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Mini review

A critical review of the impact of uncertainties on green bonds

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Abstract: Green bonds are relatively new in the financial market compared to other financial securities but are useful in financing environmentally friendly projects. Just like other financial securities, green bonds are affected by various factors, such as economic policy uncertainty. Our aim of this paper was to conduct a systematic literature review of the impact of economic policy uncertainty on green bonds. We sought to do a thorough analysis of the existing literature on the assessment of the impact of economic policy uncertainty on green bonds and the techniques used in assessing the impact. Our findings showed that economic policy uncertainty had a strong impact on the green bond, with its intensity varying by location. This impact tended to be more pronounced in periods of heightened uncertainty. Also, our findings highlighted that the assessment of the impact of economic policy uncertainty on green bonds gained popularity in 2019, with China emerging as a prominent contributor. However, other countries, such as Finland, even though they had few published papers, their citations signified the production of quality papers in this field. Additionally, we found that the application of the quantile analysis method was utilized by many recent studies, which signified its importance in this field. Our findings highlighted the importance of considering appropriate techniques in assessing the impact of economic policy uncertainty on green bonds while taking into account the paper quality.

Keywords: economic policy uncertainty; financial securities; environmental, social and government (ESG) bonds; environmental finance; climate bonds; sustainable development goals

JEL Codes: G15, G32

1. Introduction

Rising temperatures and increased carbon emissions continue to be matters of utmost importance. The heightened emission of greenhouse gases can be attributed to various sources, including the combustion of fossil fuels and advancements in industrialization (Szulczewski et al., 2012). Even though the International Energy Agency has formulated an ambitious goal of attaining carbon neutrality by the year 2050, the accomplishment of this aspiration necessitates a substantial infusion of economic resources (IEA 2012). One of the major ways to tackle this issue is by way of green development. Green bonds, which are connected to the green environment, are essential financial instruments used to raise funds to sponsor projects that have minimal carbon effects and are environmentally friendly (World Bank, 2019; Ahn Tu et al., 2020). Green bonds have made a considerable impact despite their recent entry into the financial market by enabling the funding of initiatives that support low-carbon emissions and contribute to a more climate-resilient environment (Weber & Saravade, 2019). The drive for carbon neutrality has sparked the development of a wide range of financial instruments designed for green business ventures. As a result, investors now have the chance to expand the scope of their investment portfolios and include sustainability into their strategies through the world of green finance (Statista, 2023). In this setting, economic uncertainty becomes a significant risk factor which is distinguished by the uncertainty surrounding upcoming legislative initiatives and regulatory frameworks. Market dynamics change as a result of the unpredictability of fiscal, regulatory, and monetary policies, which are all aspects of economic policy. Governmental policies have a broad impact, touching not only individuals but also clearly influencing things like green bonds. Economic instability and the performance of green bonds over time are notable for having a complex even though country-specific, non-linear relationship (Wei et al., 2022). As noted by Wang et al. (2022), there exists a detrimental long-term influence of economic policy uncertainty on the green bond market. This assertion finds validation in the context of China, which harbors the world's largest green bond market and witnessed a substantial global shock due to the outbreak of the Covid-19 pandemic, resulting in a significant impact on green bonds. A study by Yi et al. (2021) shows that covid-19 has brought about an increase in an index called the Cumulative Abnormal Return (CAR) and a look at the post pandemic era reveals a further reduction in this index. Tian et al. (2022) indicated that economic policy uncertainty has an asymmetrical effect on China's green bond market. According to Pham & Nguyen (2022), economic policy uncertainty on green bonds has stronger impact during high uncertainty times. A study by Syed et al. (2022) also indicated that a positive shock of economic policy uncertainty yields negative impacts on green bonds while a negative shock results in a positive performance of green bonds. The recent study by Gök (2023) reveals that changes in economic policy uncertainty Granger-causes fluctuations in the green bonds market during the Russia–Ukraine war, which started in early 2022. However, Wei et al. (2022) indicated that the relationship between green bonds and policies is not strongly correlated in the short-term. That is, green bonds are long term investment for investors and the short-term premium is not affected by economic policy turbulence, making it a nice financial instrument for investors.

However, the influence of fluctuations in financial and economic policies on the portfolios of green bonds has a noticeable but generally modest impact. This impact tends to be more pronounced in periods of heightened uncertainty, with greater effects observed in such circumstances. Despite this, the connection between green investments and economic turbulence is relatively weak, particularly during times of reduced volatility (Wei et al., 2022). Therefore, it is advisable to cautiously incorporate

green investments in a measured manner during these less turbulent periods, as they can contribute to stabilizing the economy. It is important however, to note that the risk mitigation benefits of this approach decrease as uncertainty escalates (Syed et al., 2022). Our study underscores the significance of policy clarity in maintaining financial market stability during economic crises. Certain policies play a pivotal role in minimizing the disruptive influence of uncertainty on the performance of green bonds within the market. This facilitation of hedging capacity serves to enhance the resilience of green bonds against turbulence, fostering the growth of both the financial market and economic activities (Pham & Nguyen, 2022). The unique credit attributes of green bonds position them to potentially yield more substantial financial resources than conventional bonds. This distinction arises from their specific characteristics (Baker et al., 2018). The increasing global concern surrounding climate change and its associated ramifications has prompted a surge in studies dedicated to understanding green bonds. These bonds have gained attention not only as investment avenues for stakeholders but also as an alternative means of financing projects with a low carbon footprint. While the discussion surrounding the impact of economic policy uncertainty has gained attention recently, a noticeable research gap exists in terms of a comprehensive systematic review of this impact. The ongoing emergence of papers on this topic underscores its significance; yet, a critical necessity exists to conduct an overarching analysis of these papers' contributions to the broader literature. Our aim is to assess the intricate interplay between economic uncertainty and green bonds. Our inquiry involves a thorough examination of the methodologies, techniques, and tools employed by prior researchers in their exploration of this subject. Furthermore, we intend to delve into the distinct contributions made by various countries to the existing literature, evaluating their pertinence, and identifying the journals that prominently advance this field of study. The rest of the study is structured by describing the method used for the review in the second section, the results, and a discussion in the third section, and a conclusion with a recommendation being the last section.

2. Methodology

2.1. Green bonds and economic uncertainty

We aim to investigate the impact of economic uncertainty on green bonds. As a matter of fact, green bonds and economic uncertainty cannot be underestimated as long as development is concerned. This can be relative to countries, regions, nations etc. Factors affecting the performance of green bonds are country specific instead of a generalization. A lot of research has been conducted on green bonds and economic uncertainty. Green bonds are very unique as compared to other conventional financial instruments as they finance green projects at a relatively low cost (Baker et al., 2018). The risk of investing in green bonds is far less than other bonds and financial instruments. Relatively, green bonds are well known historically with great impact on development in the financial market (Ahn Tu et al., 2020). The review method to be used is the widely known Preferred Reporting Items for Systemic Reviews and Meta-Analysis (PRISMA) statement, which states that a systemic review is a review on distinctly formulated questions to assess and critique relevant studies. Our focus is to find literature on the impact of economic policy uncertainty on green bonds and review what was done, what was found, and what further studies plan to do. In the cause of this study, we implement the five-step methodology by Denyer & Tranfield, (2009) shown in Figure 1. Using the five-step methodology by Denyer & Tranfield, (2009) for quality systemic literature review, we start with establishing the stretch of our

work by answering the following research questions: 1) How has the research landscape evolved over the years concerning publications on economic policy uncertainty and green bonds? 2) What temporal patterns and geographical trends can be identified, and how do they contribute insights into the progression of research in this domain? 3) What methods and techniques are commonly utilized in the selected papers that address economic policy uncertainty and green bonds? 4) What is the common nature of the impact of economic policy uncertainty on green bonds?
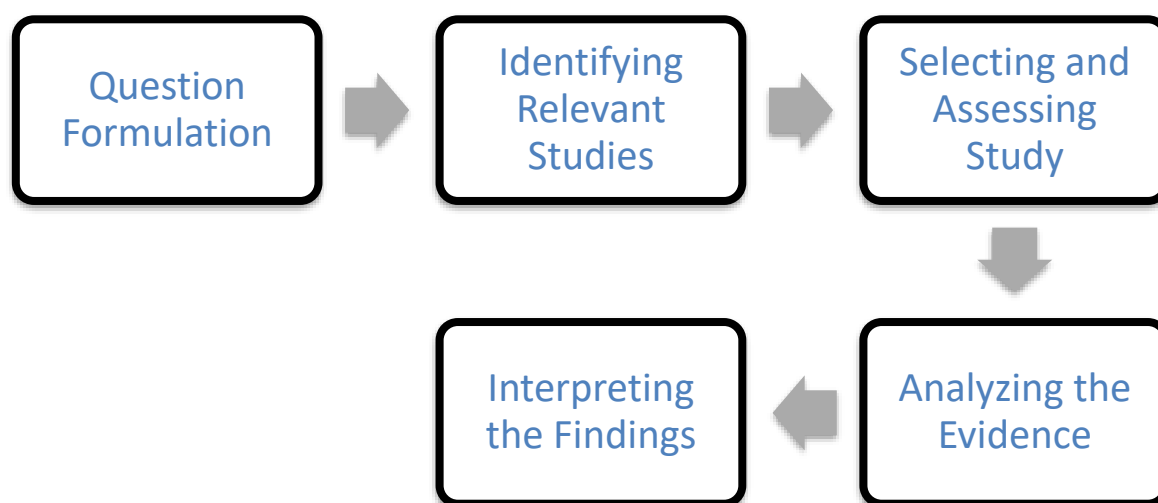

Figure 1. The Five step methodology.

2.2. Identifying relevant studies

Several studies have been conducted on the impact of economic policy uncertainty on green bonds, trying to analyze and define the correlation, impact, and implications of economic uncertainty on them. Green bonds have made a tremendous impact in financing low-carbon and climate-friendly projects (Lin & Su, 2022; Weber & Saravade, 2019). There is a nonlinear relationship, though it may be country specific, between economic policy uncertainty and green bonds over time (Wei et al., 2022). Green bonds, which are connected to the green environment, are essential financial instruments used to raise funds to sponsor projects that have minimal carbon effects and are environmentally friendly (World Bank, 2019; Ahn Tu et al., 2020).

In assessing the quality of the data, we used the Scopus database to assess articles that were published in English and in international journals between 2007 and 2023. This resulted in the exclusion of conference papers, presentation slides, book chapters, reviews, short communications and commentary, symposia, and editorial comments. Using the terms Economic AND Policy AND Uncertainty AND Green Bonds, the search yielded a total of 2,060 articles from the Scopus database. The selection process narrowed down the initial pool of articles to 561, focusing the search on the Energy and Economics, Econometrics, and Finance subject area while excluding non-article papers, non-English papers, and duplicate publications. A further screening resulted in the elimination of four hundred and ninety (490) articles, leaving seventy-one (71) articles based on the full texts assessment.

After reading the abstracts of the seventy-one (71) papers, we again excluded fifty-one (51) unrelated articles, giving us a final number of twenty (20) articles. According to our objective, the remaining twenty articles (20) were in conformity with our study after further reading their abstracts and findings; hence, no further groupings were made. Figure 2 shows how the articles were screened.
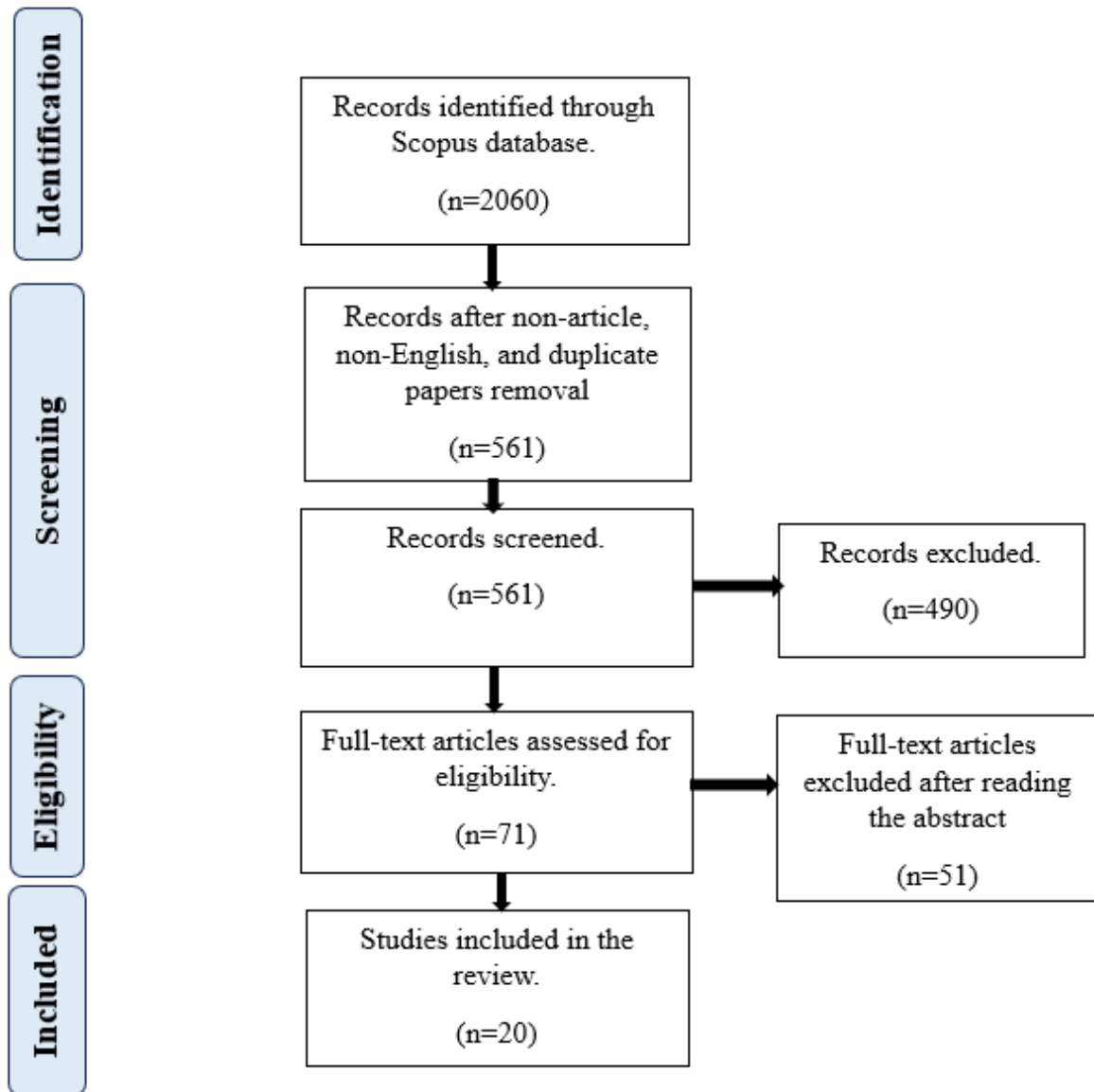

Figure 2. The systematic review methodology.

3.   Results

   In this section, we present an analysis of the literature on economic policy uncertainty and green bonds, organized around publications by journal, including their impact scores and rankings, publications categorized by year, those originating from different countries, and an examination of the methods and techniques employed in the selected papers. Our intention is to offer a comprehensive and structured overview of the field. The emphasis on reputable journals is to identify impactful

contributions on the topic. We also seek to identify temporal and geographical trends, shedding light on the evolution of research in this area from the publications by year and country. Moreover, the examination of different methods and techniques is to identify existing, emerging, and overlooked methodologies in evaluating the impact of economic policy uncertainty on green bonds. This contributes to a more profound comprehension of the existing literature on this subject.

3.1. Publication by journal

The majority of research articles were published in international journals with respect to this review. In our study, we carefully examined and narrowed down the reviewed articles to a total of 20. The specific international journals that hosted the publications on the topic under study are detailed in Table 1. Table 1 reveals interesting patterns in the distribution of published articles across various journals. Notably, Finance Research Letters stands out by having the highest number of published papers (4), showcasing its active contribution to the field. Despite publishing only one paper, Technological Forecasting and Social Change has the highest impact factor, indicating the significant influence of that single contribution. It is worth noticing that the overall ranking of the journals also played a significant role in the contributions to the field, as evidenced by the overall rank of Technological Forecasting and Social Change (ranking 657) and Environmental Science and Pollution Research (ranking 5431). Even though other journals had the highest publication rate, their impact score was relatively low as compared to the Journal of Technological Forecasting and Social Change.

Table 1. Journals where publications were made.

Name of Journal	Number of articles	Impact score	Overall Ranking
International Review of Financial Analysis	1	8	1446
International Journal of Finance and Economics	2	1.86	11553
Technological and Economic Development of Economy	1	5.57	5800
Mathematics	1	2.84	9300
Emerging Markets Finance and Trading	1	5.38	4351
Finance Research Letters	4	8.81	1239
International Journal of Financial Studies	1	2.05	13324
Environmental Science and Pollution Research	3	5.03	5431
The Quarterly Review of Economics and Finance	1	3.07	7033
Review of Economics and Finance	1	1.44	10536
Sustainability	1	4.17	7320
Economic and Political Weekly	1	0.37	13609
International Review of Managerial Finance	1	1.3	14321
Energy Policy	1	7.37	1127
Technological Forecasting and Social Change	1	11.15	657
International Review of Economics and Finance	1	3.2	6287

3.2. Publications by year

Figure 3 shows a comprehensive summary of the years covered (from 2007 through early 2023) in our analysis, along with the respective counts of publications and citations for each year. The

examination conducted indicates a significant pattern during the first 12 years, notably spanning from 2007 to 2018, where there were limited, scholarly articles pertaining to green bonds and economic policy uncertainty. However, it is worth noticing the publications in 2016, which amounted to 59 citations. In the temporal span of 2019, a notable milestone occurred when a pioneering study was undertaken by Broadstock & Cheng, (2019) to investigate the first decade of the market for green bonds. This groundbreaking research received a significant number of citations, amounting to a total of 115. Clearly, this event represented a significant turning point that indicated a notable increase in interest and involvement in this field. The increased level of attention can be attributed to a variety of circumstances, most notably the influence of the COVID-19 outbreak and the ongoing conflict between Russia and Ukraine. The occurrence of these exceptional incidents has undeniably played a role in the growing popularity and heightened academic discussion on the topic.

Figure 4 shows the cited works of the groundbreaking work by (Broadstock & Cheng, 2019) and their connectedness to other prominent papers. It is evident that (Broadstock & Cheng, 2019) is the most cited article, followed by Wang et al., (2022) and (Pham & Nguyen, 2022), as evident in the number of citations in the year 2022 shown in Figure 3. This implies that these papers have played significant roles in the impact of economic policy uncertainty on green bonds. The most cited articles based on our selection criteria are presented in Figure 5.
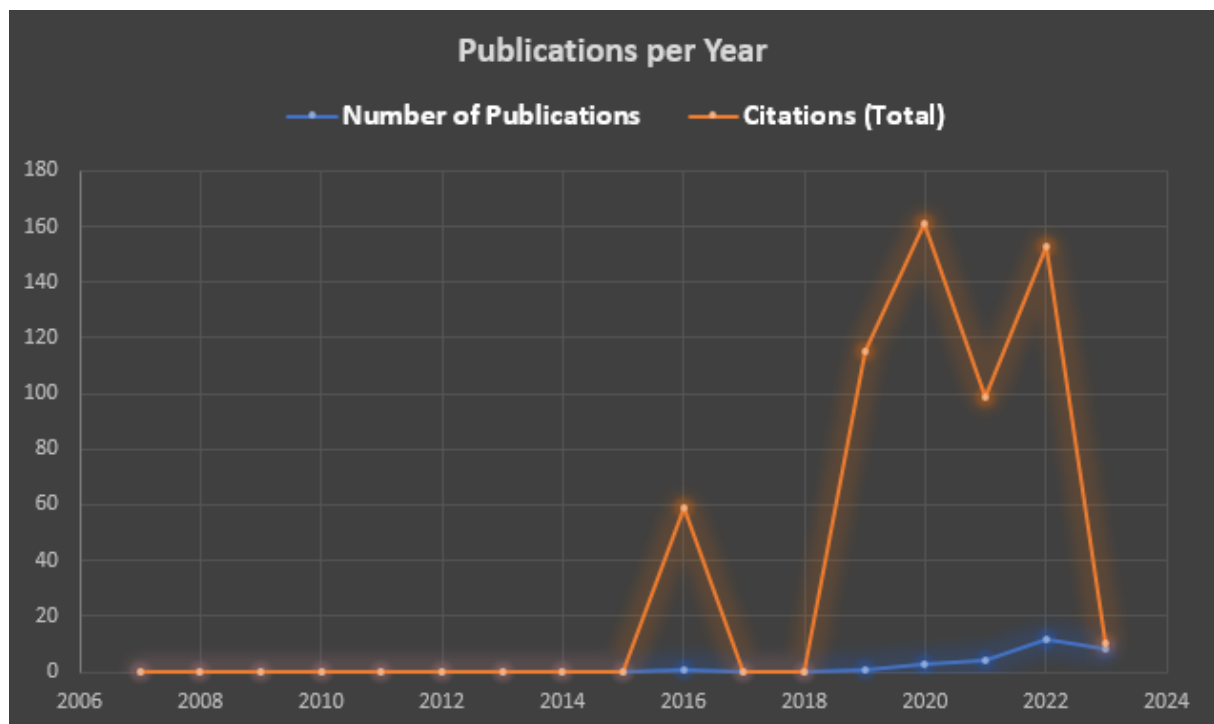

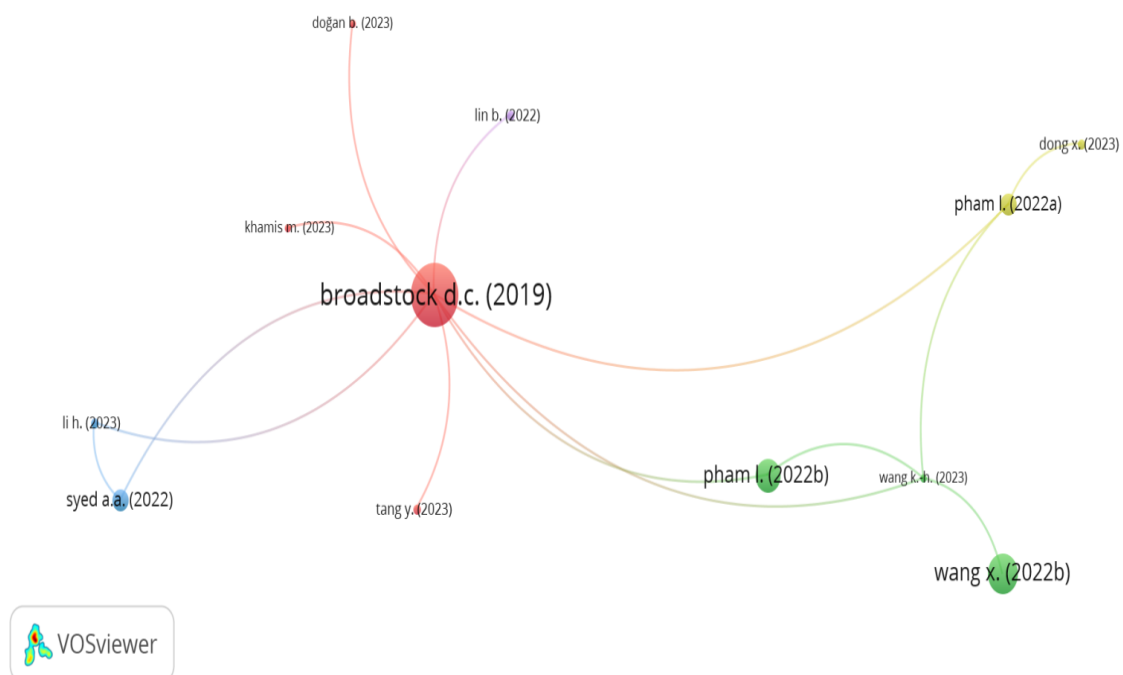**Figure 3.** Publications made per year and total citations.

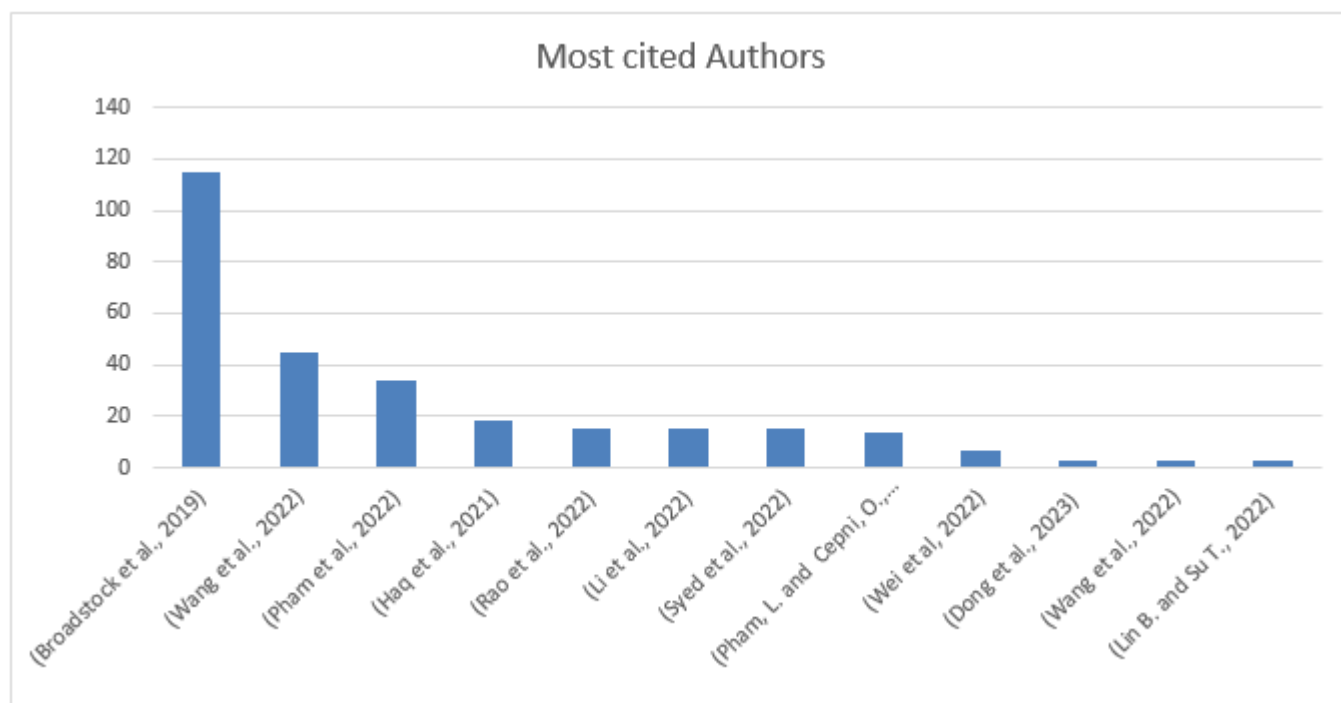**Figure 4**. Most cited papers and their connectedness.

Figure 5. Most cited authors.

3.3. Publication by Country

Table 2 shows the number of articles according to their country of origin. From the table, China emerged as a prominent contributor with the highest number of published papers (9), signifying its significant engagement and interest in the subject matter. Moreover, the substantial number of citations (208) underscores the influential nature of China's research output in shaping the discourse around economic policy uncertainty and its connection to green bonds. The robust combination of both prolific publications and substantial citations indicates that China holds a central position in driving the advancement of knowledge in this domain.

Comparatively, other countries also demonstrate noteworthy contributions. The United Kingdom, with 7 published papers and 142 citations, showcases a solid research presence and impactful contributions to the field. India, Finland, and Saudi Arabia, with varying numbers of published papers and citations, reflect their engagement and growing interest in this interdisciplinary area. While Finland and Saudi Arabia exhibit a relatively higher citation count despite a smaller number of papers, their impact could be attributed to the quality and significance of the research conducted. Collectively, these findings highlight the collaborative and global nature of research on economic policy uncertainty and green bonds, with China's comprehensive engagement indicating its pronounced influence on shaping and enriching the discourse in this evolving field.

Table 2. Countries with the most citations.

Country	Document	Citations
China	9	208
United Kingdom	7	142
India	5	103
France	4	25
Lebanon	4	75
Pakistan	4	55
United States of America	4	85
Vietnam	4	78
Russia	3	28
Tunisia	3	59
Turkey	3	69
Egypt	2	84
Finland	2	141
Saudi Arabia	2	109
Spain	2	74

3.4. Methods and techniques used

In the course of our review, it became evident that a significant portion of the examined articles relied on econometric models to gauge the influence of economic policy uncertainty on green bonds, as shown in Table 3. Notably, the quantile analysis and time varying methods emerged as the predominant choice among these approaches. The analysis reveals that economic policy uncertainty has a substantial influence on green bonds, with the magnitude of the impact contingent upon the

specific country (Pham & Nguyen, 2022; Wei et al., 2022) and subject to temporal variability (Li et al., 2023; Pham & Nguyen, 2022; Wei et al., 2022). Furthermore, scholarly works have illuminated the role of green bonds as a safe haven during periods of economic policy uncertainty (Dong et al., 2023; Haq et al., 2021; Xia et al., 2023), underscoring their crucial significance in times of instability. The techniques employed in prior studies and their corresponding findings concerning the repercussions of economic policy uncertainty on green bonds are presented comprehensively in Table 3.

Table 3. Methods used by papers and their findings.

Author	Key Methods	Impact of EPU on Green Bond
Wei et al., (2022)	Wavelet-Based Quantile Analysis	Non-linear granger causality which varies across time
Haq et al., (2021)	Dynamic Correlation Multivariate GARCH Model	Green bond act as a safe haven for EPU
Pham & Nguyen, (2022)	Markov Switching Dynamic Regression Model	Time varying and state-dependent relationship
Wei et al., (2021)	Quantile Auto-regressive Distributed Lag Model	Heterogeneous effect in different levels of green bond market efficiency
K.-H. Wang & Wang, (2023)	Dynamic Conditional Correlation-Mixed Data Sampling (DCC-MIDAS) and Quantile-on-Quantile technique	Asymmetric and often a positive impact
(Anh Tu et al., 2020)	Analytic Hierarchy Process	Green bonds are important accelerators for the green bond market
Syed et al., (2022)	Nonlinear Autoregressive Distribution Lag Estimation Technique	Positive shock result in negative impact and negative shock result in positive impact
Xia et al., (2023)	Asymmetric time-varying connectedness and EGARCH models.	Green bond act as a safe haven for EPU
Gök, (2023)	Time-varying Granger causality method	Granger-causes fluctuations in the green bonds market
Li et al., (2023)	Time-Varying parameter Vector Autoregression and Bayesian Time-Varying Parameter Vector Autoregression	Positive significant impact in the short-term on carbon price which have connection with green bond
Dong et al., (2023)	DCC-MIDAS-X model	Green bonds outperform conventional bonds as a safe haven when EPU levels are high
Tian et al., (2022)	Spillover index approach with the estimated vector autoregression model	Asymmetrical effect on China's green bond market

4. Discussions

Our results reveal that a majority of studies examining the relationship between economic policy uncertainty and green bonds are centered in China, as evident from investigations conducted by scholars such as Doğan et al. 2023, Haq et al. 2021, Li et al. 2023, Lin & Su 2023, Syed et al. 2022, and Wang et al. 2022, Wei et al. 2022. This trend is notably influenced by China's prominent standing as the global leader in the green bond market. According to data from the Statistica research department (Statista, 2023), China's issuance of green bonds surpassed 85 billion U.S. dollars in total. In a closely

contested ranking, the United States secured the second position with green bonds worth 64.4 billion U.S. dollars issued. Noteworthy is Germany, ranking third and acclaimed as the premier European nation on the list, with a release of 61.2 billion U.S. dollars' worth of green bonds in 2022. Despite the United States and Germany boasting higher volumes of green bond issuance, their academic contributions to understanding the impact of economic policy uncertainty on green bonds remain relatively limited. This phenomenon, however, can be attributed to prevailing policy orientations within these nations.

From our analysis, the emergence of research papers exploring the implications of economic policy uncertainty experienced a notable upsurge from 2019 onwards, a trend closely linked to the global ramifications of the COVID-19 pandemic and the escalating tensions surrounding the Russia-Ukraine conflict (Tang et al., 2023; Wang & Wang, 2023; Xia et al., 2023). The unprecedented disruptions caused by these events undoubtedly sparked heightened scholarly interest in comprehending the intricate interplay between economic policy uncertainty and its effects on various aspects of financial markets, investments, and economic stability. As such, the timing of this surge in academic contributions serves as a testament to the real-world impact of geopolitical and macroeconomic events on shaping research agendas and priorities within the field.

5. Conclusions

In conclusion, our finding shows that a lot of research has been carried out on the impact of economic policy uncertainty on green bonds using various methods and techniques. The most dominant method deployed is the quantile analysis method. We used Scopus to select the related literature, of which we included 20 related articles that were relevant for the study, spanning from 2007 to 2023. The year in which most publications were made was 2019, which suggests that more publications are being done in recent times where most of the papers are published in China. The countries of origin of the articles with the most citations include China, the United Kingdom, India, France, Lebanon, and Pakistan, but based on the published papers and their citations, Finland is noted as the country that produced the relatively high-quality papers compared to the other countries. Additionally, we found that most of the articles were from popular journals, including the International Journal of Finance and Economics, Finance Research Letters, International Journal of Finance and Economics, and The Technological Forecasting and Social Change, which have high rankings. It is worth noting that a substantial number of recent research papers have utilized econometric methodologies, underscoring their effectiveness. Nevertheless, we propose that forthcoming investigations also delve into the potential of machine learning techniques to assess the ramifications of economic policy uncertainty, given their adeptness in handling nonlinear datasets.

Considering the search conducted in early 2023, it is crucial to recognize that the research outcomes and interpretations in this paper may be constrained by the dynamic nature of the field. Future developments might offer further perspectives on the connection between economic policy uncertainty and green bonds. Another potential limitation is the exclusion of papers from different subject areas, as relevant publications might not be encompassed in this study. Following this analysis, the findings suggest a potential avenue for future research, as outlined in Table 4.

Table 4. Future research directions.

Direction	Explanation	Useful Papers
Temporal Analysis	Conduct a detailed temporal analysis to understand how economic policy uncertainty's impact evolves over time. Consider the pre-COVID-19, during, post-COVID-19, and other geopolitical events.	(Chakrabarti et al., 2021; Hannan & Tuma, 1979)
Applications of Machine Learning	Explore the potential of machine learning techniques in assessing the impact of economic policy uncertainty on green bonds. Evaluate their effectiveness in handling nonlinear datasets.	(Gyamerah et al., 2023; Kocaarslan & Soytas, 2023)
Influence of macroeconomic events	Investigate how other macroeconomic events other than the COVID 19 and geopolitical conflicts impact economic policy uncertainty and how it subsequently influences the green bond market.	(Doğan et al., 2023)
The Israel-Hamas War	The short- and long-term impact of the recent Israel-Hamas war on economic policy uncertainty is also an interesting avenue for exploration	(Samuel, 2023)

Use of AI tools declaration

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflicts of interest.

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