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Climate Change Risk and Firm Risk: A Bibliometric Analysis using Biblioshiny

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Abstract: *This bibliometric analysis investigates the multifaceted impact of climate change on firm risk using data from the Scopus database. Climate change poses significant risks, including physical risks from extreme weather events, transition risks due to evolving policies and regulations, and reputational risks from stakeholders' environmental concerns. The study highlights that firms in high-risk sectors like energy and agriculture are particularly vulnerable. Financial markets are increasingly integrating environmental, social, and governance (ESG) factors into investment decisions, influencing firms' cost of capital and access to financing. Effective climate risk management, such as investing in renewable energy and improving operational efficiencies, can enhance firm resilience and create opportunities for innovation. The analysis underscores the need for interdisciplinary approaches and comprehensive risk assessment models. Despite data limitations and variability in measurement methodologies, the study emphasizes the importance of proactive strategies for firms to navigate the evolving economic landscape and contribute to global sustainability goals. Future research should focus on industry-specific impacts, effective disclosure practices, and the role of emerging technologies and governance structures in managing climate risks. This study provides valuable insights into the complex relationship between climate change and firm risk, advocating for strategic risk management to ensure long-term viability.*

Keywords: Climate Change; Firm Risk; ESG Factors and Risk Management.

I. INTRODUCTION

Climate change poses significant risks to firms, impacting their operations, profitability, and overall risk profile. Existing literature highlights various dimensions through which climate change affects firm risk, including physical risks from extreme weather events, transition risks from shifting policies and regulations, and reputational risks associated with stakeholders' environmental concerns (Bolton et al., 2020). Physical risks are manifested through disruptions in supply chains, damage to infrastructure, and increased operational costs due to extreme weather conditions such as floods, hurricanes, and droughts (Stern, 2007). Transition risks emerge as firms face the challenge of adapting to new environmental regulations, carbon pricing mechanisms, and the shift towards a low-carbon economy, which can lead to stranded assets and increased costs of compliance (Caldecott et al., 2016). Furthermore, firms are increasingly scrutinized by investors, customers, and regulatory bodies for their environmental practices, and failure to address climate-related issues can result in reputational damage, loss of consumer trust, and decreased market value (Eccles, Ioannou, & Serafeim, 2014).

Research indicates that firms with poor environmental performance or those operating in high-risk sectors are more vulnerable to these risks. For instance, studies have shown that companies in industries such as energy, agriculture, and insurance are particularly susceptible to climate-related financial losses (Patel, 2021). The financial markets are also responding to climate risks by integrating environmental, social, and governance (ESG) factors into investment decisions, thereby influencing firms' cost of capital and access to financing (Giese et al., 2019). This shift underscores the importance for firms to develop robust climate risk management strategies and to enhance their resilience against the multifaceted impacts of climate change (Task Force on Climate-related Financial Disclosures, 2017).

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As the global climate crisis intensifies, it is imperative for firms to adopt comprehensive risk management strategies that address the physical, transition, and reputational risks associated with climate change. By integrating ESG factors into their core business strategies, firms can not only mitigate risks but also capitalize on opportunities for innovation and sustainable growth in the evolving economic landscape.

One of the primary limitations is the absence of extensive, longitudinal datasets that track the specific climate-related exposures and adaptive responses of individual firms over long periods. Without these datasets, it becomes challenging to establish robust causal linkages and to elucidate the long-term ramifications of climate risks on firm stability (Gros & van den Burg, 2020). Most studies rely on cross-sectional data, which only provides a snapshot in time, making it difficult to capture the dynamic nature of climate risks and their evolving impact on firms.The existing literature tends to focus on specific industries or geographic regions, resulting in a fragmented understanding. For instance, research may concentrate on the agricultural sector in North America or the energy sector in Europe, but these findings may not be easily generalizable to other sectors or regions. This narrow focus impedes the ability to develop a holistic understanding of climate risks across diverse sectors and global contexts.

Another critical limitation is the substantial variability in the operational definitions and measurement methodologies of climate risks. Different studies adopt different frameworks and metrics to assess climate risks, leading to inconsistencies and complicating comparative analysis across different studies. For example, some studies may measure physical risks using historical weather data, while others might use projections of future climate scenarios. This lack of standardization makes it challenging to aggregate findings and draw broad conclusions about the impact of climate change on firm risk.

One central research question that emerges in this context is: **How do climate change risks impact firm risk?** This question is multifaceted, encompassing various dimensions of risk, including physical risks (such as damage from extreme weather events), transition risks (stemming from regulatory changes and shifts in market dynamics), and reputational risks (related to stakeholder perceptions of a firm's environmental stewardship) (Bolton & Kacperczyk, 2021). Firstly, the current lack of comprehensive, longitudinal datasets that track individual firms' climate-related exposures and adaptive responses over extended periods hampers the ability to establish robust causal linkages. Without such data, it is difficult to capture the dynamic nature of climate risks and their evolving impacts on firm risk (Gros & van den Burg, 2020). Most studies to date have relied on cross-sectional data, providing only a snapshot in time rather than a continuous view of risk evolution.

This lack of standardization complicates the aggregation of findings and the formulation of generalizable insights.Furthermore, the rapidly changing landscape of climate science and regulatory frameworks necessitates continuous updates and revisions to maintain the relevance of research findings. As new climate models and policies are introduced, firms' risk profiles can change, underscoring the need for researchers to stay current with these developments (Gros & van den Burg, 2020).Investigating how climate change risks impact firm risk is a complex but vital research endeavour. Addressing this question requires overcoming significant data limitations, standardizing measurement methodologies, and expanding the scope of research to encompass diverse industries and regions. By doing so, future research can provide more robust and generalizable insights into the intricate relationship between climate change and firm risk.

II. METHODOLOGY

The Scopus database, which includes a wide range of papers in business, management, economics, and finance, has been regarded as more convenient and comprehensive based on the recommendations of variousresearchers. For their bibliometric analysis, the researcher has chosen the Scopus database. To find relevant articles, the analysis used certain keywords, such as "Climate change risk*" AND "Firm Risk*," were applied to the title, abstract, keywords, and text search bar. 22 research publications were obtained as a result. However, these selections still need to be improved by adding more inclusion standards.

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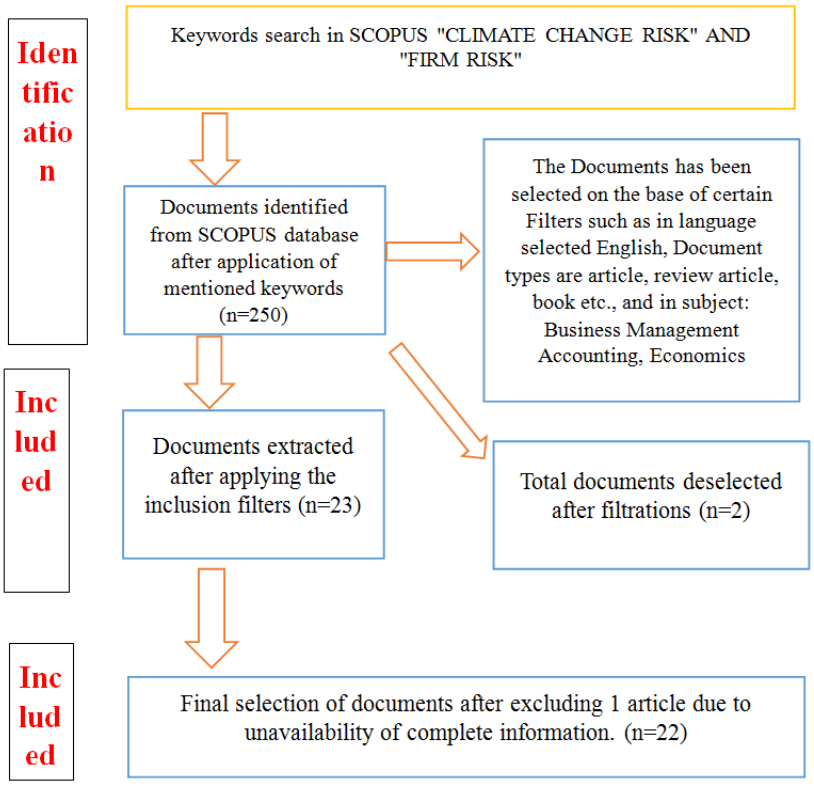

Figure 1. Prisma Framework

III. SOFTWARE AND TECHNIQUE

After the final selection of the documents from the Scopus database, the extracted documents in a CSV file are exported to Biblioshiny in R Studio software. Biblioshiny is a visualisation application of R Studio that helps in analysing the bibliometric data extracted from the databases for the bibliometric analysis of theconcerned subject or field.

IV. RESULTS

Table 1 presents a summary of the data collected from the Scopus database using the defined keywords "CLIMATE CHANGE RISK" AND "FIRM RISK". It provides information about authors, their collaborations, documents, and their contents.

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2015:2024
Sources (Journals, Books, etc)	20
Documents	22
Annual Growth Rate %	86.12
Document Average Age	0.864
Average citations per doc	10.36
References	0
DOCUMENT CONTENTS	
Keywords Plus (ID)	72
Author's Keywords (DE)	98
AUTHORS	
Authors	68

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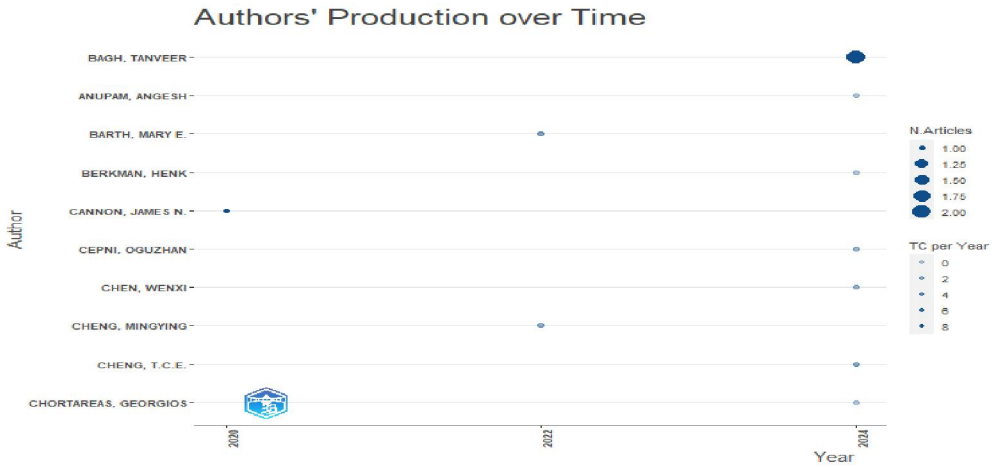
Authors of single-authored docs	1
AUTHORS COLLABORATION	
Single-authored docs	1
Co-Authors per Doc	3.14
International co-authorships %	50
DOCUMENT TYPES	
article	22

Table 1. Summary of Main Information about Data

Author's Production



Picture 2

The table shows details about different academic articles, including the authors, publication years, titles, journals, unique identifiers (DOIs), total citations, and average yearly citations. It covers articles published between 2015 and 2024 on topics like risk-taking after COVID-19, climate change, ESG practices, and corporate social responsibility. Each article is listed with its journal and a DOI for easy access.The total citations show how many times each article has been cited, indicating its influence. The average citations per year give a clearer view of its yearly impact. For example, James N. Cannon's 2020 article has been cited 40 times, averaging 8 citations per year. On the other hand, newer articles from 2024, such as those by Tanveer Bagh and Henk Berkman, haven't been cited yet due to their recent publication.

Most Frequently and Trending Keyword

The treemap visualization categorizes research topics by their prevalence and importance, with "climate change" being the most prominent, representing 9% of the total. Other key topics, each accounting for 3%, include "supply chain management," "operation management," "costs," and "risk assessment." Various specialized topics, each representing 2%, include "climate change risks," "climate transition," "cost of equity," "disaster prevention," "emission reduction," "emissions mitigation," and "financial decisions." This diverse range highlights the multidisciplinary nature of the research, integrating environmental, financial, and operational concerns. The treemap underscores the importance of climate change while also showing significant attention to operational and financial management, making it a useful tool for identifying research focus areas and gaps.

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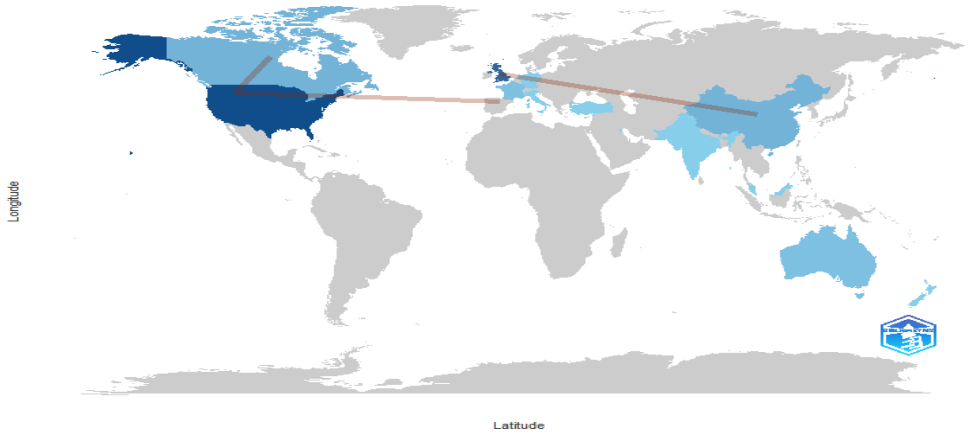
Picture 3

Collaboration World Map



Picture 3

The map illustrates the geographic distribution of research activities and collaborations worldwide. The darkest blue regions, particularly the United States, indicate the highest levels of research activity. Canada, Western Europe, and parts of Asia also show significant involvement, with China and India being notable contributors. Australia displays moderate research activity. The connecting lines represent active collaborations between these regions, emphasizing strong international partnerships in research. Overall, the map highlights the global and interconnected nature of research efforts.

Most Global Cited Documents

This provides valuable insights into the academic impact and relevance of various research papers through their citation metrics, including DOIs, total citations, citations per year (TC per Year), and normalized total citations (Normalized TC).

Highly Cited Papers: The papers by CANNON JN (2020), HOSSAIN AT (2022), and LI ZF (2021) stand out as the most cited, with 40, 34, and 30 citations respectively. These high citation counts indicate that these works have significantly influenced their fields, contributing to ongoing research and discussions.

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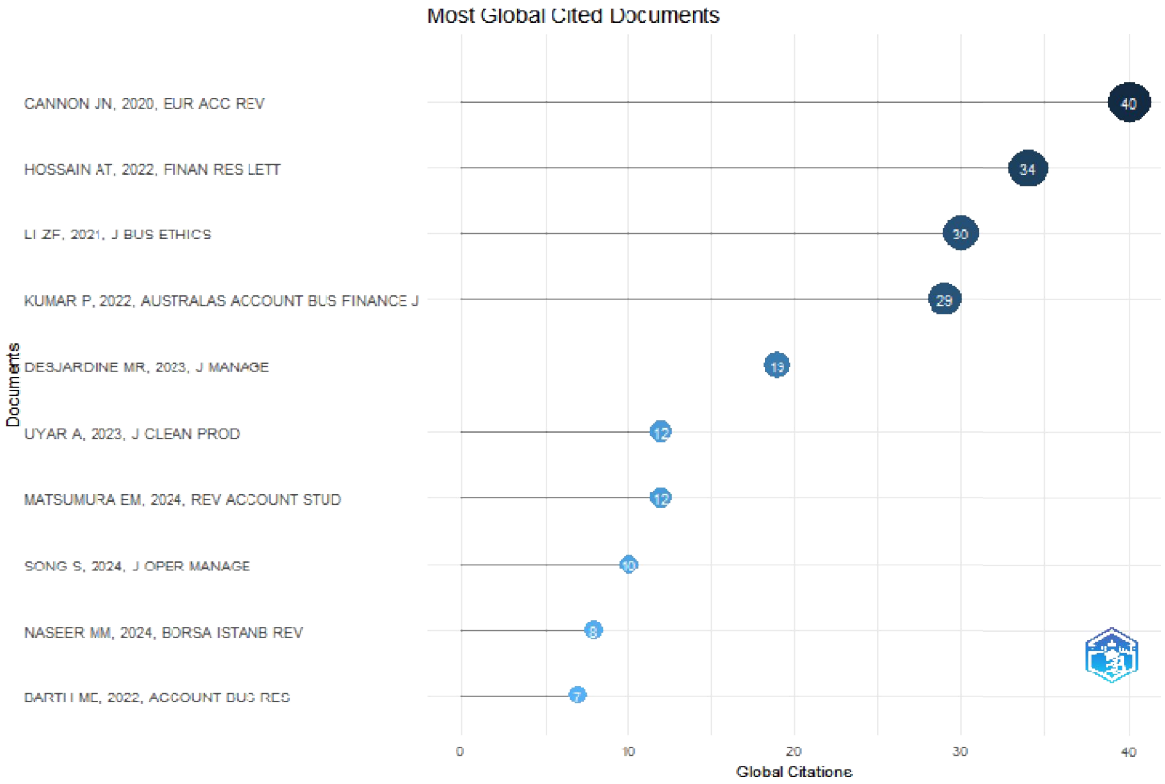
Recent High-Impact Papers: Recently published papers such as those by MATSUMURA EM (2024), SONG S (2024), and NASEER MM (2024) have already garnered substantial citations, with 12, 10, and 8 citations respectively. This quick accumulation of citations suggests that these papers address current, high-interest topics and have made immediate impacts.



Moderately Cited Papers: Papers by KUMAR P (2022), DESJARDINE MR (2023), and UYAR A (2023) have received moderate attention, with citation counts ranging from 12 to 29. These papers contribute meaningfully to their fields and are recognized by their peers, though not to the same extent as the top-cited works.

Lower-Cited Papers: Research by BARTH ME (2022), GHAFOOR A (2023), and DROBETZ W (2024) have lower citation counts (5-7 citations). These papers may be newer or in less widely discussed niches but still add value to their respective areas of study.

Uncited Papers: Several papers, such as those by KHAN MH (2024), HUNJRA AI (2024), BERKMAN H (2024), and CHORTAREAS G (2024), have not yet been cited. This lack of citations could be due to their recent publication dates or niche topics that have not yet gained broader academic attention.

Overall Impact: This citation analysis highlights the academic influence and reach of these papers. Highly cited works are recognized for their significant contributions and are frequently referenced in subsequent research. Recently published papers with high citation rates indicate emerging areas of interest and relevance. Understanding these citation patterns helps identify key research trends and influential works in various academic fields.

V. DISCUSSION

Climate change risk is multifaceted, affecting firms through direct and indirect pathways. Direct risks include physical damages to assets and infrastructure due to extreme weather events such as hurricanes, floods, and wildfires. These events can lead to substantial financial losses, business interruptions, and increased insurance costs. Indirect risks, on the other hand, stem from regulatory changes, market shifts, and reputational damage. Governments worldwide are enacting stringent regulations to curb greenhouse gas emissions, which can impose compliance costs on firms, especially those in carbon-intensive industries.

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The transitional risks associated with moving towards a low-carbon economy are equally significant. Firms must adapt to new technologies, processes, and market demands, which can be resource-intensive and disruptive. Companies failing to innovate or align with sustainability trends risk losing competitive advantage, facing increased scrutiny from investors, and encountering difficulties in accessing capital. The growing emphasis on Environmental, Social, and Governance (ESG) criteria further intensifies these risks, as stakeholders increasingly demand transparency and accountability in corporate sustainability practices.

Research highlights that effective climate risk management can enhance firm resilience and create opportunities for value creation. Companies that proactively address climate risks can differentiate themselves through sustainable innovations, improve operational efficiencies, and access new markets. For instance, investing in renewable energy sources can reduce long-term operational costs and hedge against fuel price volatility. Additionally, firms that integrate climate risk into their strategic planning can better anticipate regulatory changes and align with evolving consumer preferences towards sustainable products.

The scholarly attention on climate change risks also underscores the importance of interdisciplinary approaches. Integrating insights from environmental science, finance, and operational management provides a holistic view of the challenges and opportunities. Such integration is vital for developing robust risk assessment models, improving disclosure practices, and enhancing stakeholder engagement.

Overall, the discourse on climate change risks and firm risk reveals that addressing these challenges is not just about mitigating negative impacts but also about seizing strategic opportunities. Firms that lead in climate risk management can strengthen their market position, foster innovation, and contribute positively to global sustainability goals.

VI. CONCLUSION

The analysis of climate change risks and firm risks reveals the profound and multifaceted impact of climate change on corporate operations, financial performance, and long-term sustainability. Firms face both direct risks, such as physical damages from extreme weather events, and indirect risks, including regulatory changes and market shifts. The transition to a low-carbon economy poses additional challenges, requiring significant adaptation in technology, processes, and market strategies. Effective climate risk management is essential for enhancing firm resilience and capitalizing on new opportunities. Proactive strategies, such as investing in renewable energy, improving operational efficiencies, and aligning with ESG criteria, can differentiate firms and provide competitive advantages. Integrating interdisciplinary insights from environmental science, finance, and operational management is crucial for developing comprehensive risk assessment models and improving stakeholder engagement.

The research highlights that addressing climate change risks is not solely about mitigating negative impacts but also about leveraging strategic opportunities for innovation and value creation. Firms that lead in climate risk management can enhance their market position, drive sustainable innovation, and contribute to broader global sustainability efforts. By understanding and proactively managing climate risks, firms can better navigate uncertainties and ensure long-term viability in an increasingly climate-conscious world.

VII. FUTURE SCOPE

Further research on climate change risks and firm risks should explore various dimensions to provide a comprehensive understanding and actionable insights. Key areas include the industry-specific impacts of climate change, effective climate risk disclosure practices, and the role of emerging technologies in managing these risks. Investigating the economic implications of regulatory changes, the influence of corporate governance structures, and the insurance industry's role in climate risk management is crucial. Additionally, studying the correlation between climate risk management and financial performance, behavioural responses within organizations, and the efficacy of public-private partnerships can offer valuable perspectives. Research should also focus on the unique challenges in emerging markets, the role of sustainable innovation in gaining competitive advantage, and developing robust metrics for measuring climate risks. By addressing these topics, scholars can help firms enhance resilience, drive sustainable innovation, and navigate the complexities of climate-related challenges.

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