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Carbon Market: Recent and Future Research[1]

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Abstract
The carbon market is an intricate topic that necessitates in-depth examination, including the formation of carbon market price and the assurance of carbon market securities. This study employs bibliometric analysis of 5,589 papers in the domains of business, management, economics, and finance sourced from the Scopus database. Low-carbon investment, blockchain and climate finance, carbon market value, the shift to low carbon, and the economic elements needed to reach zero carbon have received little scholarly attention. Green innovation and carbon performance are closely related to green investment and financing, making them important to research. The ongoing and upcoming research areas encompass the sustainable shift towards renewable energy and the assessment of market worth in the carbon market. Monetary policy and market dominance in the carbon market could promote carbon market research. Determining carbon market pricing and finding regions for green bond transactions are also possible.

Keywords: Carbon valuation, carbon financing, carbon market ecosystem

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Karbon Piyasası: Yeni ve Gelecek Araştırmalar

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Özet

Karbon piyasası, karbon piyasası fiyatının oluşumu ve karbon piyasası menkul kıymetlerinin güvence altına alınması da dahil olmak üzere derinlemesine inceleme gerektiren karmaşık bir konudur. Bu çalışmada, Scopus veri tabanından elde edilen işletme, yönetim, ekonomi ve finans alanlarındaki 5.589 makalenin bibliyometrik analizi kullanılmıştır. Düşük karbonlu yatırım, blok zinciri ve iklim finansmanı, karbon piyasası değeri, düşük karbona geçiş ve sıfır karbona ulaşmak için gereken ekonomik unsurlar akademik olarak çok az ilgi görmüştür. Yeşil inovasyon ve karbon performansının yeşil yatırım ve finansmanla yakından ilişkili olması, bu konuları araştırma açısından önemli kılmaktadır. Devam eden ve gelecekteki araştırma alanları, yenilenebilir enerjiye doğru sürdürülebilir geçişi ve karbon piyasasında piyasa değerinin değerlendirilmesini kapsamaktadır. Karbon piyasasında para politikası ve piyasa hakimiyeti, karbon piyasası araştırmalarını teşvik edebilir. Karbon piyasası fiyatlandırmasının belirlenmesi ve yeşil tahvil işlemleri için bölgeler bulunması da olabilmektedir.

Anahtar Kelimeler: Karbon değerleme, karbon finansmanı, karbon piyasası ekosistemi

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1. INTRODUCTION

A carbon market is a distinct financial market that facilitates the trading of carbon credits. Carbon credits are essentially licenses that grant the buyer the right to release a specific quantity of carbon dioxide or other greenhouse gas. Several carbon markets are administered and supervised by governmental or international entities, mandating specific industries to partake, while others are completely discretionary.

According to the CO_2 Emissions in 2022 report, it has been indicated that in the midst of the global energy crisis, there has been a notable shift from natural gas to coal. Consequently, there has been a year-on-year increase of 1.6% in CO_2 emissions from coal, reaching an approximate value of 15.5 gigatons. Exhibiting a growth rate that significantly surpasses the average observed over the past decade, reaching an unprecedented peak. The emissions derived from petroleum experienced a year-on-year increase of 2.5%, reaching a total of 11.2 gigatons. Approximately 50% of the overall growth can be attributed to the aviation sector.

In the year 2022, it is anticipated that there will be a reduction in carbon dioxide (CO_2) emissions resulting from the combustion of natural gas and various industrial processes. The year-on-year decline in natural gas emissions amounted to 1.6%, which can be attributed to the tightening of gas supplies resulting from Russia's invasion of Ukraine. The decrease in emissions of natural gas is notably significant in the European region, with a reduction of 13.5%. The Asia Pacific region also witnessed an unparalleled reduction in natural gas emissions, amounting to a decline of 1.8%. Industrial emissions decreased by 1.7% year-on-year, reflecting the downturn in the manufacturing sector across various regions. Notably, China witnessed a 10% reduction in cement production and a 2% decrease in steel production, contributing to this decline.

In a 2023 research, Morgan Stanley, an investment firm, predicts that the voluntary carbon-offsets market will experience significant growth, increasing from approximately $2 billion in 2022 to an estimated $100 billion in 2030 and around $250 billion by 2050. The Boston Consulting Group takes a more prudent approach in its projections, anticipating a market size of $10 billion to $40 billion by 2030 (Regional Greenhouse Gas Initiative, 2023). However, it also anticipates a substantial increase in demand, as shown by a study of company executives. One factor is the increasing number of organizations who are establishing net-zero emissions goals and acquiring more offsets to achieve them. Additionally, the implementation of enhanced monitoring, reporting, and verification procedures would instill buyers with a higher level of assurance that their funds are being allocated as intended. Simultaneously, the compliance market, which is currently significantly larger than the voluntary market, is also expanding due to the increasing number of nations implementing cap and trade programs or broadening the scope of industries subject to these regulations.

Based on data provided by the International Energy Agency (IEA), it is projected that carbon dioxide (CO_2) emissions resulting from energy combustion and global industrial activities will attain a magnitude of 36.8 gigatons by the year 2022. The projected increase in emissions is estimated to be approximately 0.5 gigatons, surpassing the previous historical record set in 2021. According to the International Energy Agency (IEA), the primary sources of the projected rise in emissions in 2022 will predominantly stem from the combustion of coal and oil.

Greenhouse gas emissions are universally acknowledged as a significant catalyst for global warming and its detrimental consequences worldwide. Carbon markets establish a monetary value for emissions, incentivizing nations and corporations to decrease their emissions gradually and imposing financial penalties on those who exceed their allocated emissions. According to The World Bank, carbon markets facilitate the allocation of resources and cost reduction, allowing countries and corporations to effectively transition to a low-carbon economy (The World Bank,

2022). A carbon market is a distinct financial market that facilitates the trading of carbon credits (World Economic Forum, 2023). Carbon credits are essentially licences that grant the buyer the right to release a specific quantity of carbon dioxide or other greenhouse gas. Several carbon markets are administered and supervised by governmental or international entities, mandating specific industries to partake, while others are completely discretionary. The purchasers of carbon credits or allowances primarily consist of industries, countries, or companies that exhibit substantial carbon emissions due to their reliance on fossil fuels or extensive energy consumption. Examples of industries that contribute to environmental pollution include steel factories, coal-fired power plants, gas power plants, data centers, and the transportation sector (World Economic Forum, 2023).

The entities engaged in the sale of carbon credits encompass both corporate entities and nations, whose operations either possess the capacity to sequester carbon dioxide emissions or generate minimal quantities of carbon dioxide. Some examples of environmentally conscious initiatives include companies focused on forest conservation, as well as the implementation of renewable energy generation through solar power plants (PLTS), wind power plants (PLTB), and organic waste processing activities. The immediate trading of carbon credits is not feasible. The certification of traded carbon credits is a requirement that must be fulfilled by international certification bodies, such as Verra and Gold Standard.

Carbon credits are exchanged within both the voluntary and mandatory carbon markets. The government does not currently regulate trading in the voluntary carbon market. Within the voluntary market, emitters engage in the practice of offsetting their carbon dioxide (CO_2) emissions by procuring carbon credits from projects specifically designed to mitigate or eradicate CO_2 emissions. Transactions can take place either through direct interaction between buyers and sellers or with the involvement of intermediaries such as brokers. Carbon trading refers to the commercial exchange of certifications or permits that grant the right to emit a specific quantity of carbon dioxide (CO_2) or other greenhouse gas emissions. Carbon release certification or permits, commonly referred to as carbon credits or carbon emission quotas (allowances), are additional terms used to describe these mechanisms. Carbon dioxide (CO_2) emissions arise from various sources, including the combustion of fossil fuels (such as coal, gas, and oil), the combustion of forests, and the decomposition of organic waste. The carbon trading mechanism is a method of emissions reduction that was established by the United Nations (UN) climate agreement, known as the Kyoto Protocol, on 11 December 1997. It is one of three approaches outlined in the agreement for the purpose of reducing emissions.

Based on the "State and Trends of Carbon Pricing 2023" report published by the World Bank on May 23rd, it is presently observed that approximately 23 percent of worldwide greenhouse gas emissions are encompassed by a total of 73 carbon reduction mechanisms. These mechanisms include both emissions trading systems (ETS) and carbon taxes. The current level of coverage has increased from 7 percent, which was observed a decade ago at the time of the report's initiation by the World Bank. According to the World Bank, global revenues generated from carbon taxes and emissions trading systems (ETS) are projected to reach a record high of $95 billion in 2022. In the present year, several nations, namely Australia, Indonesia, Malaysia, and Vietnam, have planned to initiate carbon markets utilizing the Emissions Trading System (ETS).

A nation that decreases emissions below the specified threshold can offer a surplus for sale. Unutilized emissions are quantified in metric tons of carbon dioxide equivalent (CO2). Other countries or firms who fail to reach their targets might buy one-ton units of CO2 to compensate for the emissions gap. According to the UN Development Agency, developing nations will require up to 6 trillion US dollars to fund their climate efforts by 2030. This information is outlined in the Nationally Determined Contributions (NDC). The most recent IPCC assessment

determined that countries will not meet their goals if their financial resources are three to six times below the required levels by 2030.

The significance of a government establishing a carbon market is to facilitate the funding required to address the climate crisis. The European Commission states that international carbon markets can play a crucial role in cost-effectively lowering global greenhouse gas emissions. Article 6 of the Paris Agreement permits parties to utilize international trade through the carbon market to assist in meeting emission reduction goals. This is how the UN Climate Change Agency defines emissions trading. The location for trading emissions is known as the carbon exchange or market. The carbon market is also a reflection of ideas from economics, namely a fear that bad management of Earth's resources could have a negative impact on or even limit long-term economic growth, as well as an awareness of how market mechanisms could be used to resolve externalities (Calel, 2011).

Su, et al (2023) conducted a bibliometric analysis on the topic of carbon finance. The analysis indicates variations in carbon funding based on keyword analysis, including carbon capture, economic growth, carbon sequestration, financial development, modeling, and carbon price predictions. Studying the effects of energy consumption, renewable energy, and urbanization on carbon emissions is a promising area for future research in the subject of carbon financing.

In addition to the research carried out by Su et al., (2023), this study also carried out a bibliometric analysis concerning carbon in the context of the economic area, namely the carbon market. Within the fields of economics, business, management, and finance, the purpose of this study is to identify the research trends that are occurring in carbon markets. The content of this paper can be summarized as follows. Subsequently, a literature review is presented, followed by a detailed explanation of the research technique employed in this work. Subsequently, the study findings and discussions culminate in definitive conclusions and suggestions.

2. CONCEPTUAL FRAMEWORK

2.1 Carbon Market

The carbon market represents a set of requirements for greenhouse gas emission rights, expressed in tonnes-CO_2 (ton CO eq). The right mentioned here could refer to the right to emit greenhouse gases or the right to decrease greenhouse gas emissions. Meanwhile, type greenhouse gases eligible for trading in carbon markets typically. The Kyoto Protocol lists six types of greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitric oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6) (CHRGJ, 2023).

Carbon markets frequently aim to minimize greenhouse gas emissions in a cost-effective manner. The carbon market incentivizes the implementation of low-cost climate change mitigation activities before higher-cost ones. If carbon markets are prohibited in implementing emission reduction regulations, there is a risk that expensive mitigation actions will be necessary while the potential for cost-effective mitigation remains underutilized. The carbon market mechanism is implemented through an Emissions Trading System (ETS) or cap-and-trade system, typically as a compulsory market based on a policy to restrict and decrease greenhouse gas emissions (CHRGJ, 2023).

Carbon-based markets are categorized by their types and the underlying factors that led to their establishment. The voluntary carbon market exists to reduce greenhouse gas emissions. 26 voluntary carbon markets differ from regulatory ones. This demand leads to direct carbon trading between parties seeking carbon from a provider. Sometimes goals and needs are combined to boost market growth and attract intermediaries, investors, and stock exchange services. As the voluntary market relies on good intentions to cut carbon emissions, its magnitude is modest and

hard to assess. However, recent developments suggest that voluntary carbon markets increase steadily. In contrast to voluntary carbon markets, this type is established due to legislation mandating greenhouse gas emission reductions. The policy is executed through the carbon market. The Kyoto Protocol, for instance, mandates greenhouse gas emission reductions while enabling carbon markets to achieve them (PMR, 2018). The scale of mandatory carbon markets is influenced by emission reduction/limitation laws, making them easier to foresee and plan for than voluntary carbon markets.

The carbon market is typically categorized into two groups based on the trading method: (a) trading and (b) crediting. Trading involves organizations and companies as market participants. Countries are required to cut or limit carbon emissions, a measure known as a cap. A stamp is typically affixed. Participants are allocated emissions quotas/allowances at the start of the period in a market-based system. Participants must surrender quota units to specified institutions at the conclusion of the period to account for their actual emissions. Participants who successfully validate their stamp can buy extra quota units from those with unused quotas, facilitating carbon trading. This method requires parties affected by emission laws to submit annual greenhouse gas emission reports to the designated institution. This data can show if the party's emissions exceed the limit. Policymakers set next-year emission limits using this data. Emission limiting regulations and emissions trading systems are common in high-emission industries. Thus, a large emissions reduction is expected at a low cost.

Crediting is also known as baseline-and-crediting. Trading certified lower emissions commodities according to market rules is the strategy. These products are carbon credits. The average carbon credit reduces one metric ton of CO_2. This strategy focuses on project/activity emissions, avoiding the need for installation/organization emissions data preparation and collection. Calculations and monitoring methods unique to the activity are needed to compare baseline and actual emissions. As activities increase, more techniques must be devised. The procedure estimates and monitors emissions from solar energy generation, composting urban solid waste, and other operations.

2.2 Carbon Trading

Carbon trading involves the purchasing and selling of certificates that represent reductions in carbon emissions resulting from climate change mitigation efforts. Observed a significant contrast between the terms "carbon market" and "carbon trading." The market is the origin of trade. In addition to the two phrases mentioned, another term that has gained prominence is "market-based mechanism", particularly following the Paris Agreement. This word refers to a mechanism that operates according to market rules, specifically in the context of carbon. If this market-based system culminates in this outcome, it does not involve the exchange or purchase of carbon credit certificates or emission quotas (PMR, 2018).

The advantages of carbon trading are numerous and significant. From a governmental and regulatory standpoint, carbon trading emerges as a more viable and readily implementable approach compared to direct carbon emission limitations and taxation measures. The implementation of direct regulation would incur higher costs in relation to the budget and constrain the potential for industry-led economic expansion (CHRGJ, 2023).

Carbon trading enables the government to effectively monitor the quantity of carbon emissions generated within its jurisdiction in a structured fashion. This phenomenon can be attributed to the fact that the quantification of emissions and absorption capacity is conducted in accordance with established criteria. The circulation of carbon credits within the carbon market is expected to contribute significantly to the regulation of carbon emissions released into the atmosphere.

Furthermore, the implementation of carbon trading mechanisms will create novel economic prospects for nations involved in the initiative.

2.3 The Mechanisms of Carbon Trading

The carbon credit trading scheme is a mechanism that allows for the buying and selling of carbon credits as a means to mitigate greenhouse gas emissions. The system, alternatively referred to as the baseline-and-crediting or carbon offset system, is another commonly used term. The aforementioned scheme does not necessitate the implementation of quotas or allowances at the onset of the designated period. This is due to the fact that the designated commodity, referred to as carbon credits, is derived from the certification of reductions in carbon emissions resulting from the execution of projects aimed at mitigating such emissions. Typically, a single carbon credit is deemed to be commensurate with the mitigation of one metric tonne of carbon dioxide emissions (PMR, 2018).

The carbon credit scheme operates by assigning a credit value to participants at the conclusion of a designated period (ex-post). These credits can then be sold and utilised by participants to fulfil emission reduction objectives or achieve a carbon-neutral or zero-emission status. In the context of the Emissions Trading Scheme (ETS), it is noteworthy that the credit value is predetermined (ex-ante), enabling the trading of newly acquired credits based on the emitter's operational endeavours (CHRGJ, 2023).

The Emissions Trading Scheme (ETS), also referred to as the cap-and-trade system, is a mechanism for regulating and reducing greenhouse gas emissions. This method is typically used in compulsory carbon markets, where the government imposes restrictions on the quantity of carbon emissions that can be sold. Under this framework, the emissions being traded pertain to future emissions that will be generated (Calel, 2011). The participants in this market mechanism comprise of various entities, including organisations, companies, and even countries. The requirement to decrease or restrict emissions is enforced through the issuance of quotas (allowances) at the start of the designated period. Participants who are bound by emission limitations must regularly submit reports of their emissions (often on a yearly basis) to the designated institution. At the conclusion of the term, participants who above the limit have the option to acquire extra allowances from participants who have unused quotas (where the emissions produced are below the established limit), and vice versa (PMR, 2018).

3. RESEARCH METHOD

Bibliometric analysis is a methodical and numerical strategy employed to scrutinise bibliographic data contained in articles and journals (Zupic and Tomaž, 2015). The aforementioned analysis is frequently used to scrutinise references to scientific publications in a journal, define the scientific scope of the magazine, and classify scientific papers according to their various research topics. This methodology is relevant across several fields, including sociology, humanities, communications, marketing, and other social sciences. Bibliometric analysis utilises a method of citation analysis to find articles that are referenced by other publications, as well as a co-citation analysis method to identify papers that are referenced by several other articles (Van Eck et al., 2010).

Bibliometrics is an academic discipline that uses mathematical and statistical analysis to study the links between writers of scholarly journals. Bibliometric analysis enables the identification of writers who have referenced a certain journal, the journals that have been referenced, and the quantification of the number of authors participating in referencing the journal. This refers to the number of terms contained in a single article or abstract under a specific title.

As the number of terms used in study increases, the probability of observing a particular phrase also increases. By employing bibliometric analysis tools, it is feasible to automate the process of estimating the number of writers linked with the keywords under research (Zupic and Tomaž, 2015). Furthermore, it is feasible to determine the author's institutional affiliation and the language employed in a certain publication and its feature that may be used to determine the identity of the publisher of the journal. The duration required to identify the most prolific publisher, who generates the biggest quantity of journals, increases proportionally with the number of publishers present inside a journal (Zupic and Tomaž, 2015).

Bibliometric analysis has two main goals. Firstly, to evaluate the research and publication accomplishments of individuals and institutions in order to assess their research performance; and secondly, to uncover the structure and dynamics of a specific study topic through science mapping (Van Eck and Waltman, 2011). Every field has its own specific intricacies. When assessing research performance, quantitative calculations are used, such as total citations, average citations, and collaboration index, to measure specific indicators. Within the realm of scientific mapping analysis, co-word analysis is a beneficial technique for examining the relationships between a certain subject and other subjects in a specific field.

Many affordable bibliometric analysis tools and software are available. Bibexcel, citespace, PoP, rstudio, SITKIS, UCInet, Gephi, and VOSviewer comprise the software suite. VOSviewer is usually the easiest way to visualise and comprehend author relationships (Visser et al., 2021). VOSviewer helps visualise academic publication keywords. It considers keyword frequency and relationships. One way to visualise this challenge is via a mindmap or treemap (Van Eck & Waltman, 2011). The visualisation results can also be transferred to VOSviewer for public review and availability. Additional bibliometric articles should be thoroughly analysed. VOSviewer visualises bibliographies or datasets with title, author, journal, etc. Academic researchers use VOSviewer for bibliometric analysis. This involves finding untapped study areas and the most referenced academic publications in specific domains, among other purposes. VOSviewer can retrieve bibliographic data from Web of Science, Scopus, Dimension, and Pubmed. VOSviewer also interprets RIS, Endnote, and RefWork datasets. The API function lets VOSviewer extract data from Crossref, Pubmed PMC, Semantic Scholar, OCC, COCI, and Wikidata.

According to Visser et al., (2021), not all databases have the capacity to handle all types of analysis. Web of Science and Scopus are two extensively utilised databases that offer comprehensive assistance for a wide range of analytical purposes. The disparities in data architectures and policies among various databases lead to the availability of distinct forms of analysis for each database. The table demonstrates that the Pubmed database does not provide assistance for citation analysis, bibliographic pair analysis, and co-citation analysis. Dimensions is quite similar to WOS and Scopus, as it offers extensive support for many analytical approaches (Visser et al., 2021).

The bibliometric analysis results acquired via VOSviewer offer useful insights into the patterns of co-authorship, allowing for the assessment of an author's collaborative endeavours with other researchers. The analysis will produce visual depictions of the findings, organised by the author's name, the author's institution, or the author's country of birth.The co-occurrence analysis produces a visual depiction that demonstrates the interconnections between keywords in a network.

Citation functions as a visual representation of the document being analysed. The observed or tested papers will be linked to other documents that have also undergone observation or testing, as long as they reference other publications that have been submitted to the same level of scrutiny. This research offers useful insights about the relationships between papers through citations, as

well as the frequency of authors citing their own work. This tool is valuable for analysing bibliographic coupling. If the articles being analysed have the same references, they will be displayed and linked together. This analysis illustrates the level of interconnectivity among the examined documents.

Co-citation is a different idea that differs from both citation and bibliographic coupling. Co-citation is the visual representation of the references used by the papers being examined or observed. If references are used, they will be hyperlinked inside the article in accordance with academic traditions. Article A incorporates references 1 and 2 as corroborating sources. References 1 and 2 demonstrate a substantial correlation. If article B cites references 1 and 5, it can be deduced that reference 1 is connected to reference 5, except for reference 2. The representation of co-citation is influenced by multiple elements, such as the cited reference, the journal's name, and the names of the authors of the referred work. This analysis is a useful method for finding the main sources referenced in a specific set of articles being studied.

VOSviewer employs two separate calculating algorithms, specifically full counting and fractional counting. The technique of complete enumeration remains unaltered, but the method of partial enumeration depends on the number of co-authors involved in the document being analysed. When using Vosviewer to get data, it is crucial to be aware that the tool shortens words in the title or abstract. Afterward, it proceeds to visualise the relationships among the fragmented words or concepts. The network will exhibit the relationships among the terms that are being visualised. The overlay feature will exhibit documentation of previous research endeavours, while the density feature will denote the concentration or importance of research groups. Density can be a useful tool for investigating parts of study that are rarely pursued.

4. FINDINGS

The purpose of this section is to provide an explanation of the bibliometric analysis output that was generated by the VOSviewer tool. This analysis looked at the frequency of sample publications that were used in the current study. The output is comprised of three unique categories of graphs that provide an explanation of the findings that were obtained via bibliometric analysis in relation to three different factors. These factors include the degree of concentration displayed by a research group, the publication history, and the interrelationships that exist between the variables that are being investigated in the research investigation. An analysis that provides an explanation of the three findings of the bibliometric analysis is presented in the next section.

4.1. Data

The study employs metadata in CSV format extracted from the Scopus database for data analysis. A total of 5,589 publications from the database were included in the analysis, following the application of selection criteria that restricted the scope to the domains of business, management, economics, and finance. These publications were specifically chosen based on their utilisation of the keyword "carbon market." The following table presents the specific information regarding the publications utilised in the bibliometric analysis conducted within the scope of this study.

Table 1. Types of publications

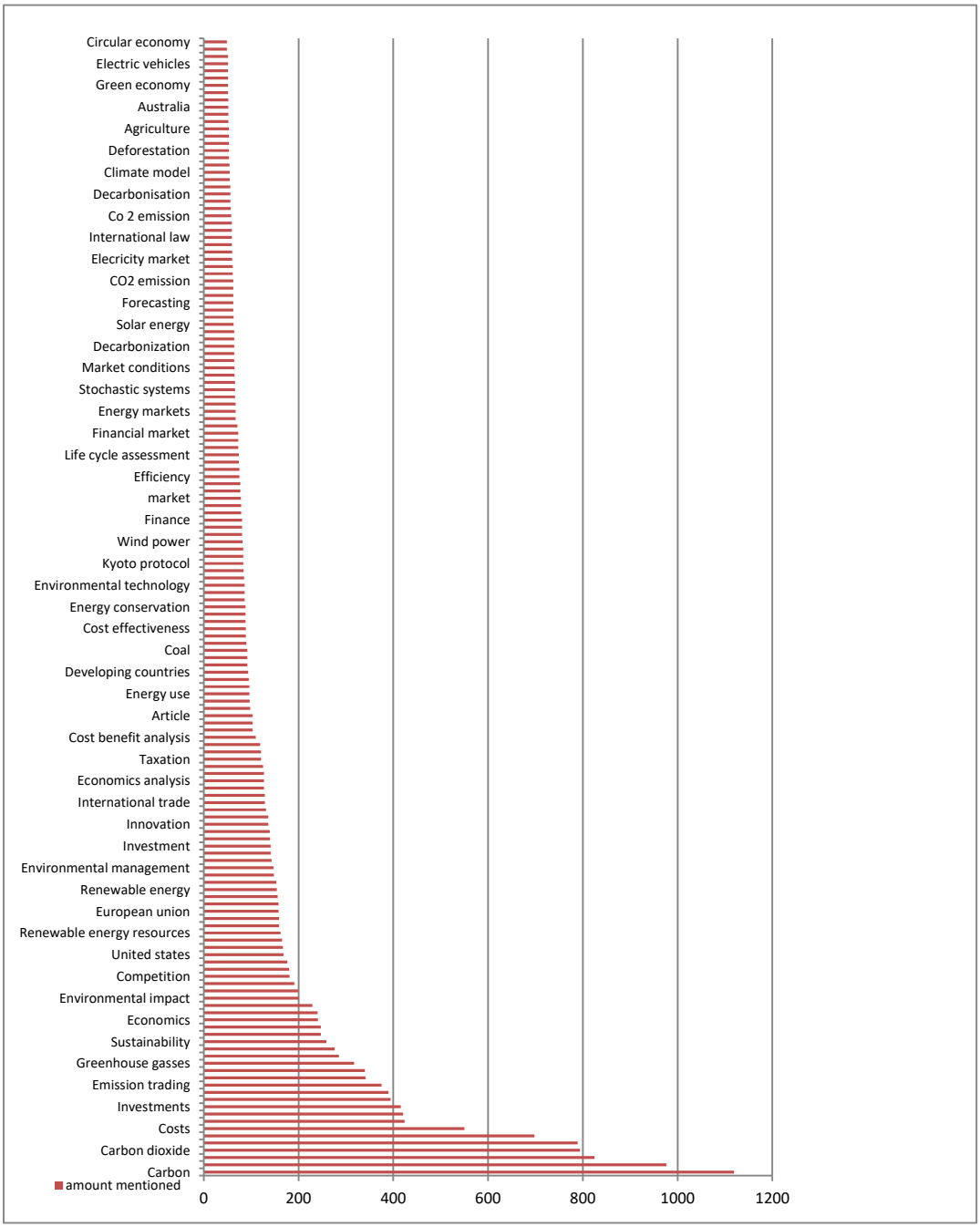
No	Type	Amount	No	Type	Amount
1	Article	4.316	7	Short survey	26
2	Book Chapter	473	8	Conference Review	14
3	Conference Paper	345	9	Retracted	12
4	Review	185	10	Editorial	11
5	Book	103	11	Erratum	7
6	Note	95	12	Business article	2

Source: Scopus database

Based on the data presented in the table, it is evident that the research incorporates a total of twelve distinct types of publications. The initial and most abundant category comprises publications in the form of articles. Out of the entire corpus of publications utilised in this study, a sum of 4,316, constituting 77% of the total, were identified as articles. The category of book chapters holds the second position, comprising approximately 9% or 473 instances. Following this, the third position is occupied by 345 conference papers, accounting for approximately 6% of the overall publication data. Subsequently, reviews constitute the fourth most prevalent category employed in this study, comprising approximately 185 instances or approximately 3% of the total. The fifth and sixth positions are held by books and notes, comprising approximately 2% each, with quantities of 103 and 95 pieces, respectively. The positions from seventh to twelfth are filled consecutively by short surveys, conference reviews, retracted articles, editorials, errata, and business articles, accounting for 26%, 14%, 12%, 11%, 7%, and 2% of the total publications utilised, respectively.

The selected publications in the table exhibit a wide range of keywords. The graph presented below illustrates the range and quantity of keywords employed in the publication data utilised for this study. The publication's data reveals that the top five keywords, ranked in descending order of popularity, are "carbon," "carbon dioxide," "cost," "investment," "emission trading," and "greenhouse gases." In contrast, the sequential analysis of the publication data reveals that the five keywords with the lowest frequency of usage are "circular economy," "electric vehicles," "green economy," "Australia," and "Agriculture." The utilisation of these specific keywords is indicative of the focus observed in the publications encompassed within the research sample. Therefore, it is evident that the primary emphasis of carbon market research in the domains of business, management, economics, and finance revolves around the topics of carbon, carbon dioxide, expenses associated with carbon emission reduction, investments, emissions trading, and Greenhouse gases. In contrast, it is noteworthy that certain terms such as "circular economy," "electric vehicles," and "green economy" have not garnered significant scholarly attention from researchers.

Figure 1. Keywords in the publications



Source: Scopus Database

The following table presents a visual representation of the utilisation of language within the selected sample of publications examined in this study.

Table 3. Languages uses in the publications

No	Language	Amount	No	Language	Amount
1	English	5.480	8	Portugese	6
2	Russian	36	9	Undefined	4
3	French	30	10	Ukranian	4
4	German	24	11	Korean	4
5	Spanish	20	12	Slovenian	1
6	Chinese	11	13	Czech	1
7	Italian	8	14	Croatian	1

Source: Scopus Database

The initial instance of English language implementation encompassed a total of 5.480 publications within the scope of this research sample. Russian ranks second with a total of 36 publications. French was employed by a substantial number of publications, reaching up to 30 in total. There are 24 publications that utilise the position immediately following the German language. Subsequently, there exist a total of 20 publications written in the Spanish language. The publications were distributed as follows: Chinese, Italian, Portuguese, an undefined language, Ukrainian, Korean, Slovenian, Czech, Croatian, with 11, 8, 6, 4, 4, 4, 1, 1, 1, and 1 publication, respectively.

4.2. Results

The figure 3 below depicts the outcomes of a bibliometric analysis that elucidates the interconnectedness among research variables employed by researchers in the selected sample of publications. The figure presented herein illustrates numerous networks depicting the interrelationships among variables within a collection of sample publications that have been subjected to analysis using bibliometric techniques. The magnitude of a variable, which is interconnected with other variables to form a network, is represented by a prominent circle.

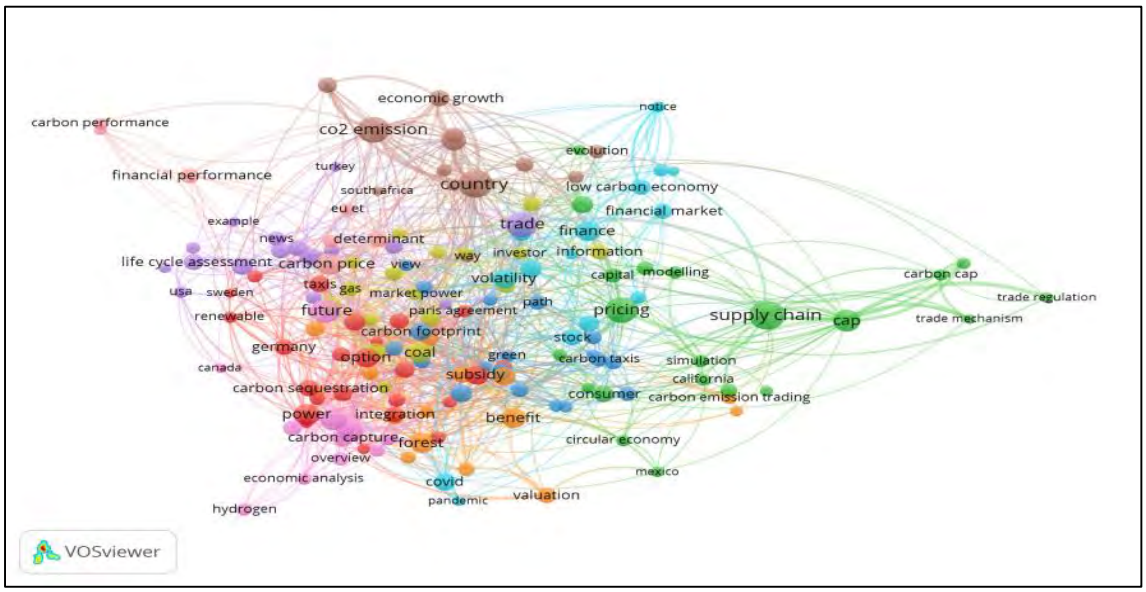


Figure 3. Bibliometric Result

For instance, the following information pertains to the network that is established when a variable is chosen within the application to determine the variables that are associated with the selected variable. In the depicted image, the variable denoted as "supply chain" has been chosen, distinguished by its larger size in comparison to the other circles. The variable known as "supply chain" exhibits a correlation with multiple variables, such as "pricing", "Carbon CAP", "CAP", "trade mechanism", and "circular economy". The terms "COVID," "carbon emission reduction," "option," "environmental impact," "low carbon," "environmental regulation," "information," "capital," "modelling," "customer," and "carbon footprint" are utilised in the following discussion. The primary objective of bibliometric analysis in network form is to ascertain the associations between variables in a given set of publications. This analysis aids researchers in identifying previously unidentified variables that are interconnected within the network.

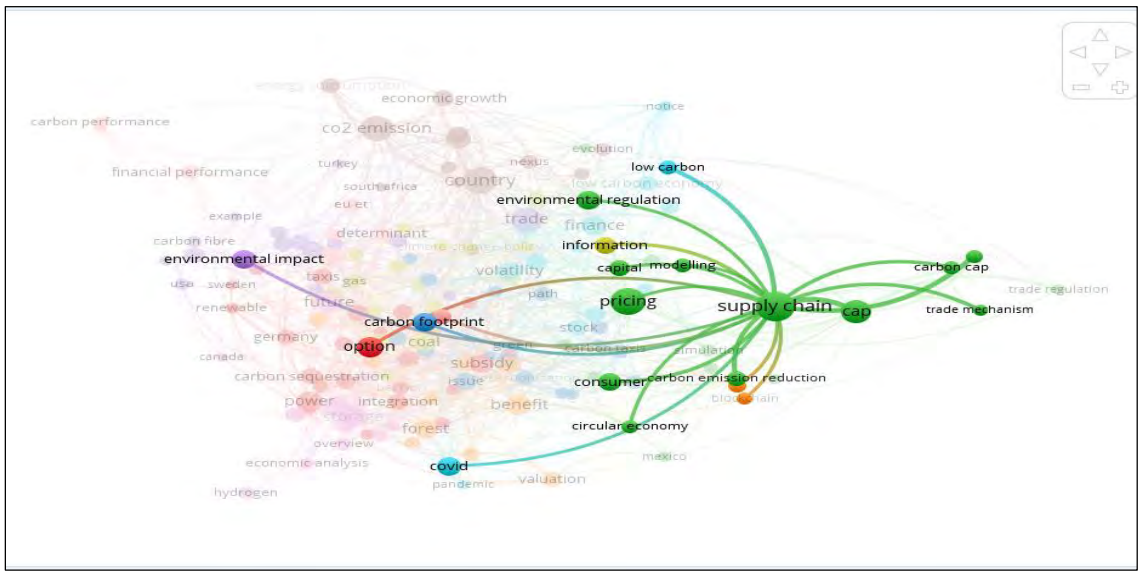


Figure 4. Bibliometric Result (Network "Supply Chain")

In addition to the variable denoting the "supply chain," the variable exhibiting a larger circle size relative to the other variables is the "pricing" variable. The variable denoted as "pricing" encompasses a network of various interconnected variables, including but not limited to "supply chain," "CAP" (Common Agricultural Policy), "trade regulation," "low carbon economy," "subsidies," "financial market," "trade," "green bonds," and other related factors. Figure 5 depicts the network encompassed within the variable denoted as "pricing."

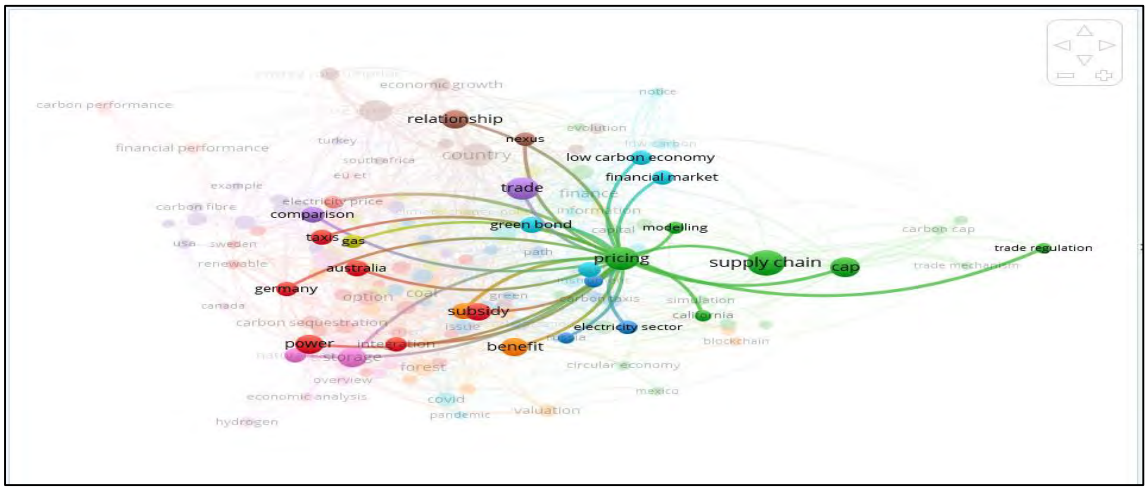


Figure 5. Bibliometric Result (Network "Pricing")

In Figure 6, the network that is used to represent the variable "trade" is shown. The output graph of the bibliometric analysis reveals that the variable "trade" displays a network that includes a number of different variables that are interconnected with one another. These variables include "European carbon market," "CAP," "pricing," "carbon CAP," "natural gas," "option," "benefit," "Paris agreement," "Environmental impact," "competitiveness," and "evolution," amongst others.

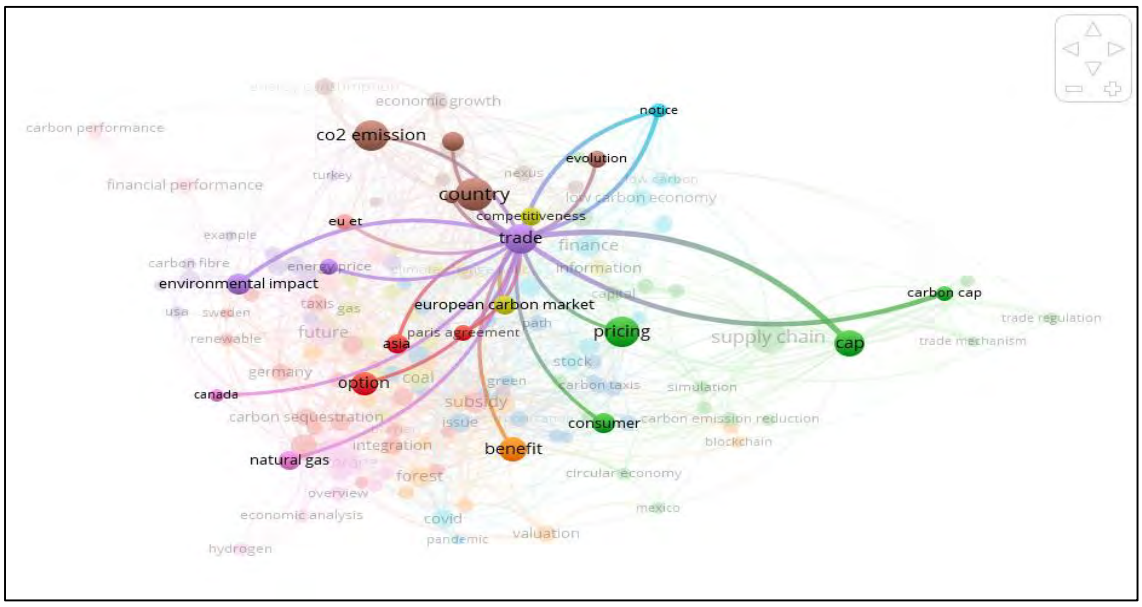


Figure 6. Bibliometric Result (Network "Trade")

A representation of the network variable "Finance" that is contained within the dataset that was utilized for this investigation can be found in Figure 7. Specifically, "energy price," "environmental regulation," "low carbon economy," "climate finance," "carbon footprint," "volatility," "commodity," "assets," and "accounting" are all examples of variables that are contained inside the network that is known to be associated with the variable "Finance."

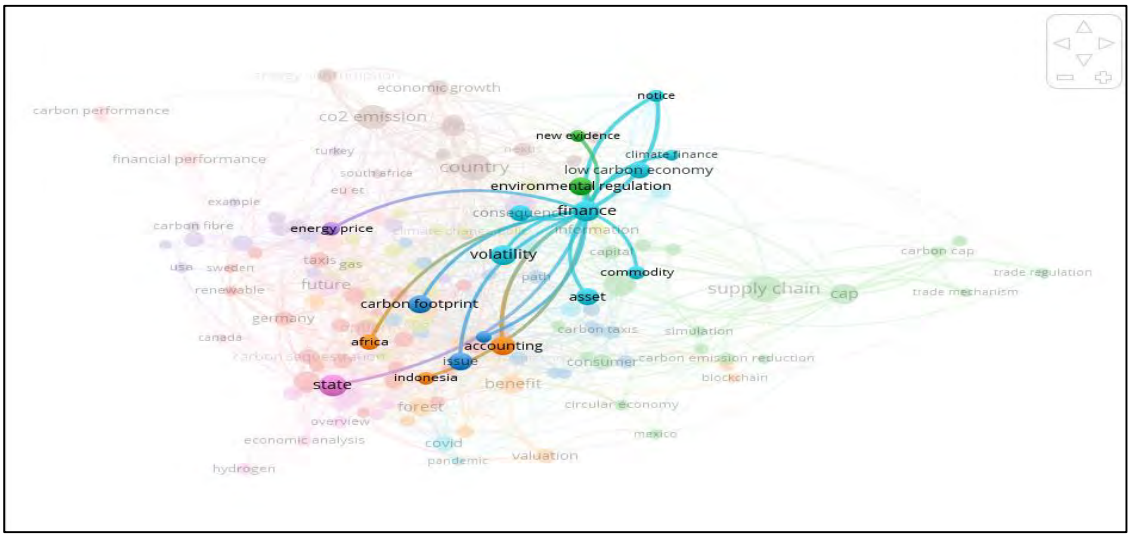


Figure 7. Bibliometric Result (Network "Finance")

Figure 8 is the final image, and it provides an explanation of the network that is associated with the variable that is referred to as "Green Bond." The use of green bonds as a means of funding and investing in environmental issues is an alternative strategy. Figure 7 illustrates a network of variables that is included in the dataset that was used for this research sample. As a result of this bibliometric research, the following factors have been discovered as being related with the network of "Green bonds": "pricing," "stock," "low carbon transition," "subsidies," "environmental policy," "carbon price," "financial market," and "low carbon economy."

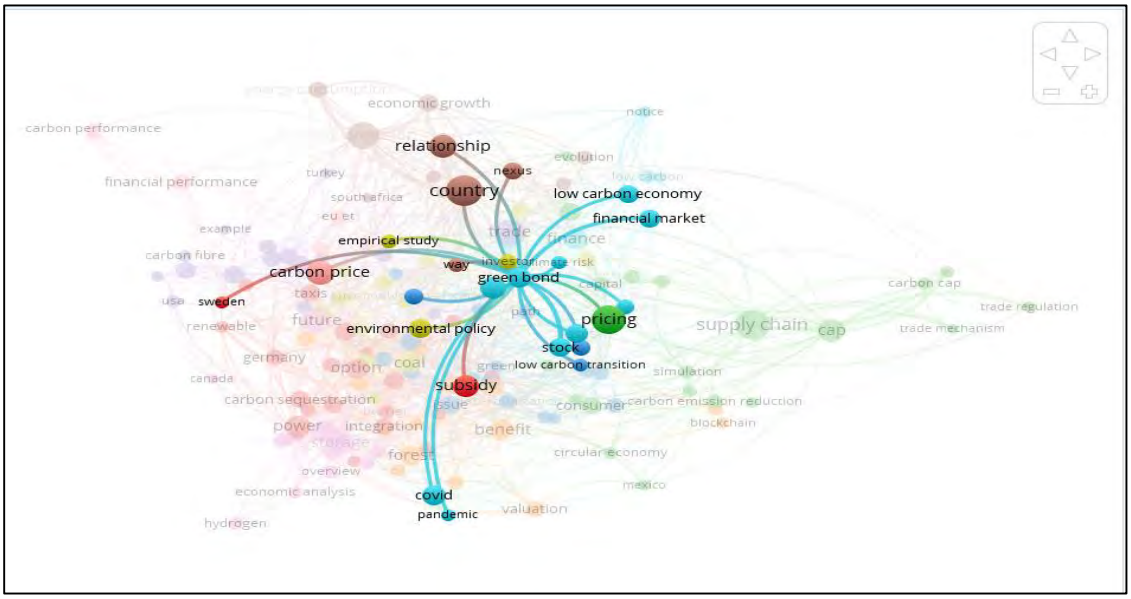


Figure 8. Bibliometric Result (Network "Green Bond")

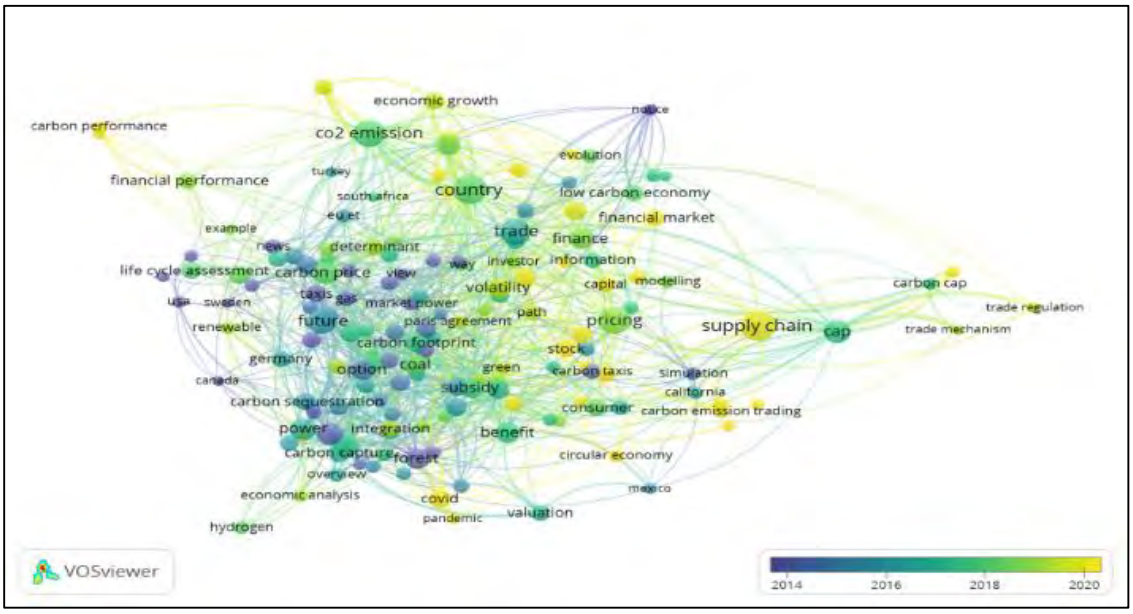


Figure 9. Bibliometric (By Year) Result

In contrast to the results obtained from network bibliometric analysis, the findings of this overlay bibliometric analysis provide an explanation of publication time. This temporal aspect reveals that variables of specific colours were chosen as research variables during particular years. The level of darkness in colour corresponds to the level of brightness in the publication, thereby signifying that variables depicted with darker colours are indicative of past executions. Conversely, a light hue signifies that the variable under consideration pertains to the most recent advancements in research. The provided visual representation displays a bar graph that signifies the publication dates of carbon market reports. It is evident that the most recent publication occurred in 2020, while the previous publication was observed in 2014 as presented at Figure 9. Previous research has examined various variables pertaining to the carbon market, including the "Paris Agreement," "gas," "trade," "option," "forest," "carbon sequestration," and other relevant factors. In contemporary carbon market research, there is a growing emphasis on various variables such as "carbon performance," "carbon emission trading," "supply chain," "financial market," "trade regulation," "covid," and other related factors. These variables have recently emerged as significant focal points within the field.

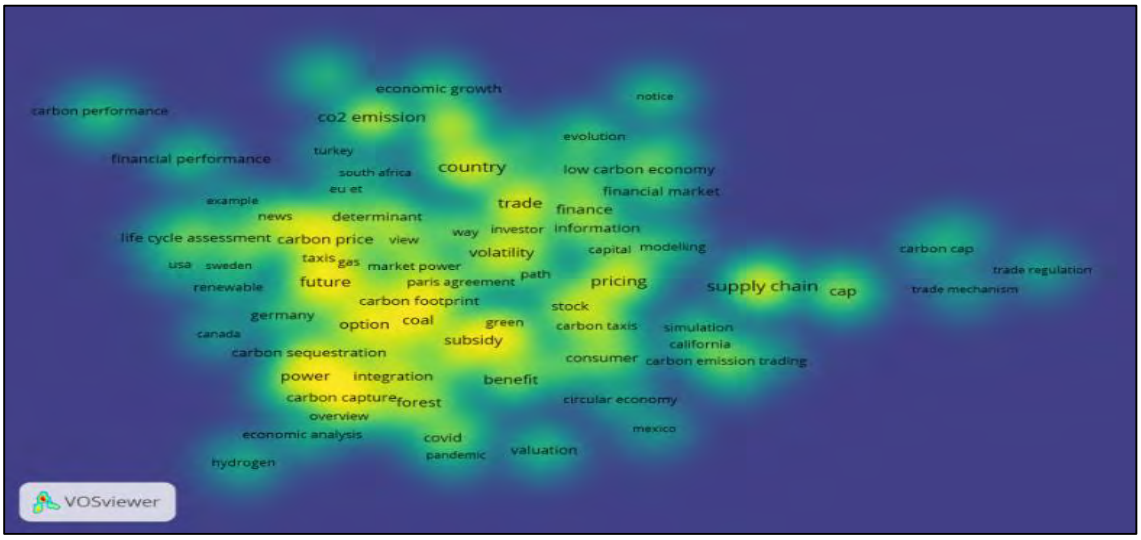


Figure 10. Bibliometric (Density) Resul

The figure 10 depicts the outcomes of the bibliometric analysis, specifically highlighting the density of sample publications examined in this study. The concept of density is employed in this study to elucidate the frequency at which variables are utilised in sample publications. The utilisation of light colours serves to depict regions wherein the variables associated with said colours are frequently examined. In the depicted image, a number of variables can be observed within the yellow region. These variables encompass "carbon price," "subsidies," "coal," "power," "carbon capture," "option," "carbon footprint," and "future." Conversely, the regions characterised by dark colours represent areas where the variables within those regions have received relatively limited attention in research. Specifically, these variables include "trade mechanism," "carbon performance," "trade regulation," and "financial performance."

5. DISCUSSION, CONCLUSION AND RECOMMENDATION

The findings indicate that the study of the "Carbon Market" encompasses a wide range of words. The variables in the "Carbon Market" research are not subject to any terms and constraints. The variable "circle size" in the initial bibliometric report indicates that network variables tend to possess similar sizes. The research on the "Carbon Market" does not identify a single most influential variable. The overlay unambiguously displays the present study variables in yellow circles, as per the second outcome. The present data suggests that the dark warrant area possesses multiple characteristics that can be examined both presently and in the future.

These three forms of bibliometric analysis output allow for research on "trade mechanism," "carbon performance," "trade regulation," and "financial performance." The findings of this bibliometric research align with other previous studies. Newell et al., (2012) examines the historical, present, and future carbon markets, as part of a collection of research on the topic of the "Carbon Market". Guo and Zhang (2014) examined the application of a carbon accumulation model for market regulation. Demirci and Öztürk (2015) analyze the function of the carbon market as a financial instrument in the forestry sector of Turkey. The study conducted by Ludeña et al., (2015) investigates the influence of carbon markets on climate change in developing countries. Pollitt (2019) examines the subject of worldwide carbon markets. Michaelowa et al., (2019) discusses the advancements made in the worldwide carbon market and the implementation of the Paris agreement. Shi et al., (2019) discuss the expansion and difficulties faced by the carbon market in Asia. In their study, Mikolajczyk and Martinez (2022) examine the global allocation of funds, the entities providing financial support, and the recipients of funding in the context of climate change and carbon market financing. Last, Nofyanza et al., (2023) examine the carbon market in Indonesia and the REDD effort.

Hepburn (2007) examines the carbon trading method outlined in the Kyoto protocol, focusing on the topic of carbon trading. In contrast to prior research, Li and Zhao (2023) examine the concept of carbon trading inside the energy sector. Additional studies have investigated the price and forecasts of the carbon market. Dellink et al., (2014) examine the global prices of carbon in both direct and indirect carbon markets. The paper by El Amri et al., (2020) delves into a comprehensive analysis of the carbon market, focusing on risk management, pricing, and forecasting. Green (2021) discuss the relationship of carbon pricing and emissions. Hao and Yang (2022) choose to examine the carbon market in China from a legal and policy lens. Wang et al., (2022) discuss improved deep learning techniques for predicting carbon trade. Trouwloon et al., (2023) investigate climate assertions in the context of corporate carbon credit trading. These studies demonstrate current patterns in the domain of carbon markets. Future research on carbon markets focuses on carbon trading mechanisms, encompassing financial instruments, regulations, carbon performance evaluation of traded carbon credits, monitoring of carbon trading activities, safeguarding of market transactions, and implementation.

Within the fields of economics, business, management, and finance, the purpose of this study is to identify the research trends that are occurring in carbon markets. Specifically, this investigation makes use of a dataset that was taken from Scopus and contains 5.589 publications of varying types. Evaluation of the dataset is carried out with the use of VOSviewer and bibliometric analysis. Based on the findings of the research, it can be concluded that the topic of "Carbon Market" contains a wide range of complex research variables and presents a multitude of features that have the potential to become the main point of both current and future research opportunities.

When it comes to the study that is currently being conducted and will be conducted in the future about the carbon market, the terms "option," "Carbon performance," "Carbon emission trading," "financial market," "carbon price," and "trade regulation" are significant keywords and probable terms. The outcomes of this research are consistent with the descriptive analysis of sample articles that were included in this study. The analysis found that the terms "financial market," "international law," and "finance" did not occur more frequently than the terms "carbon market," "carbon dioxide," and "greenhouse gases." In a similar vein, the results of the three outputs from the bibliometric analysis indicate that additional research is required for these terms in the next few years. In addition, the implementation of carbon trading calls for a comprehensive process to be carried out in order to guarantee clarity and prevent any potential confusion or harm to the parties concerned.

It is possible to analyze bibliometric analysis in following research by making use of alternative databases, such as Web of Science, Crossref, Google Scholar, and other sources that are available. When conducting bibliometric analysis, it is possible to make use of a large number of software programmes in addition to a wide range of datasets. This is done in order to accomplish the intended purpose.

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