between topics (Figure 3) suggests that most of the identified topics are clearly distinguishable semantically, i.e., they present low cosine similarity values. This finding indicates that the BERTopic model captured distinct and coherent areas of the literature. On the other hand, in several cases, higher similarity values are observed, for example, between topics related to climate policy and energy or between climate disaster issues and flood risk. This is largely expected, as climate policy directly affects the energy sector through emission regulations and the transformation of energy sources, whereas flood risk represents a specific example of the consequences of climate disasters, reflecting a more detailed dimension of this broader issue.

Figure 3. Cosine similarity between the analysed topics



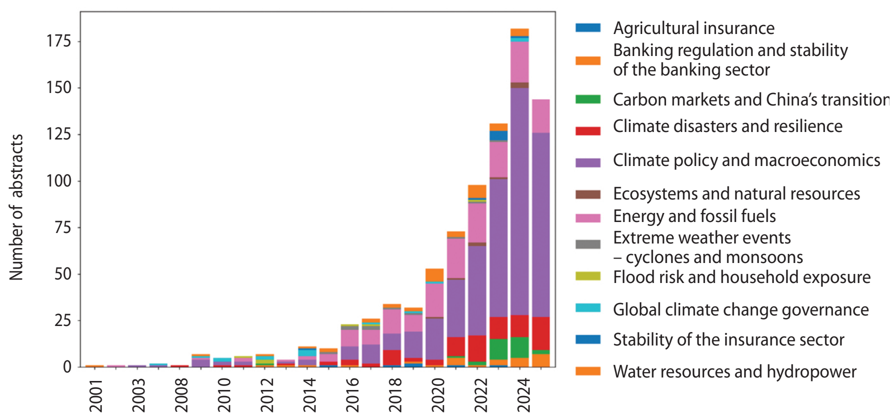
Note: Cosine similarity is a measure of semantic proximity between vector representations of topics. Values closer to 1 indicate greater content similarity, whereas lower values reflect clearer distinctions between topics.

Source: own work.

The next step is the analysis of changes in the number of abstracts assigned to individual topics over time. Figure 4 presents the cumulative number of abstracts divided into the twelve topics identified by the BERTopic model. This perspective makes it possible to capture which issues gained importance in successive years and to identify breakthrough moments in the development of the literature.

Until 2015, the number of publications remained relatively low, and interest in topics related to financial stability and climate risk was niche. The situation changed markedly after 2015, when the Paris Agreement was adopted. From that point onwards, a sharp increase in publications is observed – particularly in the areas of climate policy as well as energy and fossil fuels. This development is a natural consequence of growing regulatory pressure and the involvement of the financial sector in achieving decarbonization goals. From a risk perspective, climate policy entails a range of financial burdens for high-emission firms, which often rely on financial institutions. Examples include regulations under the EU Emissions Trading System (EU-ETS) and carbon taxation, which, according to findings in the literature, significantly worsen the situation of entities subject to these mechanisms and increase credit risk in banks (e.g., Chherawala 2024; Nehrebecka 2025; Carbone 2022). Notably, the scale of such regulations may also pose a threat to financial stability. For instance, Li et al. (2022) analyse the effects of carbon taxation on the Chinese banking sector. Their results indicate an exponential relationship between the level of the carbon tax and systemic risk, with the risk rising sharply once a certain threshold is exceeded. The findings of Li et al. (2022) also highlight significant sectoral and regional heterogeneity, implying that effective carbon tax policy requires taking this diversity into account to minimize systemic risk.

Figure 4. Cumulative number of abstracts by topic, 2000–2025

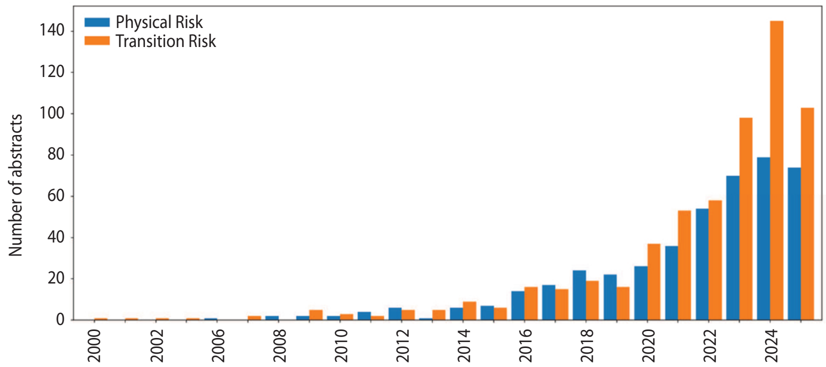


Note: The decline in the number of abstracts in the last year (i.e., 2025) does not indicate an actual weakening of research interest but results from the fact that the data were retrieved in August 2025 and therefore do not cover the entire calendar year.

Source: own work.

As shown in Table 1, the extracted topics include both those referring to physical risk – for example, *extreme weather events: cyclones and monsoons* or *flood risk and household exposure* – as well as those related to transition risk, such as *climate policy and macroeconomics* or *carbon markets and China's transition*. This confirms that the academic literature on financial stability addresses both dimensions of climate risk. In the next step, the semantic similarity of abstracts to the definitions of physical risk and transition risk provided by the European Banking Authority (EBA 2020) was analysed. This approach made it possible to assess the extent to which the examined publications correspond to the division of climate risk that dominates in the literature and supervisory practice.

Figure 5. Number of abstracts referring to physical and transition risk, 2000–2025



Source: own work.

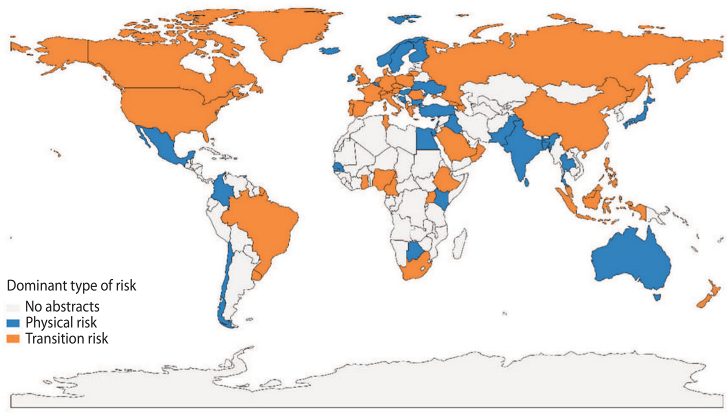
As illustrated in Figure 5, it is worth noting that although physical risk (e.g., the consequences of extreme weather events or long-term climate changes) remains an important subject of research, since 2022, transition risk has attracted increasing attention. Between 2022 and 2025, the number of abstracts addressing transition risk significantly exceeded the number of publications on physical risk. This highlights the growing importance of issues related to climate policy, emission regulations, and the transformation of economic sectors in the discussion of financial stability.

The next stage of the analysis introduces a geographical perspective, which makes it possible to capture how interest in different types of climate risk is distributed across the literature depending on the country of author affiliation. Figure 6 presents a world map indicating the dominant category of climate risk – physical (blue) or transition (orange) – in the abstracts assigned to individual countries. The grey areas denote the absence of abstracts in the sample.

Geographical analysis highlights spatial differences in research on climate risk. In highly developed countries, particularly in Western Europe and North America, transition risk dominates, reflecting intensive regulatory processes and decarbonization policies. In contrast, in countries more directly exposed to the consequences of climate change – such as India (e.g., due to monsoon seasons) or Australia (e.g., due to wildfires and floods) – physical risk plays a more prominent role.

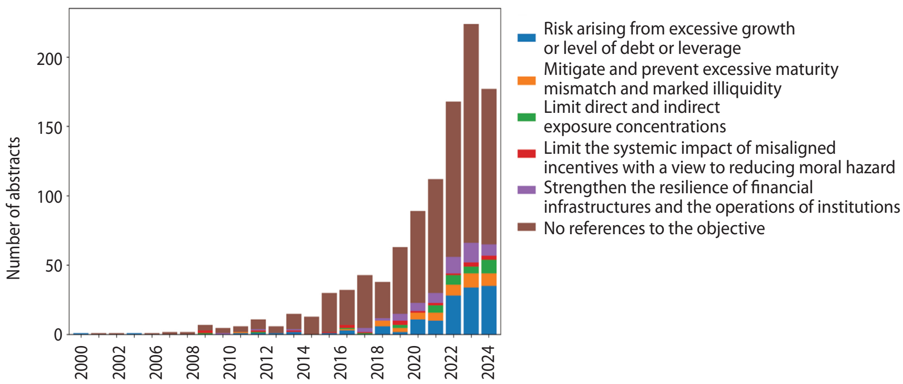
The next step of the analysis was to assess the extent to which the examined academic literature refers to the intermediate objectives of macroprudential policy. The reference point consisted of the definitions of these objectives provided in the ESRB recommendation of April 4, 2013 (ESRB/2013/1), as well as the academic articles indicated in the research methodology section. These documents were then transformed into semantic representations via the Sentence-BERT model. Each abstract was compared with these definitions on the basis of cosine similarity, and it was assigned to the objective whose definition was semantically closest to the abstract's content. The results of this analysis are presented in Figure 7.

Figure 6. Geographical distribution of the dominant category of climate risk (physical vs. transition)



Source: own work.

Figure 7. Number of abstracts referring to individual intermediate objectives of macroprudential policy, 2000–2025



Source: own work.

The trend illustrated in Figure 7 highlights the clear dominance of the "No reference to objective" segment. This means that, in most abstracts, there is insufficient evidence of operationalization in terms of specific macroprudential policy objectives. In other words, despite its growing scale, the literature still more often describes the mechanisms and channels through which climate risk affects the financial sector (e.g., the impact of climate risk on credit risk, liquidity, or asset valuation) than directly refers to the architecture of systemic risk management and macroprudential policy tools (e.g., capital buffers, concentration limits, or liquidity requirements). This represents a research gap that should become the subject of further studies, as well as an impulse for conceptual work on new prudential instruments dedicated to climate risk.

Among the abstracts that could be assigned to a specific macroprudential objective, the category *excessive credit growth and leverage* appears relatively more frequently, which is consistent with the climate-related credit risk channel. This mechanism can be associated with the excessive financing of "brown" sectors (e.g., mining, coal-based energy). The literature confirms that in some countries, banks still maintain significant exposure to sectors vulnerable to climate policy regulations (e.g., Borsuk 2023; Battiston et al. 2020). At the same time, however, the literature also signals the risk of overvaluation episodes in the segment of "green" assets (e.g., Malim Franco et al. 2025; Doksæter et al. 2021). A potential reversal of sentiment toward such assets could result in sharp price changes and an increase in credit risk for institutions financing the transition. From a macroprudential perspective, this justifies the need to monitor credit expansion both in high-emission sectors and in areas heavily financed by environmentally sustainable loans (e.g., renewable energy). Nevertheless, the share of the *excessive credit growth and leverage* category remains modest compared with the "no reference" segment.

To conduct a robustness check, the analysis was repeated on an independent dataset drawn from the Web of Science. This enabled to verify whether the topic structure previously identified on the basis of Scopus abstracts was also confirmed in another literature database. It should be noted, however, that some publications are indexed in both databases, meaning that a certain number of analysed abstracts may overlap. The results of the Web of Science analysis are presented in Table 2.

Table 2. Research topics addressed in abstracts (Web of Science)

Topic number	Representative words based on the BERTopic model	Assigned topic label
1.	'bank sector', 'climate policy_uncertainty', 'climate policy', 'impact climate', 'economic growth', 'carbon market', 'financing', 'renewable_energy', 'regulation', 'environmental'	Climate policy and the banking sector
2.	'carbon pricing', 'climate policy', 'fossil_fuel industry', 'carbon price', 'renewables', 'renewable', 'fossil_fuel', 'coal power', 'power generation', 'co2'	Energy and fossil fuels
3.	'bank sector', 'bank stability', 'bank france', 'bank', 'commercial bank', 'central_bank', 'macroeconomic', 'impact bank', 'inside debt', 'money market'	Stability of the banking sector
4.	'disaster management', 'ecosystem', 'disaster', 'flood', 'critical infrastructures', 'climate impact', 'biodiversity patterns', 'risk_layering', 'resilience', 'biodiversity'	Climate disasters and resilience

Table 2. (cont.)

Topic number	Representative words based on the BERTopic model	Assigned topic label
5.	'supply_hydropower generation_environment', 'water availability', 'water resource', 'water supply_hydropower', 'supply hydropower', 'water management', 'water supply', 'supply_hydropower', 'hydropower generation', 'hydropower'	Water resources and hydropower
6.	'international regulation', 'international institutions', 'international regulatory', 'international relations', 'globalization', 'international monetary', 'governance', 'foreign policy', 'institutions', 'international'	Global climate change governance
7.	'tropical cyclone', 'monsoon', 'weather', 'severe cyclone', 'cyclone', 'wind_speed intensity', 'range weather', 'cyclone amphan', 'cyclone track', 'indian ocean'	Extreme weather events – cyclones and monsoons
8.	'insurance industry', 'insurance market', 'insurance companies', 'insurance sector', 'insurance', 'insurers non_financial', 'european insurers', 'insurers', 'insurance company', 'conventional insurance'	Stability of the insurance sector
9.	'climate discourse', 'political climate', 'climate targets', 'polarization stakeholder', 'international climate', 'stakeholder', 'political debates', 'perceived endangered', 'outputs stakeholder', 'partisan polarization'	Political polarization and climate discourse
10.	'extreme_weather_events income', 'income inequality', 'large_climate change', 'growth large_climate', 'growing income', 'social resilience', 'impact economic', 'measures income', 'resilience family', 'resilience score'	Income inequality and social resilience to climate change
11.	'flood hazard', 'flood households', 'home flood', 'residential property', 'household exposure', 'flood', 'housing market', 'likely flood', 'housing', 'predict household'	Flood risk and household exposure
12.	'utility asset', 'property asset', 'policy property', 'property', 'local governments', 'utilities', 'real estate', 'residential', 'estate', 'utility'	Real estate market and municipal assets

Source: own work.

A comparison of the results obtained from Scopus and Web of Science reveals that the vast majority of topics overlap, confirming the stability of the topic structure. However, the Web of Science analysis identified three new themes*: political polarization and climate discourse*, *income inequality and social resilience to climate change*, and the *real estate market and municipal assets*. Their emergence is justified given their significant implications for financial stability.

Political polarization and frequent shifts in governing parties increase regulatory uncertainty (Osofsky and Peel 2022). Moreover, increasing polarization hampers effective climate action (Berkebile-Weinberg et al. 2024), thereby increasing physical risk. The new theme of social inequality emphasizes differences in adaptive capacity to climate change. The literature shows that climate-related threats disproportionately affect lower-income countries and individuals. Lower-income societies face greater exposure to extreme events and possess limited adaptive capacity. This is particularly visible in developing countries, which – despite contributing relatively little to global emissions – suffer the greatest losses and have limited institutional and financial resources to mitigate them (Wildowicz-Szumarska and Owsiak 2024; Taconet et al. 2020; Kurowski and Sokal 2023). Ultimately, these factors, combined with rising income inequality, weaken the resilience of socioeconomic systems to climate change.

The third new theme identified in the Web of Science analysis concerns the *real estate market and municipal assets*. This area is becoming increasingly important for financial stability, as real estate markets are exposed both to the effects of physical risk (e.g., the impact of flood risk on property prices – Miller and Pinter 2022) and to regulatory consequences stemming from growing energy efficiency requirements (e.g., Amen and Kempen 2025).

The analysis of abstracts from the Web of Science led to the following conclusions, which remain consistent with the results obtained from the Scopus database:

1. Research is dominated by the theme of linkages between climate policy and financial stability.
2. In recent years, issues related to transition risk have gained clear prominence (to a much greater extent than physical risk).
3. The literature focuses primarily on the mechanisms through which climate change affects financial stability while paying limited attention to the management of this risk within the framework of macroprudential policy.

Appendix 2 presents charts illustrating these conclusions on the basis of the Web of Science data.

Conclusions

The pace of climate change is making it increasingly a systemic risk (Carney 2015). Because of its scale and complexity, climate change affects every part of the economy and can endanger the stability of financial systems through different financial channels. Understanding how the academic literature conceptualizes the links between climate change and financial stability is therefore crucial both for further research and for the design of effective regulatory instruments.

The aim of the article was to examine how the academic literature identifies the mechanisms linking climate change with financial stability. This objective was addressed through a semantic analysis of more than one thousand abstracts from the Scopus database, supplemented with a robustness check based on abstracts from the Web of Science. The BERTopic method was applied to systematize the research themes and assign them to categories of climate risk and macroprudential policy objectives. The results show that within the literature on financial stability, climate policy and its implications for the financial system remain the dominant themes. From the perspective of climate risk categories, transition risk has gained particular importance in recent years, clearly surpassing the attention devoted to physical risk. This indicates a growing interest in the regulatory and economic consequences of climate policy, which currently appear to be viewed by researchers as having a stronger impact on financial system stability than the effects of extreme weather events.

The results also highlight that the literature addresses the management of climate risk within macroprudential policy only to a limited extent. This represents a clear research gap, given the systemic nature of climate risk and its potential consequences for financial stability. In practice, this means that further research is needed on the role of macroprudential instruments dedicated to climate change. Reflection on how existing tools can be adapted to climate challenges and whether new regulatory solutions are required is crucial both for regulators and for banking and insurance practices.

This study has certain limitations that should be acknowledged. First, the BERTopic method was applied to a relatively small number of abstracts compared with other bibliometric analyses, which reflects the relatively limited academic interest in the linkages between climate change and financial stability. Second, the analysis was based exclusively on abstracts, which do not always fully capture the content of entire publications. The use of full texts could reveal additional research themes and provide a deeper understanding of the mechanisms linking climate risk and financial stability.

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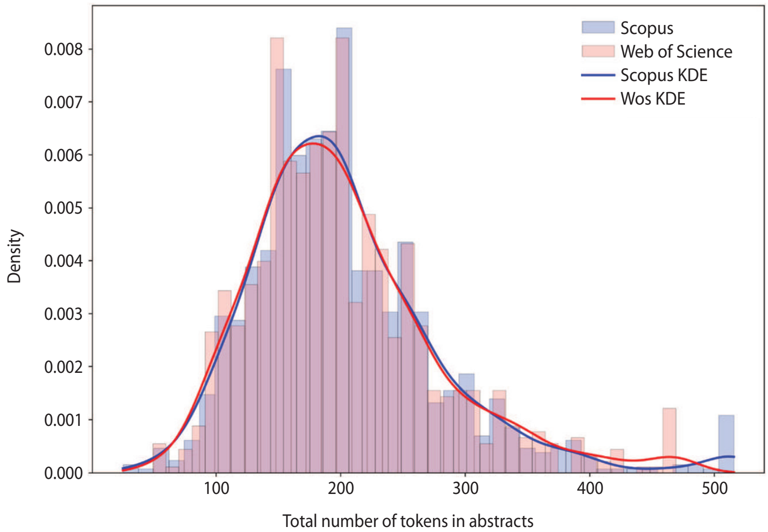
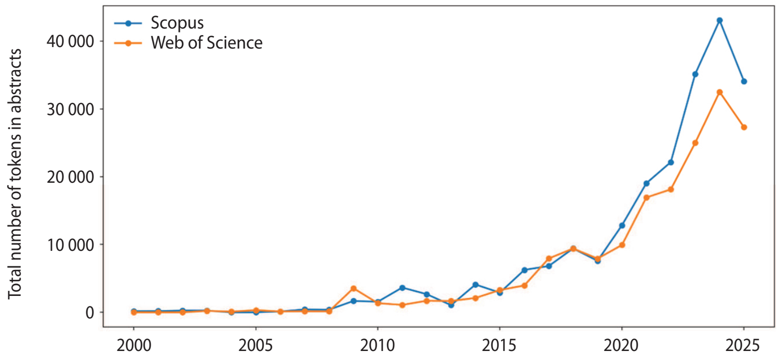
Appendix 1. Descriptive statistics of the analysed abstracts

Figure A1.1. Distribution of document length in the Scopus and Web of Science databases



Source: own work.

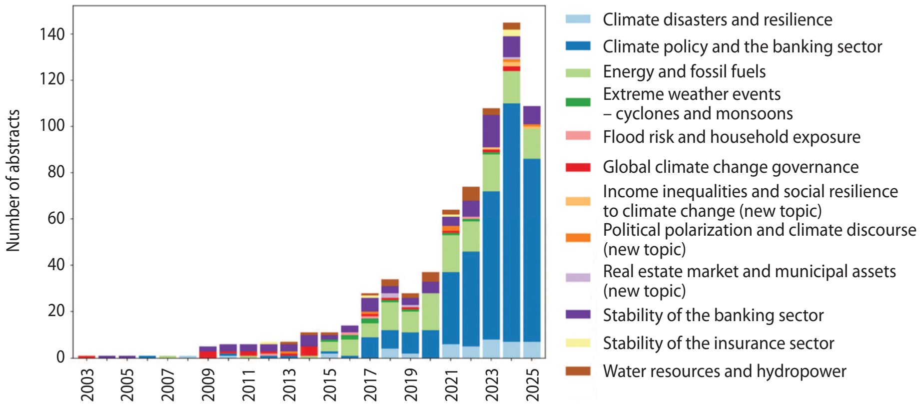
Figure A1.2. Total number of tokens in publications per year (Scopus and Web of Science)



Source: own work.

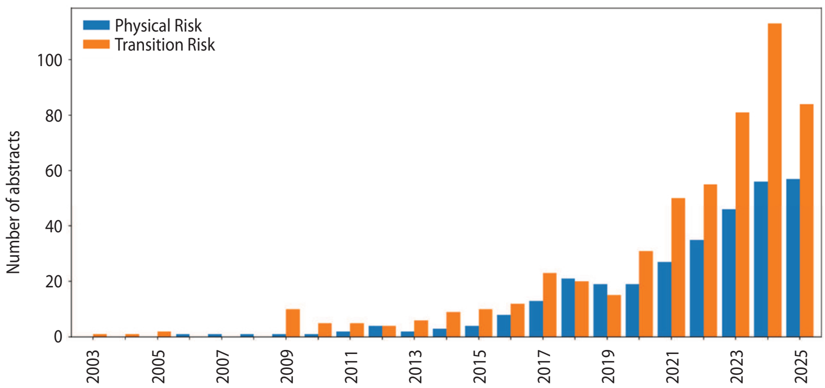
Appendix 2. Results of the analysis for the Web of Science database

Figure A2.1. Cumulative number of abstracts by topic, 2003–2025 (Web of Science)



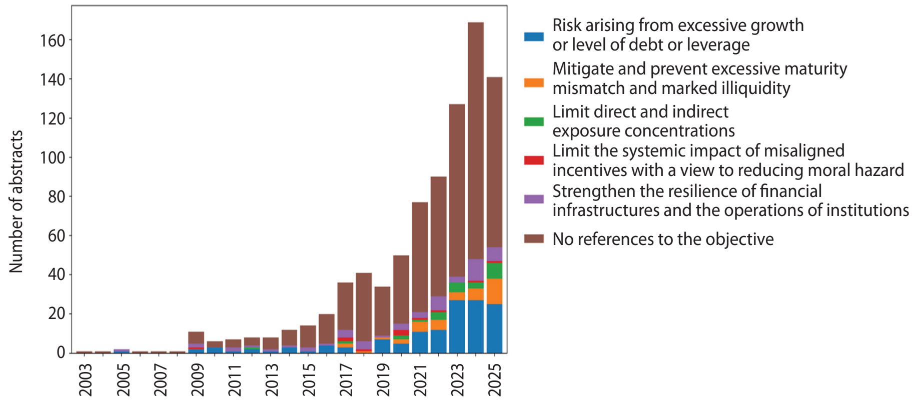
Source: own work.

Figure A2.2. Number of abstracts referring to physical and transition risk, 2003–2025 (Web of Science)



Source: own work.

Figure A2.3. Number of abstracts referring to individual intermediate objectives of macroprudential policy, 2003–2025 (Web of Science)



Source: own work.