Global scientific performance and research trends of the interrelation between climate change and economic growth

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Abstract. This paper conducts a comprehensive bibliometric analysis to explore the existing literature on the interrelation between climate change and economic growth through the prism of environmental policies. Utilising both VOSviewer and Bibliometrix software, we analyse 2,131 articles from the Web of Science database between 2000 and 2024, focusing on the fields of Economics, Social Sciences, and Environmental Science. Our investigation identifies key trends, research hotspots, patterns, and gaps in the literature, highlighting the significant impact of climate change on the macroeconomic environment. Bibliometric networks created on account of keywords such as "climate change risks," "macroeconomy," and "environmental policy" reveal strong interconnections among research clusters, particularly emphasising the role of public policy in managing climate-related risks. Notably, our findings evidence the geographical distribution of research on this topic, which is more prominent in non-EU countries despite the European Union's recent policy focus on sustainability. This paper underscores the necessity for targeted research and policy measures to address the economic implications of climate change, emphasising the role of consumer behaviour, uncertainty, and expectations with a country-specific focus. Our research contributes to the existing literature by providing a detailed mapping of the intellectual landscape and suggesting directions for future research to support effective climate policies.

1 Introduction

Climate change represents one of our most pressing global challenges, having significant ramification to environmental sustainability, economic stability and public policy [1]. Yet as the urgency of climate change grows, so does the need for understanding the academic landscape that serves the field of climate action research and all the consequential policy and

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decision-making it entails. In this respect, our study employs the means of bibliometric analysis in order to systematically evaluate the academic literature on climate change through a science mapping approach, as to key trends, research gaps and emerging themes. By analysing publications, citation networks, and co-authorship patterns, our objective is to provide a detailed overview of how climate change is addressed within the fields of economics, social sciences, and environmental studies. Our expanded research also investigates how these climate threats intersect with macroeconomic factors, supporting the need for informed, evidence based environmental policy which aims to mitigate various impacts of climate change on economic and societal well-being.

For the purpose of conducting our comprehensive analysis of existing literature, we utilised two key bibliometric tools, namely VOSviewer and Bibliometrix. Section 3 outlines the methodology used, detailing the manner in which VOSviewer and Bibliometrix were used by incorporating the Web of Science database for mapping the academic networks, visualise clusters of keywords and utterly assess the global distribution of climate change research. It emphasises the need to define the proper keywords prior to conducting the study and to use filters for narrowing the search terms in order to highlight only core areas of research such as macroeconomics and environmental policy, ensuring a focused and relevant analysis.

Further, the results of the bibliometric analysis are presented in Section 4, which integrates the benefits of both VOSviewer and Bibliometrix for a comprehensive analysis of the intellectual landscape. This section notes the major research themes, influential studies and emerging trends while addressing geographical and thematic gaps in the literature. By using Bibliometrix, we introduce additional layers of science mapping, identifying key publications, citation patterns, and co-occurrence relationships among keywords.

Thus, our paper explores the relationships between climate change, economic growth, and environmental policies, illustrating how these topics cluster together and are interconnected within the academic discourse.

2 Literature Review

The relationship between climate change risks, economic growth, and environmental policies has been of considerable interest to the academic environment, especially since the global economy faces many challenges in connection with degradation and climate-induced risks. Research on this topic has grown significantly in recent decades due to the pressing concern to understand the implications of climate risks on the overall economic development and the manner in which policies can mitigate these risks. As a result, academic research has developed in this field, specifically assessing the interaction between climate change risks and economic growth and as well as the role of environmental policies in addressing these challenges.

2.1 Climate change and Macroeconomic risks

The literature has consistently highlighted the significant risks that climate change poses to macroeconomic stability. Studies have shown that climate-related disasters, such as extreme weather events and rising sea levels, can disrupt economic activities, damage infrastructure, and reduce productivity, leading to lower economic growth rates [2]. These risks are significant for developing economies that are more vulnerable to the adverse effects of climate change due to the fragility of the infrastructure and limited financial capacity to invest in mitigation and adaptation measures [3]. Emerging literature also highlights the long-term impacts of climate change on agricultural productivity, energy demand, and human health, which further constrain economic growth [4].

In addition to economic consequences, climate change introduces significant uncertainty into the global economy, given the fact that the extent, timing and uncertain nature of technological and policy responses to climate change can deter investment and innovation of such solutions. According to Aglietta et al. [5], this uncertainty raises the cost of capital and discourages firms from undertaking long-term projects, particularly in sectors heavily dependent on stable environmental conditions, such as agriculture, real estate, and energy. Thus, climate change poses both direct and systemic risks to economic growth that require robust and immediate policy responses.

2.2 The Role of Environmental Policies in Mitigating Climate Risks

Adopting effective environmental policies has proven to be a key strategy to protect economies from the risks associated with climate change. Accordingly, governments across the world have begun to appreciate the need for policies that sustain environmental viability without compromising on the need for economic robustness. A substantial portion of the literature has focused on the role of carbon pricing, renewable energy subsidies, and regulatory frameworks in reducing greenhouse gas emissions and promoting transitions to low-carbon economies [6]. These policies help both mitigate climate risks and open new economic opportunities with innovation and green technologies serving as drivers of long-term economic dynamism [7].

For example, adopting the European Green Deal has positioned environmental policy at the core of economic growth strategies in the European Union. This policy framework aims to decouple economic growth from resource use, promote circular economies, and achieve carbon neutrality by 2050 [8]. The EU's experience provides a model for other regions, illustrating how comprehensive policy frameworks can address climate change risks while supporting economic development. However, as highlighted by previous studies, the global distribution of research and policy implementation on climate risks is uneven, with a greater focus observed in non-EU countries, particularly in emerging markets that face higher vulnerabilities to climate change [9].

2.3 Economic Growth Through Green Transitions

Another critical research areas concerns the potential for environmental policies to drive in economic growth through green transitions. Investment in renewable energy, energy efficiency technologies, and sustainable industries can create new economic growth that avoids the environmental damage of previous growth patterns. For instance, studies by Bowen and Hepburn [10] demonstrated the potential for green growth policies, especially those that promote renewable energy investments and energy efficiency, to generate employment, boost energy security, and improve trade balances. This transition is critical in light of the need to balance climate change mitigation with economic development, especially in fossil-fuel-rich countries.

However, the literature also points to challenges in achieving green growth. Several studies have underscored the need for substantial investment in research and development (R&D) to achieve technological breakthroughs that can make green transitions economically viable on a large scale [11]. Additionally, consumer behaviour and market dynamics play crucial roles in the success of environmental policies. Research by Gillingham et al. [12] shows that public acceptance and behavioural responses to environmental policies, such as carbon taxes and subsidies for renewable energy, are critical for their effectiveness. Policies must, therefore, be carefully structured to determine those economic incentives that contribute to sustainable behaviour, to ensure broad societal support for climate mitigation efforts.

3 Methodology

Given the increasing urgency of climate change as a global policy issue, there is a growing need to rigorously assess the academic landscape surrounding this topic. The challenges of climate change are complex and interconnected, with rich implications for macroeconomic stability, public health, and long-term sustainability, and policymakers, economists, and environmental scientists are trying their hand at grappling with climate change. Thus, our study seeks to highlight the dynamics of climate change research through a systematic bibliometric analysis by using a science mapping approach. This approach allows us to map the evolution of scientific knowledge on the topic, assess the influence of single studies, and identify the emerging trends that are shaping perceptions of the implications of climate change for economic growth and environmental policy.

Bibliometric analysis provides a quantitative framework to evaluate the extent and depth of academic research systematically. Using this methodology, we can assess how research on climate change has developed over time, identify dominant themes and recurring patterns, and evaluate the influence of key studies. By analysing the volume of publications, citation metrics, and the network of co-authorships and citations, we can construct a comprehensive overview of the intellectual landscape in climate change research. This enables us to highlight which areas of climate change—whether related to economic impacts, environmental risks, or policy responses—are receiving the most attention from the academic community. Such insights are crucial in understanding the global distribution of research activity and identifying whether some underrepresented regions or topics require more academic focus.

In addition to mapping the intellectual landscape, our analysis seeks to demonstrate how climate change risks intersect with economic growth, mainly through the lens of environmental policies. Climate change is an environmental and economic issue influencing key macroeconomic variables such as productivity, investment, and consumption. By incorporating macroeconomic data into our bibliometric analysis, we can more clearly illustrate how climate change impacts economic indicators and growth trajectories.

This type of analysis provides an evidence-based foundation that allows researchers to measure the extent of scientific activity, evaluate the performance of different research streams, and use quantitative metrics to track progress in the field. The descriptive and diagnostic analysis enables us to pinpoint areas where the research volume may be high but theoretical or empirical gaps remain.

3.1 Data Sources & Tools

Selecting the appropriate tools and methods is paramount to carrying out such analysis. In this respect, for our study, we utilised the Web of Science database to ensure that the data analysed was reliable and comprehensive.

Web of Science is reputed to be one of the most concise, high-quality databases for academic research, covering a wider variety of disciplines and sub-disciplines, and providing access to peer-reviewed literature. We use this database to make our analysis on a massive quantity of articles that represent the current level of research on climate change. We used specific keywords such as “climate change risks”, “macroeconomy” and “environmental policy” to create the bibliometric networks that were described above to reflect the key themes of our study. These keywords were thoughtfully chosen to represent the nuances of climate change and its economic and environmental dimensions.

To improve the accuracy of our bibliometric study, we filtered the data supplied by Web of Science to specific fields of study: Economics, Social Sciences and Environmental Science. By using this broad approach, it is possible to survey literature related specifically to the nexus of climate change and its social and economic consequences, allowing us to offer

a more nuanced analysis of how climate change is being responded to by economists, environmental scientists and social scientists. In addition, limiting our analysis to publications in the English language makes the research more accessible and intelligible, given English is the main language in literature. This helps to ensure that our findings are relevant and accessible to a wide range of stakeholders, including policymakers, academics, and international organisations.

Ultimately, our bibliometric analysis contributes as a mapping exercise also offering actionable insights for future studies and policy development. The aim of this papers is to summarize the increasing knowledge on climate change and the economy in a way that provides insights into trends, gaps, and patterns in the literature. Moreover, the macroeconomic implications of climate change highlight the need to develop and implement sound environmental policies to deal with growing climate risks. The wide-ranging study underscores the urgency of ongoing research, cross-disciplinary cooperation, and evidence-based policymaking for tackling the multidimensional issues raised by climate change.

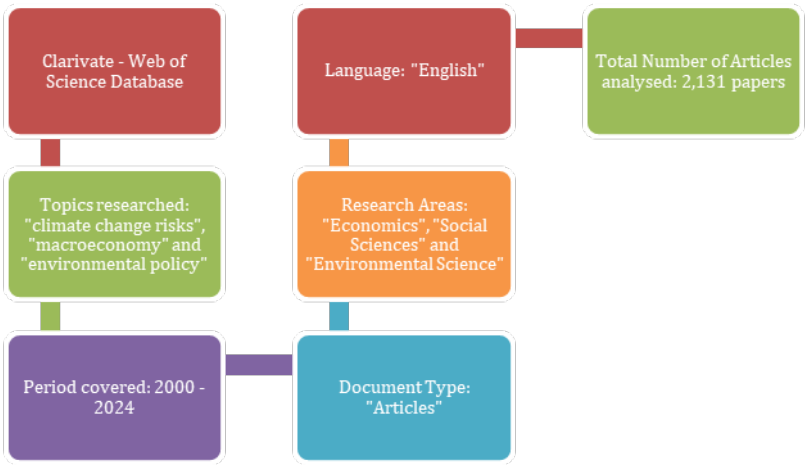

Fig. 1. Steps undertaken prior to the Bibliometric analysis. Source: Data processed by the Authors.

During the first step of our analysis, we utilised VOSviewer, a specialised software for creating, visualising, and assessing bibliometric networks. This particular tool is appropriate for scoping out complex areas of research like climate change because researchers can generate networks from citation relations, co-authorships, and other scholarly interactions like publications and journals. By constructing these networks, we can visualize how different areas of climate research connect, and how certain topics—such as climate risks, macroeconomic impacts, and environmental policy—tend to cluster amongst themselves. Using VOS viewer's text-mining capabilities, we can even produce thematic clusters based on which key terms were most frequently found in abstracts and articles relevant to our research. Which is critical for determining the most popular topics of discussion and how these relate to wider trends in the literature.

In addition to VOSviewer, we also utilised Bibliometrix, an advanced R-based tool designed for extensive bibliometric analysis and science mapping [13]. While VOSviewer specialises in creating visual bibliometric networks, Bibliometrix provides a more in-depth exploration of bibliometric data through its extensive analytical capabilities. This tool visualises citation relationships and co-authorship networks and delves deeper into the intellectual and thematic evolution of research fields, making it particularly valuable for complex, multidisciplinary topics like climate change.

Through the combined use of VOSviewer and Bibliometrix, we could comprehensively map the intellectual landscape of climate change research. While VOSviewer allowed us to create broad thematic clusters and visualise collaborative networks, Bibliometrix offered a more granular analysis of research trends, intellectual relationships, and thematic shifts. Together, these tools provided a robust framework for identifying the key topics currently dominating climate change research and the evolving nature of the academic discourse surrounding climate risks and economic growth.

3.2 Science Mapping Analysis

To explore climate change effects on economic growth, we did a science mapping by using VOSviewer and Bibliometrix.

By analysing co-occurrence patterns and citation networks through the prism of VOSviewer and Bibliometrix, the science mapping technique provided a deeper understanding of how climate change research is interconnected. Co-word analysis and mapping co-authorship networks was performed using VOSviewer, enabling us to visualise how key concepts clustered in the literature (e.g., climate change and macroeconomy) and how authors collaborated with one another. This was supplemented by Bibliometrix, which features document coupling, three-field plot visualisations, co-occurrence analysis and other advanced features that collectively map the intellectual structure of the field and provide exact references to the most influential studies and thematic clusters. The combination of both tools gave us a more complete picture of the academic landscape, showcasing the links in content between research themes and the cooperation structures of the academic environment. This bivariate analysis gave us detailed insights into the evolution and structure of climate change research, highlighting its key movers and shakers.

4 Results & Discussion

4.1 Co-word / Co-occurrence of keywords analysis

The analysis of keywords co-occurrence, conducted through the prism of VOSviewer and Bibliometrix, unveiled substantial thematic clusters within the extant literature. In this context, subsequent to the selection of the database and the execution of bibliometric analysis, we identified several additional terminologies pertinent to our research inquiry. These terminologies encompass, but are not confined to, "ecological macroeconomics," "economic growth," "uncertainty," "behaviour," and "expectations."

The analysis of these supplementary terms clarifies that the implementation of environmental policies is largely behaviour-oriented. Keywords such as "uncertainty" and "expectations" highlight the prevailing attitudes of consumers, revealing that people respond to environmental regulation indirectly by way of their perceptions and anticipations. This highlights the critical necessity of addressing consumer behaviour and managing uncertainties to effectively implement and sustain environmental initiatives. Understanding these consumer attitudes is imperative for policymakers to develop more effective strategies that foster environmental sustainability, align with public expectations, and alleviate concerns.

In summary, following the analysis of a total of 2,131 scholarly articles from the Web of Science Database, the bibliometric analysis software VOSviewer illustrated 47 keywords as relevant to our research focus. The keywords that exhibited the highest degree of interconnection, along with their respective occurrences, are represented in Figure 2 below. Consequently, the principal keywords within the corpus of articles examined encompass

"macroeconomics," which appeared 11 times, "growth," which ocurred 8 times, and additionally “climate change” and “economics,” both appearing 5 times.

As anticipated, the clusters demonstrate a robust interrelationship, each being directly relevant to our investigation.

The yellow cluster comprehensively represents the focal point of our study, namely the interconnection between climate change and macroeconomics, while concentrating on the management of climate change risks and the mechanisms through which public authorities can mitigate or minimize such risks. Furthermore, it is observable that the direct linkage between the clusters is exclusively denoted by “policy” and “models,” which illustrates the tendency of public authorities to embrace environmental policies for the collective benefit of the population.

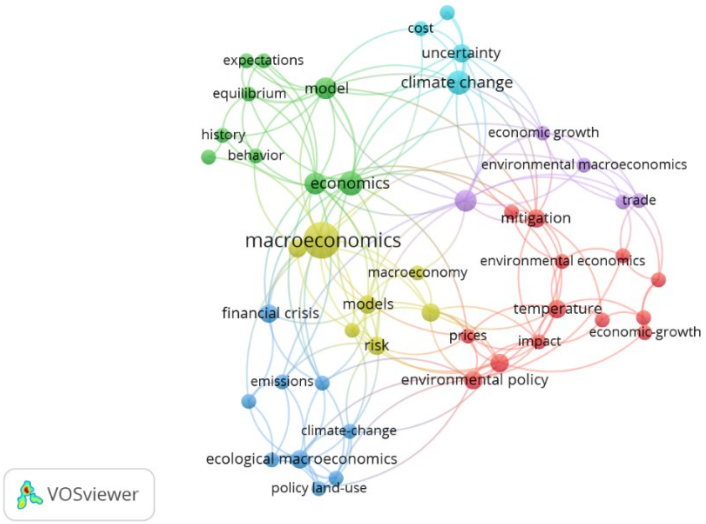

Fig. 2. Keywords analysis. Source: Authors own computation in VOSviewer.

Similar to keywords clusters analysed prior in VOS Viewer, Figure 3 displays a Co-Occurrence Network that visualises the relationships between frequently used keywords in the selected body of literature. The network highlights clusters of interrelated topics, with macroeconomics and environmental policy emerging as central nodes, connected to a range of other significant concepts like monetary policy and climate change. The thickness of the lines connecting these nodes signifies the strength of their co-occurrence, indicating how these themes are commonly discussed in academic studies. This figure provides a detailed map of the interdisciplinary connections within the literature, allowing researchers to understand the field’s core focus areas and marginal topics that may require further investigation.

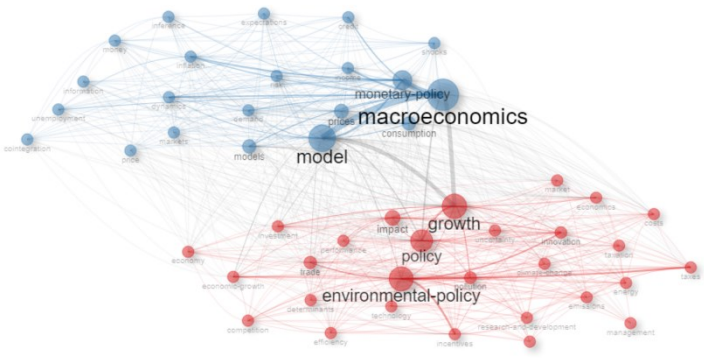

Fig. 3. Co-Occurrence Network – Keywords. Source: Authors' own computation in Bibliometrix.

Figure 4 provides a Treemap visualisation showcasing the most frequently occurring keywords in the literature related to climate change, economic growth, and environmental policies depicted above. Keywords such as macroeconomics (7%), environmental policy (5%), and growth (5%) appear prominently, indicating that they are central themes within the academic environment. Smaller boxes like climate change and international trade, each with lower percentages, signal underexplored areas in the literature, offering potential opportunities for future research. This figure is crucial for understanding the distribution of research focus and identifying gaps that could drive future scholarly inquiry.

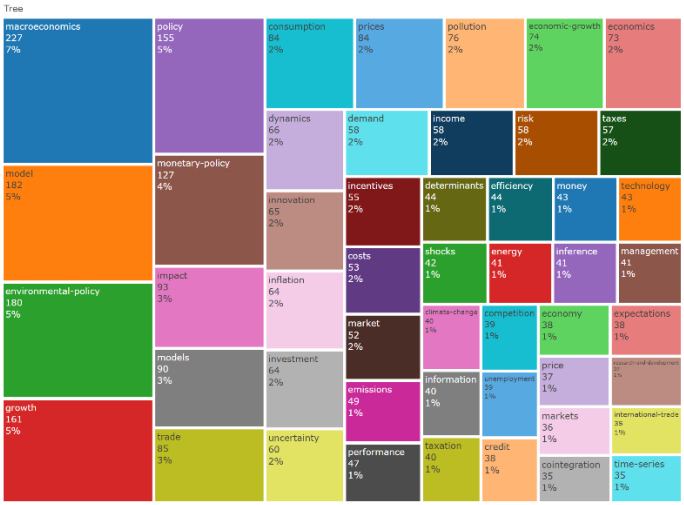

Fig. 4. Treemap visualisation – Keywords. Source: Authors own computation in Bibliometrix

4.2 Citation Analysis

Given the extensive time period encompassed in our analysis and the inclusion of 2,131 articles examined using VOSviewer software, we identified 15 countries with interconnected citation networks. As illustrated in Figure 5, the United States emerges as the country with the highest number of citations on topics related to climate change risks and global

environmental governance, appearing in 15 documents. This is followed by Australia and Sweden, each represented in 9 documents. Contrary to expectations, climate change risk is not a prominent topic in the literature from European Union countries, despite the European Commission's recent sustainability policies. Instead, this subject is more extensively discussed in non-EU literature.

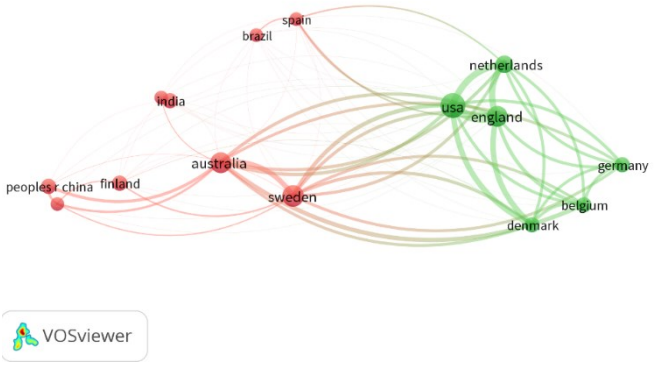

Fig. 5. Citation analysis - Countries' clusters. Source: Authors own computation in VOSviewer.

Despite the European Union's commitment to sustainability, our research revealed that climate change research is not a major focus in EU countries' academic activity. Such an assessment raises the question of why this topic is not being investigated to its full potential in nations with environmental legislation. One probable explanation is that the European Commission has just recently begun emphasizing sustainability. This could suggest that EU countries have not had enough time to catch up on climate change research. Another potential is that EU countries will prioritize other research topics above climate change. For example, vital causes such as economic recovery from the epidemic, healthcare improvements, and technology advancements may currently surpass climate change in academic research.

Furthermore, Figure 6 illustrates the authors with the most citations in scientific works about the relationship between climate change risk and the macroeconomic environment. It focuses on previously implemented environmental policies and their associated impacts, as revealed by a study of citations per author. Using the given parameters, the VOSviewer system found 49 authors, each with at least one publication to their name.

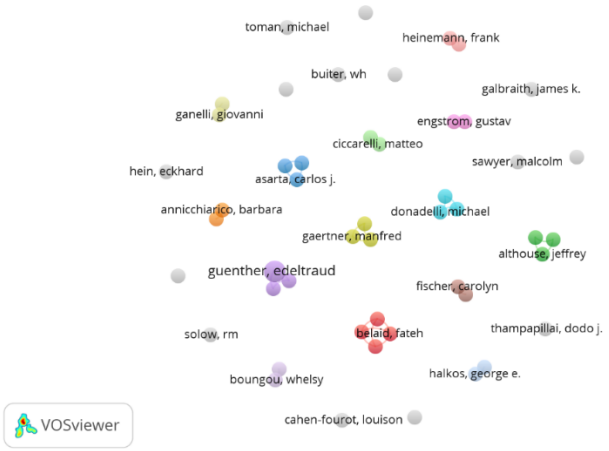

Fig. 6. Citation analysis - Number of citations per author. Source: Authors own computation in VOSviewer.

In line with the analysis performed in VOS Viewed, Figure 7 offers an analysis of the corresponding authors' countries, highlighting the geographic distribution of research on climate change and economic growth. The United States, United Kingdom, and Germany emerge as the leading contributors to the field, with the USA producing a significant number of single-country publications (SCP). This suggests a strong emphasis on domestic research in the US context, possibly reflecting national-level responses to climate policy.

In contrast, European countries, notably the United Kingdom, Germany, and Italy, display a higher proportion of multiple-country publications (MCP), indicating a more collaborative approach to climate-related economic research. This reflects a growing recognition of climate change as a global challenge that necessitates cross-border collaboration. Furthermore, the contributions from emerging economies like China and Poland indicate a global broadening of interest in how climate change impacts economic growth as these countries grapple with balancing economic development and environmental sustainability.

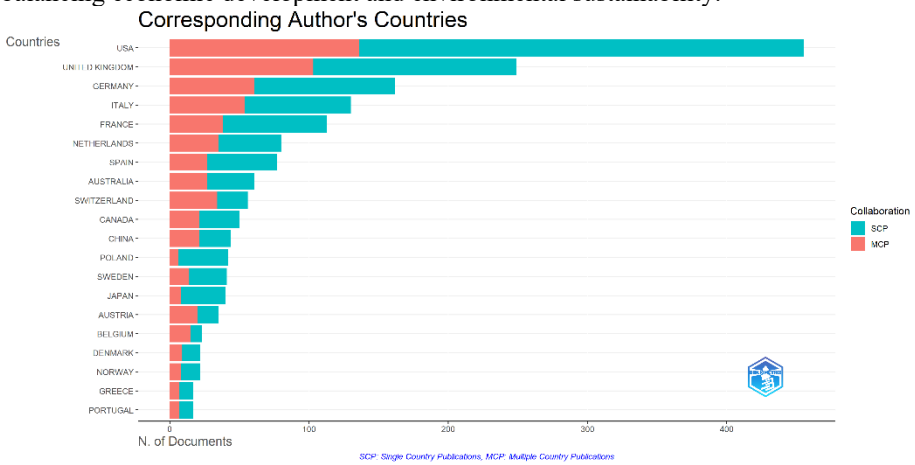

Fig. 7. Corresponding Author's Countries. Source: Authors' own computation in Bibliometrix.

Furthermore, Figure 8 presents a Three-Field Plot linking cited references (CR), authors (AU), and keywords (DE). This visualisation reveals the intellectual structure of the field,

mapping influential works to specific authors and their associated research topics. For instance, key contributors such as Napolitano M. and Roventini A. are strongly connected to macroeconomic-related research, focusing on fiscal and monetary policy research areas. This type of analysis not only demonstrates the collaborative nature of the field, but also highlights the foundational contributions that have shaped today's conversation around economic policy and environmental sustainability.

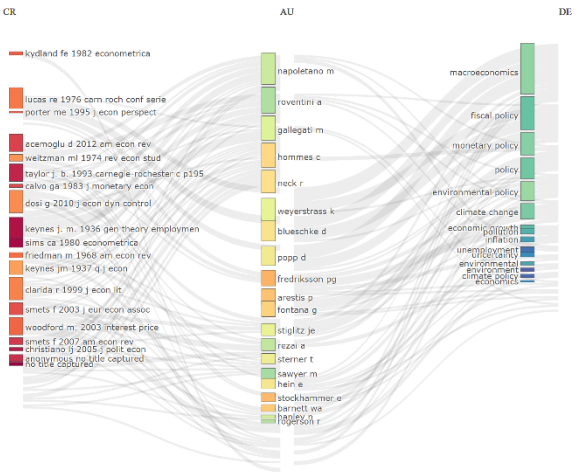

Fig. 8. Three-Field Plot linkage – Citation analysis.
Source: Authors' own computation in Bibliometrix.

4.3 Bibliographic coupling

Bibliographic coupling is a bibliometric technique that measures the degree of similarity between scholarly works based on shared references. Two documents are considered bibliographically coupled if they cite at least one common source, indicating a potential conceptual connection [14]. This method is valuable for mapping the intellectual structure of a research field, allowing researchers to identify clusters of related studies and uncover emerging themes. Unlike co-citation analysis, which looks at how often two documents are cited together, bibliographic coupling focuses on the reference lists of the documents, making it helpful in understanding the foundational literature underpinning current research [15]. By analysing bibliographic coupling relationships, scholars can gain insights into the dynamics of academic discourse within specific fields.

As such, we have used document coupling to reveal the main clusters within the academic environment, as depicted in Figure 9, which ultimately reveals the distinct focal point within the academic discourse. The bibliographic coupling analysis reveals four distinct clusters that highlight key research themes. The upper-right cluster, encompassing topics such as "macroeconomics" (54.8%), "policy" (65.5%), and "monetary policy" (44.8%), exhibits high centrality and impact, underscoring its significance in understanding how macroeconomic frameworks and policies address environmental challenges. Similarly, the upper-left cluster, focused on "innovation" (89%), "environmental policy" (77.8%), and "incentives" (100%), shows extremely high confidence scores, reflecting the solid scholarly emphasis on leveraging innovation and policy mechanisms to combat climate issues.

In contrast, the lower-left cluster that covers “growth” (13.6%), “macroeconomics” (4.1%) and “business cycles” (15.4%) operates at low centrality and impact - suggesting these topics are not exactly in the present jargon but have more room to evolve - and potential

within that framework to examine the relationship between growth dynamics and environmental policies. Similarly, the lower-right cluster is much narrower, referring to terms like "monetary policy" (55.4%), "shocks" (83.4%) and "macroeconomics" (41.1%) and indicates an early line of research on economic resilience to climate-induced disruptions. Overall, the findings highlight the prevalence of environmental policies and macroeconomics in current scholarship, finding paths towards more complementary approaches for fostering growth, monetary policy, and fiscal responses to challenges that are transdisciplinary in nature.

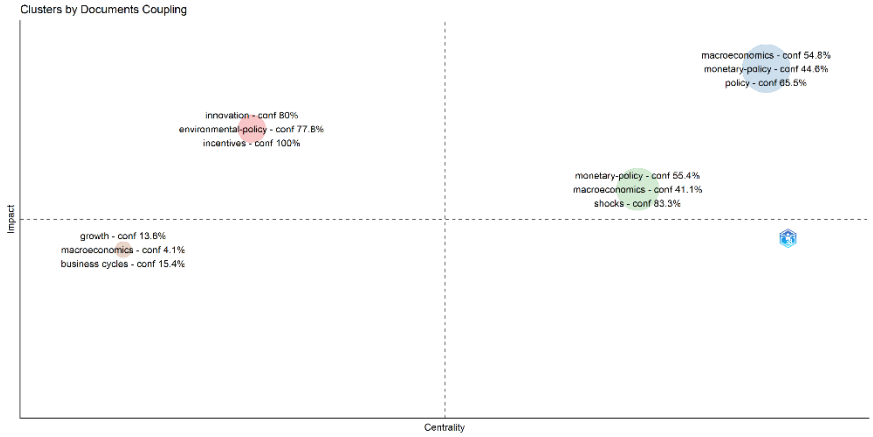

Fig. 9. Document coupling. Source: Authors' own computation in Bibliometrix.

Our science mapping analysis revealed key findings regarding the current state of climate change research. First, we observed a sharp increase in research output over the past two decades, reflecting heightened awareness of climate-related risks and the urgency of addressing them. Geographically, research efforts were unevenly distributed, with non-EU countries dominating studies on climate change and economic growth, particularly the US, while EU countries lagged behind despite their commitments to policy action.

The science mapping analysis also identified underexplored areas in the literature. At the same time, the debate about environmental policies eclipsed discussion of conventional economic topics — for example the role of fiscal and monetary policy in alleviating climate change was comparatively undeveloped. In particular, public policy which represents the above economic challenges should be part of economic analysis about climate change, as best practices for realising the above gap.

The significant and multifaced impacts of climate-related activities on economic stability and growth have generated a call for measuring climate change in the contemporary macroeconomic backdrop. Climate change poses significant risks to multiple sectors—agriculture, energy, and infrastructure, to name a few—and could impede productivity and economic output. Moreover, the increasing frequency and intensity of extreme weather events require substantial economic outlays for disaster response and recovery, putting a strain on public resources. Understanding the economic ramifications of climate change is vital in designing adaptive strategies and policies that promote resilience and sustainability [16-17]. Addressing climate change's macroeconomic effects also allows for more informed decision-making, leading investments in green technologies and sustainable practices that can offset negative impacts while promoting long-term economic growth.

This bibliometric perspective underscores the need to further integrate climate policy with economic frameworks, especially in understanding how global economic systems will adapt to climate-induced challenges. Future research should address the gaps in economic growth

uncertainties linked to climate change while building on the robust foundation of environmental policy research to craft sustainable economic strategies.

5 Conclusions

In conclusion, the bibliometric offers delve into the evolving literature related to climate change, its effects on economic growth and environmental policy, and provides a foundation for future research in this important and dynamic field. Our findings show the overwhelming focus of studies on environmental policies and the financial aspects of climate change but also several poorly explored topics, such as the impacts of climate change on macroeconomic stability and inequality. However, despite greater cross-border cooperation, geographic divides persist, with some countries — notably the United States — dominating the output while EU countries do a poor job when it comes to managing climate change risks. These gaps are primarily concerning to the current research as future work should strengthen comprehensibility of the economic difficulties posed of climate policies alone, as also implying an understanding of how economic models must cooperate with climate policies to be most effective. The study underscores the importance of interdisciplinary collaboration and continued scholarly attention to ensure that policy responses are grounded in the most comprehensive and up-to-date research available.

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