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A Bibliomatric Analysis on Carbon Trading and Analysing Current Research Trends

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Abstract
Carbon trading paves a new way to reduce global greenhouse gas emission. This concept allows us to trade carbon credit in the carbon market. This study conducts a detailed bibliometric analysis spanning the years 2000 to 2023, aiming to unravel the intricate landscape of carbon trading. Employing Biblioshiny in R Studio and VOS viewer, data sourced from Scopus is meticulously analyzed to discern trends and identify influential entities within the field. Noteworthy findings include a consistent upward trend in annual scientific production, indicative of a growing scholarly interest in carbon trading. The Journal of Cleaner Production emerges as a central repository of knowledge, while authors such as Wang X and Zhang Y stand out for their significant contributions, with Wang X particularly distinguished by a notable H-index. Geographically, China emerges as a key player, reflecting its pivotal role in driving research in this domain. Thematic analysis reveals critical areas of focus, such as carbon emissions and emission trading, alongside emerging interests in topics like total factor productivity and the green economy. Important studies, like those by Chaabane (2012), have a significant impact, and group efforts, like those by Chen Y. The paves a new way to reduce global research landscape of carbon trading and provide future research direction.

Keywords: carbon trading, bibliometric analysis, thematic analysis, Co-occurrence analysis, Citation analysis.

Introduction

Carbon trading was introduced in Kyoto protocol (1997). Trading of carbon credit or certified emission reduction is known as carbon trading. The carbon market is the platform for carbon trading. Carbon markets are an important tool in the worldwide battle against climate change. These trading platforms make it easier to exchange carbon credits, which are an important instrument for reducing greenhouse gas emissions. Carbon markets are crucial in the worldwide effort to tackle climate change, and they are essentially classified into two types: compliance and voluntary. In response to national, regional, or worldwide rules and regulations, compliance markets are developed, resulting in an organized framework for managing greenhouse gas emissions. Carbon trading programmes, (Chaabane et al., 2012) offer a sustainable supply chain framework, highlighting the necessity of effective carbon management techniques to meet sustainability goals within a budget.

The studies about carbon trading are abundant in literature. It is important to understand the research landscape of carbon trading. This will help to give an insight into the academic activities in this area and also helps to understand the future direction of carbon trading research. This study aims to conduct a

detailed bibliometric analysis for a period from 2000 to 2023, aiming to unravel the intricate landscape of carbon trading. Employing Biblioshiny in R Studio and VOS viewer, data sourced from Scopus is meticulously analyzed to discern trends and identify influential entities within the field. Bibliometric analysis is a non-reactive tool to study research collaboration(Subramanyam, 1983).

Review of literature

The body of knowledge regarding bibliometric studies and tools provides an in-depth summary of how research collaboration and analytic approaches are changing. The growing tendency of joint efforts in scientific research is highlighted in (Subramanyam, 1983) review, which also emphasises the use of bibliometric methods as non-reactive instruments to analyse collaboration dynamics. Notably, past research that Subramanyam's work cites shows a strong relationship between research productivity and collaboration, highlighting the significance of cooperative efforts in the advancement of scientific knowledge. The study of (Aria & Cuccurullo, 2017) presents bibliometrix, an R-tool designed for in-depth science mapping analysis. By providing an integrated workflow, this open-source application helps researchers perform intricate bibliometric analyses more easily, which advances the area of bibliometrics. The study by (Linnenluecke et al., 2020) provides additional insight into the usefulness of bibliometrix, highlighting its versatility as an open-source R-programmed tool and its assistance for science mapping. Their research highlights the value of bibliometrix in examining and illustrating the composition and development of scientific disciplines. Guidelines for conducting bibliometric analyses are provided by (Donthu et al., 2021), with a focus on the significance of methodological rigour and thorough literature reviews. In addition to providing thorough methodological procedures for performing systematic literature reviews and bibliometric analyses, their work exposes the difficulties faced by researchers in navigating the large body of academic information. This ensures replicability and scientific rigour in research endeavours. When taken as a whole, these works increase our understanding of research cooperation and analysis procedures and help to spread knowledge and progress academic study.

The literature on emissions trading provides insightful information on a range of topics, including governance frameworks, policy formulation, and the effects on the environment and business. In his discussion of the creation of the European Union Emissions Trading Scheme (EU ETS), (Braun, 2009) credits a loosely organised policy network made up of professionals from many industries. This network promoted information exchange and shaped the plan; certain members of DG Environment were recognised as policy entrepreneurs. According to (Clarkson et al., 2015), which examine the valuation relevance of greenhouse gas emissions under the EU ETS, allocation deficits are negatively correlated with valuation, whereas carbon allowances for enterprises have no discernible effect on it. The significance of taking regulatory implications into account for upcoming research and company disclosure policies is highlighted by their findings. The impact of carbon pricing and emissions trading on supply chain performance is highlighted by (Zakeri et al., 2015), who offer a supply chain perspective on these policies. According to their analysis, carbon pricing may not always result in the best supply chain results; this has ramifications for the formulation and application of policy. In their 2008 study, (Bumpus & Liverman, 2008) compare voluntary carbon offsets with programmes such as the Clean Development Mechanism to examine the governance of global carbon offsets. They shed light on how economic geography and market environmentalism have shaped the governance frameworks for carbon offsets and provide an understanding of the intricacies of global climate policies. Considering emissions trading programmes, (Chaabane et al., 2012) offer a sustainable supply chain framework, highlighting the

necessity of effective carbon management techniques to meet sustainability goals within a budget. Finally, (Chen et al., 2021) investigate how China's carbon emission trading plan affects green innovation in businesses. They find conflicting results, including a notable decline in green patents and a lagging influence on innovation, especially in some industries and geographical areas. All these studies add to a thorough knowledge of carbon trading programmes, their effects, and possible directions for further investigation and policy creation.

Research Objectives

1. To analyze the bibliometric information of the field of carbon trading
2. To explore the most cited sources, journals, authors, countries, references, and trends in the field of carbon trading.

Methodology

Bibliometric information of the field carbon trading is analyzed using Biblioshiny in R studio and VOS viewer, taking secondary data from Scopus in a suitable format for the period from 2000-2023 and then merged into a single CSV file for analyzing in Bilioshiny and VOS viewer.

Search procedure and filters applied.

Data was collected from the Scopus database. The research keywords – “Carbon trading” OR “Emission trading” OR “Emission allowance trading” OR “Carbon offset”. Data was collected for a period from 2000 to 2023 in English. 4177 Documents were obtained from Scopus. Then Documents were filtered using filtering strategies such as document type, source, publication stage. The study only used document types like articles and articles in final stage of publications. Documents such as books, book chapters, conference papers and other document types are excluded from the study. After applying filtering of dataset 1141 documents were finally extracted.

Table 1: MAIN INFORMATION ABOUT DATA

Description	Results
Timespan	2000:2023
Sources (Journals, Books, etc)	374
Documents	1141
Annual Growth Rate %	14.19
Document Average Age	7.7
Average citations per doc	25.74
References	45734
DOCUMENT CONTENTS	
Keywords Plus (ID)	2916
Author's Keywords (DE)	2601
AUTHORS	
Authors	2058
Authors of single-authored docs	244
AUTHORS COLLABORATION	

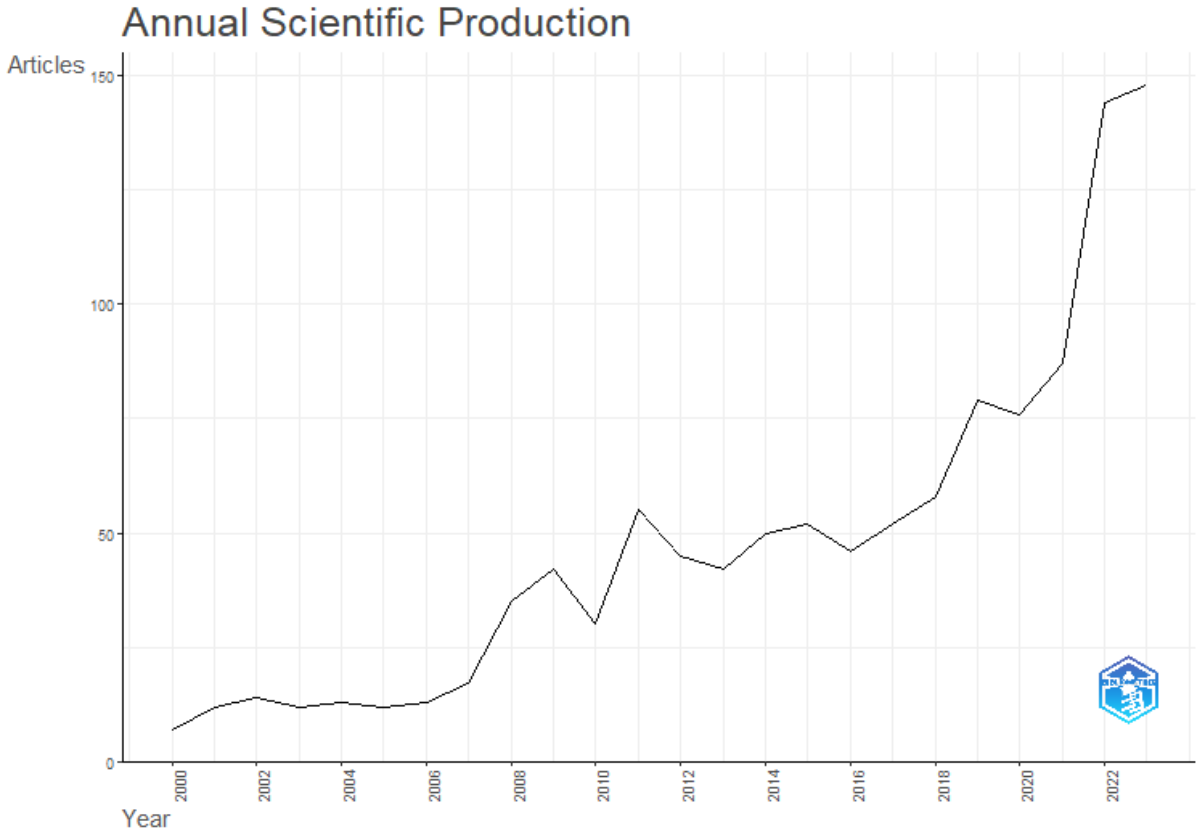
Single-authored docs	267
Co-Authors per Doc	2.69
International co-authorships %	22.52
DOCUMENT TYPES	
article	1141

Result and Discussion

Annual scientific production

Figure 1 shows the annual scientific production of articles. The number of publications was 7 in 2000, over the years there are fluctuations in annual publications. There is a general upward trend in the number of publications annually. The maximum number of publications (148) was in 2023, followed by 2022(144).

Figure 1

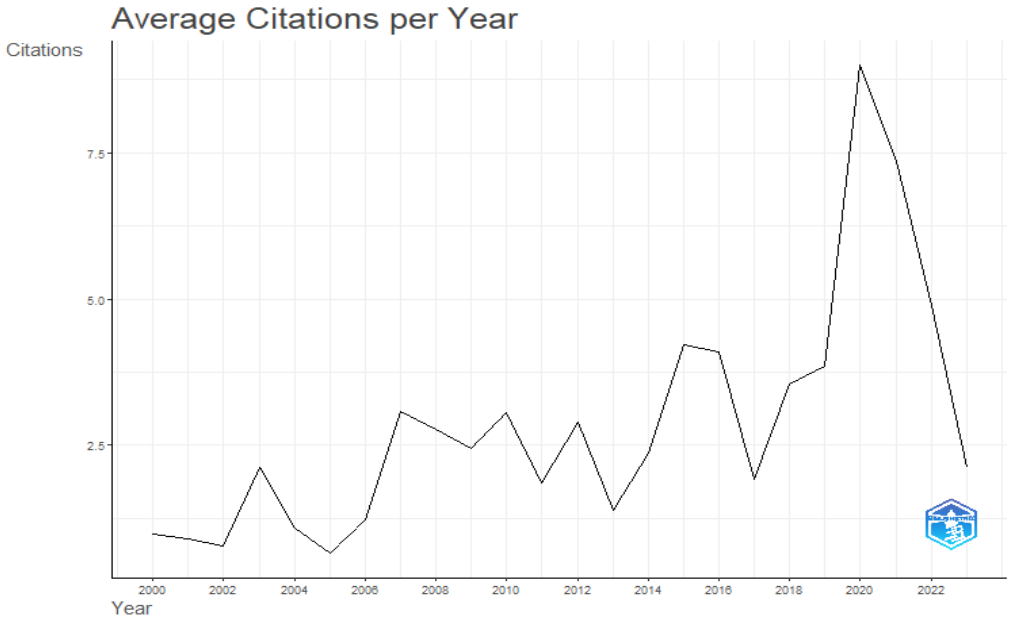


Source*: Bibliometrix*

Average citation per year

Figure 2 shows the average citation of articles per year.2021 recorded the highest average citation per article followed by 2022. 2005 recorded the least cited per article.

Figure 2



Source*: Bibliometrix*

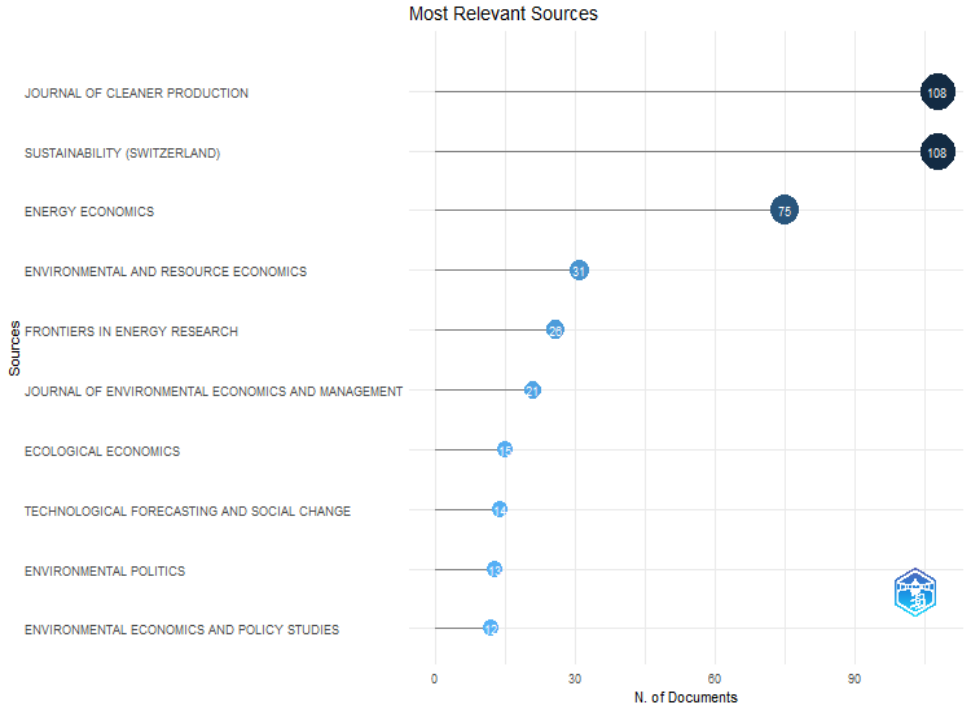
Sources

Explored the most important and cited source to identify the most prominent journal in this area.

Most relevant source

Figure 3 shows the top 10 relevant sources publishing article on carbon trading. Journal of cleaner production and sustainability (Switzerland) have the highest number of articles (108), followed by energy economics (75).

Figure 3



Source*: Bibliometrix*

Source impact factor.

H-index is used to measure the productivity and impact of source. Figure 4 shows the H index source impact factor of the top 10 sources. The Journal of cleaner production has the highest impact factor (39) followed by energy economics (35). The sustainability (Switzerland) is in the 3rd position having H index 18. This shows that article published in The Journal of cleaner production were cited more than other journals.

Figure 4

Source*: Bibliometrix*

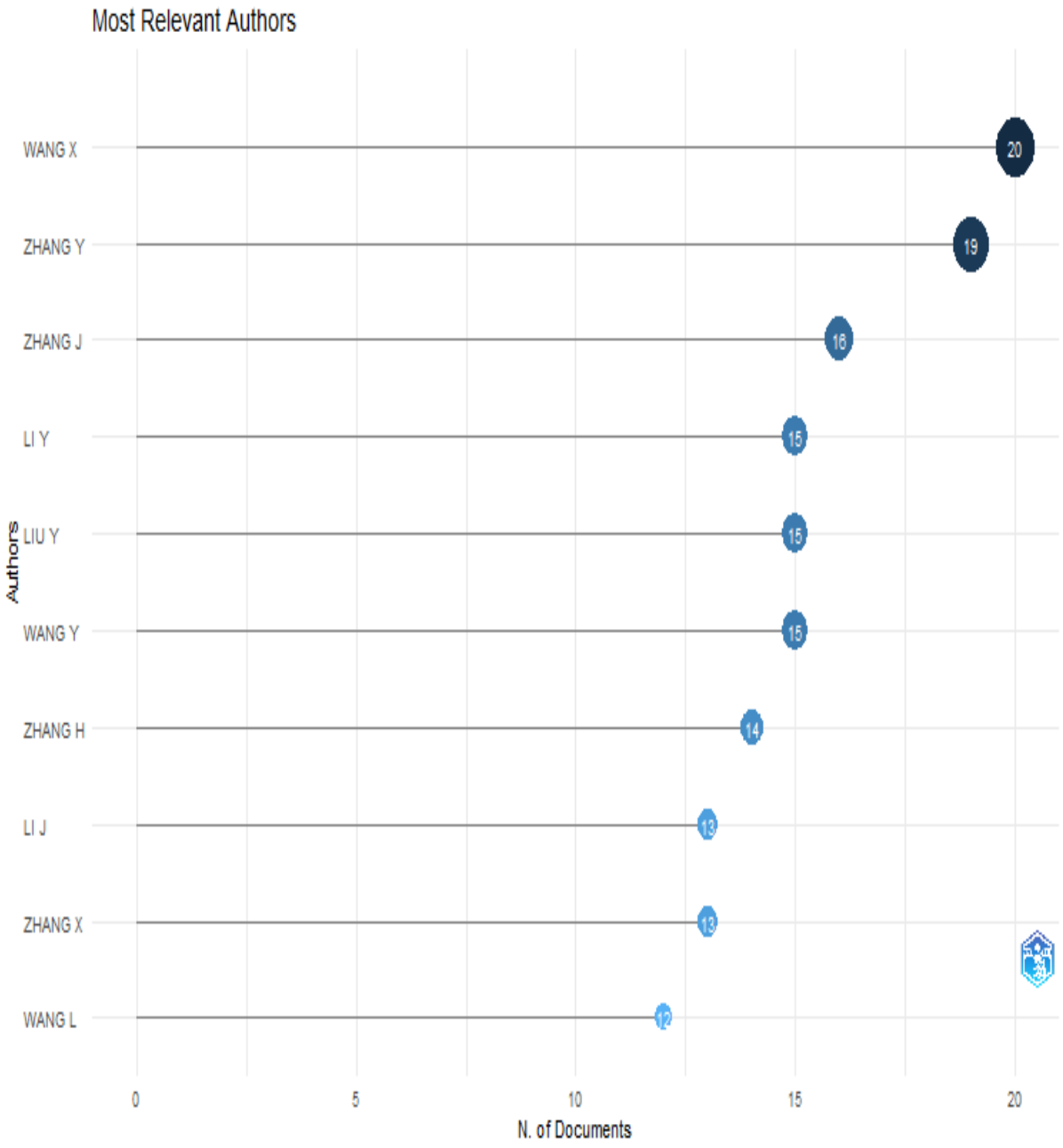
Authors

To find out the most prominent authors, analyzed authors with the highest number of publications and citations.

Most relevant authors

Figure 5 exhibits the top 10 most relevant authors on the carbon trading area from 2020 to 2023. WANG X has the highest number of publications (20) in this area followed by ZHANG Y with 19 publications. ZHANG J has 16 publications and LI Y has 15 publications.

Figure 5

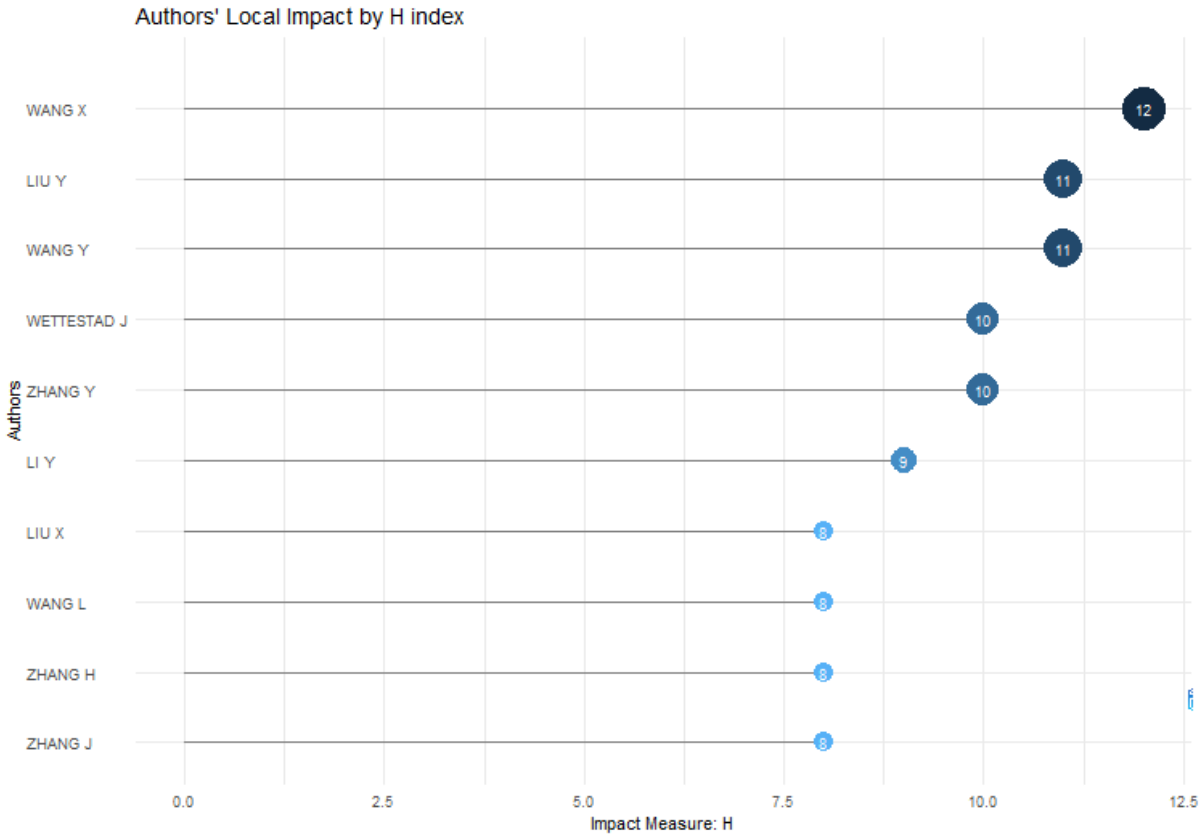


Source*: Bibliometrix*

Authors local impact by H – index

H – index used to measure the productivity and impact of authors works. Figure 6 shows the H – index of top 10 authors. Wang X has the highest H – index, he is the most impactful author. Liu Y, Wang Y and Wettestad J are the most impactful authors.

Figure 6



Source*: Bibliometrix*

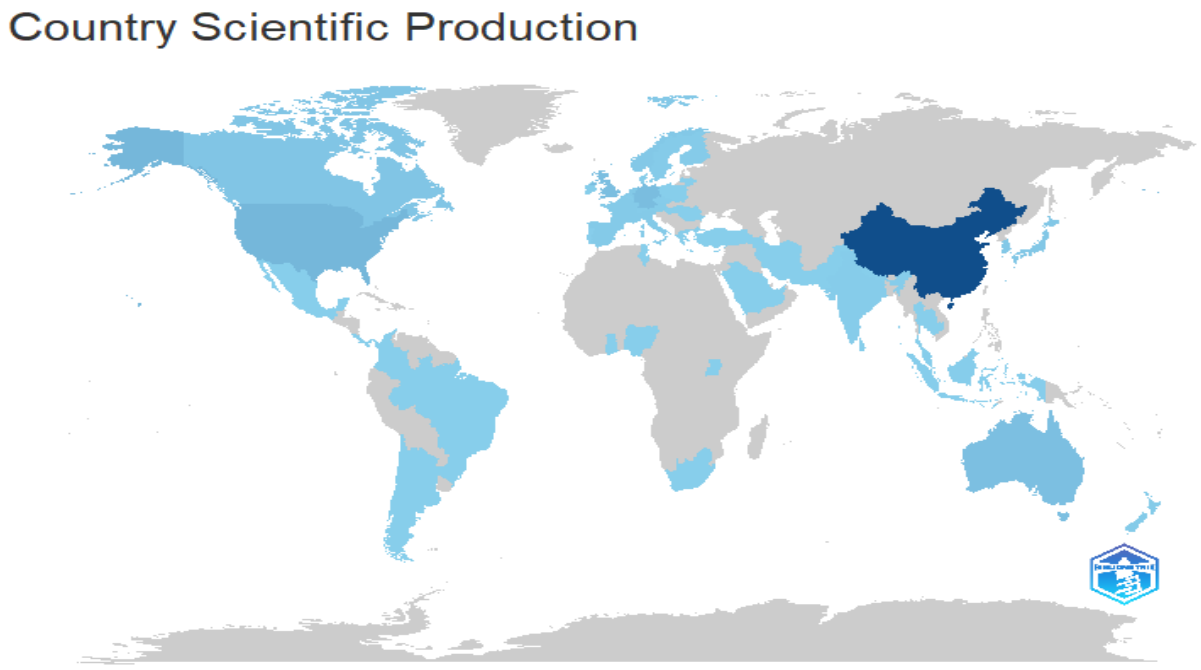
Countries scientific production

Table 2 indicate the countries having the highest number of studies in carbon trading. China had the highest number of studies (1425), which is far higher than the other countries. USA is in 2nd position with 243 studies, followed by Germany (179), UK (163).

Table 2

Countries	Frequency
CHINA	1425
USA	243
GERMANY	179
UK	163
AUSTRALIA	152
CANADA	90
JAPAN	72
NORWAY	62
SOUTH KOREA	60
NETHERLANDS	52

Figure 7



Source*: Bibliometrix*

Most cited countries

Table 3 indicate the total citation of countries. China got the highest citation (10497) followed by the United Kingdom (2550), Germany (2014), USA(1804) and Canada(1166).

Table 3

Country	Total Citation
CHINA	10497
UNITED KINGDOM	2550
GERMANY	2014
USA	1804
CANADA	1166
NORWAY	836
FRANCE	780
AUSTRALIA	694
ITALY	600
NETHERLANDS	530

Most frequent keyword

Figure 7 is a Tree map which shows the most frequent key words in the studies analysed. “Emission trading” was the most frequent word with 590 (13%) occurrences. The word Emission control was used 413(9%) times. “Carbon emissions” (6%) and “carbon” (6%) was also used frequently.

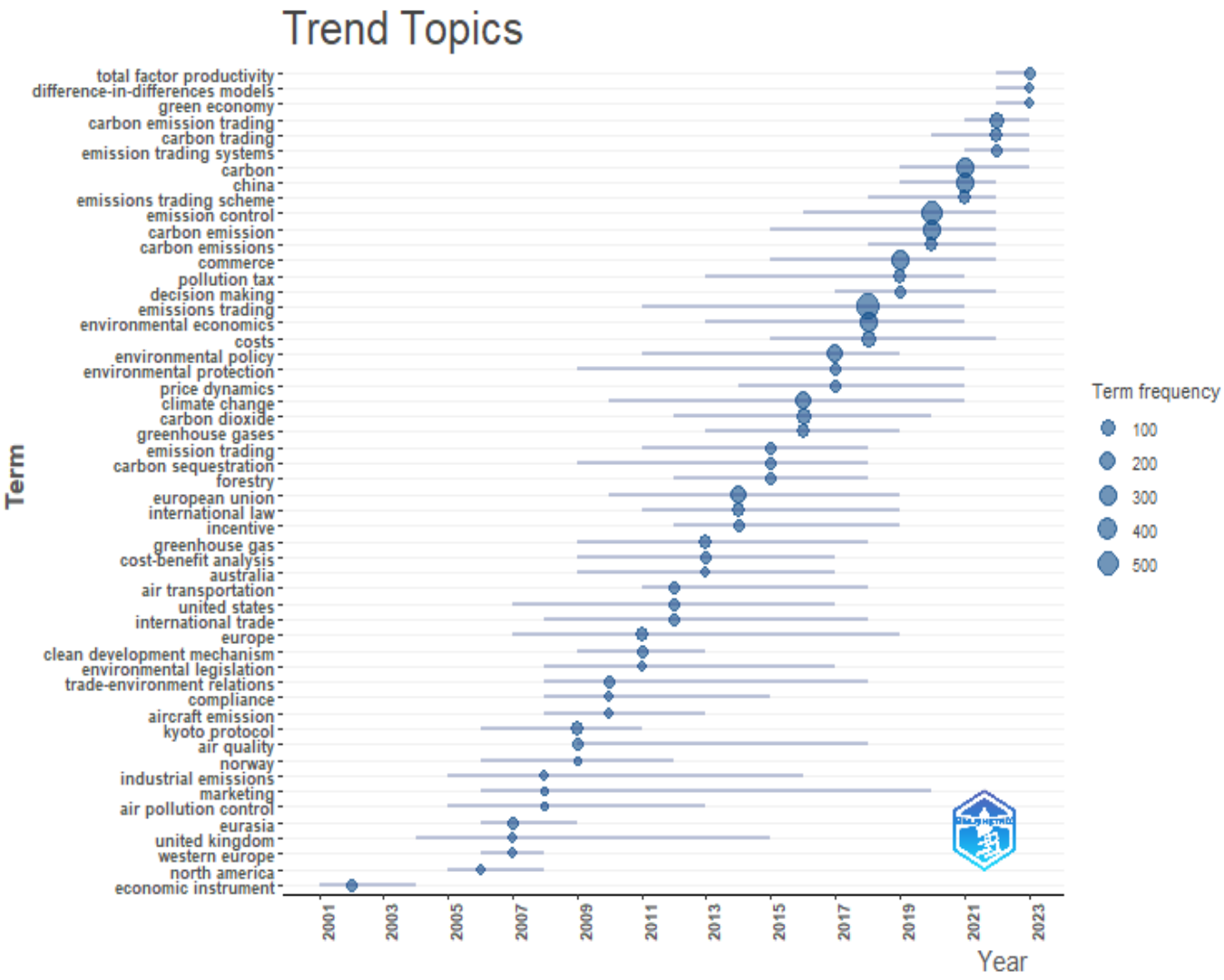
Figure 7

Source*: Bibliometrix*

Trend topics - keywords

Figure 8 depicts the trendiest topics in each year in carbon trading research. In 2023 total factor productivity (19), difference-in-differences models (16) and green economy (9) were the most frequent topics. In 2022 the topics such as "carbon emission trading" (88), "carbon trading" (59) and "emission trading system" were used frequently. "carbon" (251), "China" (219) and "Emission trading scheme" were most frequently used topics.

Figure 8



Source*: Bibliometrix*

Co-occurrence analysis

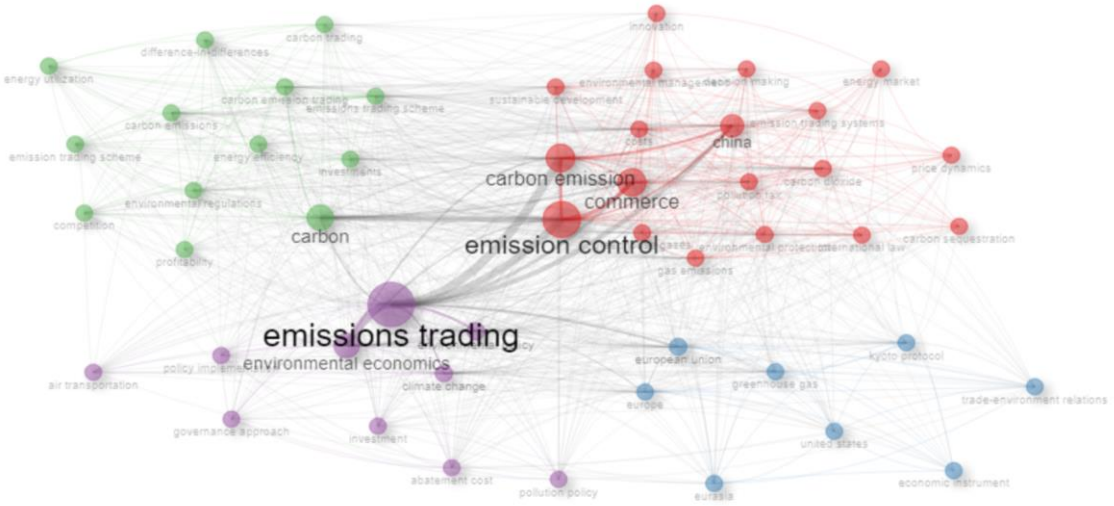
In bibliometrics, cooccurrence analysis is a potent technique for identifying the conceptual framework of academic literature, finding relationships between terms and concepts, and revealing patterns that can guide future research and investigation.

keyword co-occurrence network

Figure 9 shows the keyword co-occurrence network. A "keyword co-occurrence network" illustrates the connections between keywords according to how frequently they appear together in a corpus of documents. The network depicts each keyword as a node, with the edges, or connections, between nodes signifying the frequency with which the keywords occur in tandem inside the same documents.

The terms emissions control, carbon emissions, commerce, and related environmental and economic concepts are central and influential within the network. These terms likely represent important topics or themes within the scholarly domain under analysis.

Figure 9



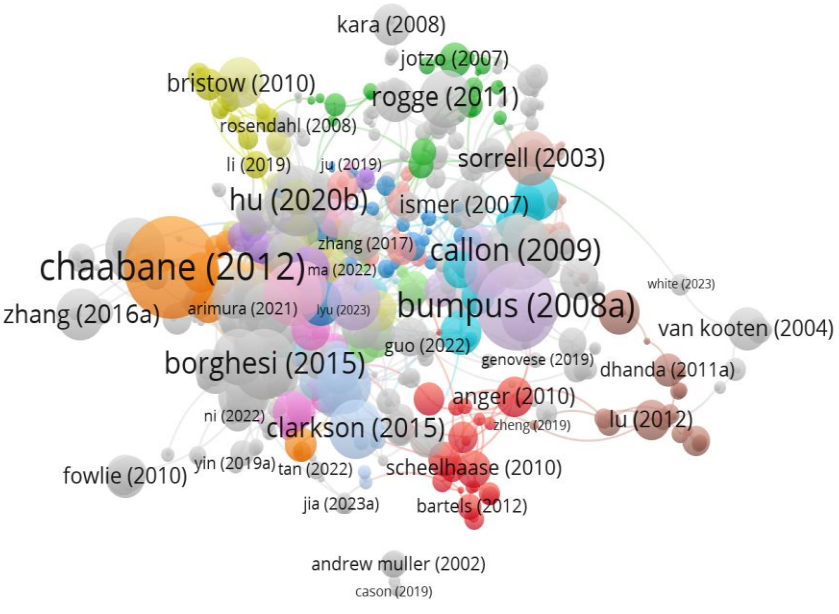
Source*: Bibliometrix*

Citation analysis

In bibliometrics and scient metrics, citation analysis is a technique used to assess the influence, applicability, and relationships between academic publications in a certain topic or discipline. It entails examining the citations found in scholarly works to determine how and why particular publications are cited by other academics. Citation analysis is a useful tool for understanding the structure and development of intellectual networks, as well as the impact of certain authors, journals, or study areas**.**

Figure 10 shows the most cited documents in carbon trading. The document of Chaabane (2012) has the highest number of citation (665). The second highest citation was in the article of Bumpus (2008). The document of Callon (2009) got 351 citation and Borghesi (2015) got 321 citations for their articles.

Figure 10

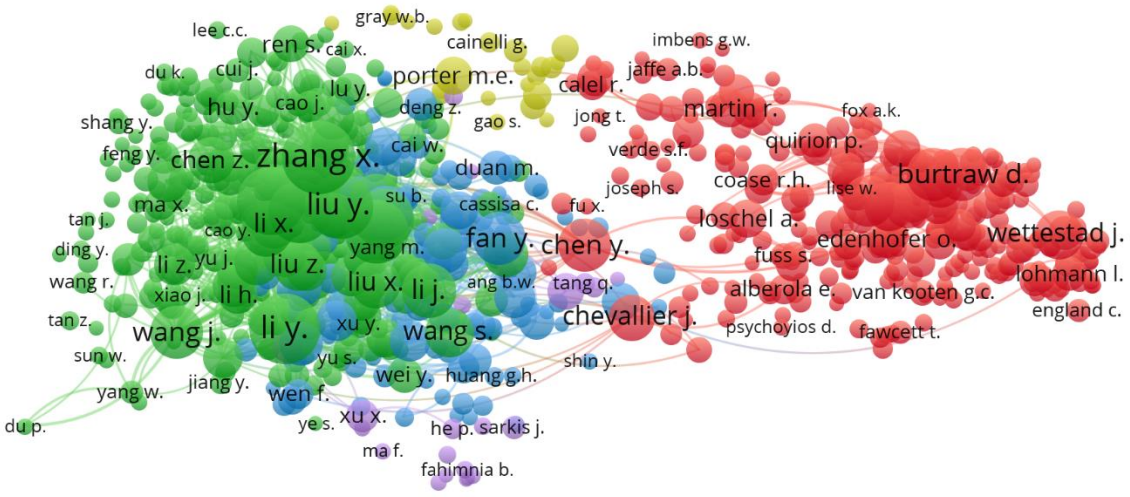


Co citation of authors

Co citation of authors is a type of bibliometric analysis. This technique determines the relationships between authors by looking at how frequently other authors quote them together. This helps to gain insight into the structure of literature, identify influential authors and explore the pattern of collaboration within this area.

Figure 9 indicates the co citation author's network. Each node represents authors and size of node shows the number of citations they received. In this network there are 781 authors within 5 clusters. In cluster 1 Chen y had the highest link with other authors. In cluster 2 Liu y and Wang y had the highest citation with other authors.

Figure 9- Authors co citation network



Conclusion

The thorough examination of bibliometric data about carbon trading sheds light on several aspects of academic activity in this area. The annual scientific production trend that has been shown to be increasing over time highlights a growing interest and activity, with notable peaks in recent years. The Journal of Cleaner Production stands out as a crucial resource due to its high impact factor and publication volume, which demonstrate its importance in spreading knowledge on carbon trading. Writers like Wang X and Zhang Y are notable for their significant contributions; the H-index indicates that Wang X has had a particularly notable impact. China stands out as a leading producer of science geographically, which is not surprising given its critical role in promoting the field's research. Terms such as "carbon emissions" and "emission trading" denote important themes. The trend analysis shows increasing interest towards topics such as total factor productivity and green economy. In citation analysis the paper of Chaabane (2012) has the most referenced paper in carbon trading, according to the research, demonstrating its considerable influence. In co-citation clusters, Chen Y takes the lead, although Liu Y and Wang Y also have a significant impact. These results highlight the value of collaboration and its major influence on the discourse and future directions of the field's study.

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