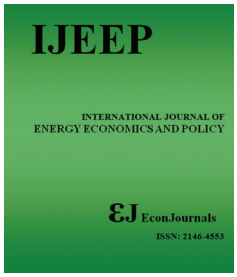


International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2025, 15(3), 635-646.

Price Determinants in the Global Emissions Trading Systems: A Systematic and Bibliometric Review

Yaolong Chen[1,2], Abdul Rais Abdul Latiff[1]*

[1]School of Social Sciences, Universiti Sains Malaysia, Penang, 11800, Malaysia, [2]School of Economics and Management, Zhaoqing University, Zhaoqing, Guangdong, 526061, China. *Email: abdulrais@usm.my

Received: 08 December 2024 **Accepted:** 06 April 2025 **DOI:** https://doi.org/10.32479/ijeep.18888

ABSTRACT

The Carbon Emissions Trading Price (CETP) is crucial in the Carbon Emissions Trading System (ETS). This study conducts a systematic and bibliometric review of 57 articles to explore the Determinants of Carbon Emissions Trading Price (DCETP) in global ETSs. The study revealed a substantial increase in the number of pertinent publications since 2018, driven by the expanding carbon market. China leads in contributions, although author collaboration is still limited. The analysis shows that energy factors are the most influential DCETP, while economic indicators, market policies, and environmental variables also play key roles. Methodologies are evolving, with recent research focusing on predictive models and advanced econometric techniques to address fluctuations in CETP. The research focus is shifting from the EU ETS to emerging markets such as China, highlighting the need for context-specific studies due to differences in the impacts of determinants across markets and models. This review integrates fragmented research, offering insights for policymakers and academics to optimize ETS design, enhance price stability, and support the low-carbon transition. Future research should prioritize new determinants, cross-market comparisons, and interdisciplinary theoretical integration.

Keywords: Carbon Emission Trading Price, Emissions Trading System, Bibliometric Analysis, Systematic Literature Review
JEL Classifications: E3, G1, N2

1. INTRODUCTION

The significant increase in carbon emissions during the 20th century has made combating the greenhouse effect a top global priority. International agreements like the Copenhagen Accord and the Paris Agreement have prompted the global community to adopt effective and measurable strategies for mitigating greenhouse gas emissions (Hu et al., 2020; ICAP, 2023). Many nations have integrated carbon emissions trading systems into their national policy to tackle climate change issues. These programs set countrywide maximum carbon emission targets and quantity emission limits for companies that meet certain standards. Then the allowances can be traded on the market. By implementing this flexible and market-based pricing system for carbon credits, the cost of carbon emissions is integrated into a company's production costs. Therefore, this approach will reduce the emission of greenhouse gases (Egenhofer, 2007; Hua and Dong, 2019).

The emissions trading system (ETS) has similarities with other financial markets, but this market has its specific characteristics and some kind of externalities (Li et al., 2022). Price is the most important factor in the trading process of carbon trading, and both the level and volatility in carbon emission trading price (CETP) will directly influence market performance. If CETP is stable and predictable, it would contribute to the sustainable development of carbon markets so that both government authorities and market participants become informed in their decision-making processes (Hao et al., 2020), promote industrial transformation, and encourage enterprises to save energy and reduce emissions. This is crucial for the sustainable growth of the carbon trading

market. Therefore, a thorough understanding of the factors influencing CETP is essential. Identifying these determinants and understanding their impact mechanisms can better guide market participants and support achieving low-carbon policy goals.

Several researchers have explored the relationship between CETP and factors such as energy price, economic development, traditional financial markets, and weather conditions, each of which shows substantial impacts on CETP (Dong et al., 2022; Song et al., 2022; Zeng et al., 2023). Besides these, carbon emission allowances supply, including total targets, coverage, and allocation methods, have been a hotspot area for theoretical research since it has a high influence on CETP (Ji et al., 2021). However, the CETP is influenced by various factors due to the unique and complex design of ETS. For instance, employing an event analysis, Fan et al. (2017) demonstrated that policies changing the supply and demand for allowances have a stronger impact on CETP, while the timing of policy announcements also matters. Lin and Jia (2019) analyzed factors influencing CETP in China's pilot carbon trading markets, revealing that CETP is positively related to emission reductions and that fewer industries and higher annual decline factors positively impact the CETP. In addition, the same influencing factors have significantly different impacts on CETP depending on the methodology used, and new determinants have emerged over time. Therefore, researchers must understand the factors affecting CETP and their respective influences. An in-depth scholarly assessment of these determinants is essential.

To date, only two early review papers have examined carbon pricing. The first one by Ji et al. (2018), adopted a traditional narrative review approach focusing on price-setting mechanisms in carbon markets. However, this approach is somewhat subjective and may have missed certain important papers. The second research, authored by Ji et al. (2019), examined a wider range of topics, including CETP volatility, pricing mechanisms, and influencing variables; however, it offers a less rigorous analysis of the influencing elements. Moreover, new factors and changes came after 5 years of rapid development in the field, which were not identified in the studies.

This study focuses on the DCETP in the global ETSs. It adopts a systematic literature review and bibliometric analysis in response to the dynamic and rapid development of the carbon market. The ETS, as the centerpiece of the international climate policy, has an efficiency and effectiveness that is influenced by the pricing mechanism. However, the literature is fragmented, and there is a research gap in the field of DCETP research. The objective of this study is threefold: first, to integrate disparate research; second, to track the research trends of the DCETP; third, to highlight collaborative networks and institutional contributions; and fourth, to deepen the theoretical and methodological foundations. By identifying the key factors affecting CETP, this study will provide insights into the evolution of the market and guide the direction of future research. In turn, this will provide decision support to policymakers, researchers, and market participants, enabling them to cope with the complexity of ETSs and facilitate their optimization.

The outline of the article is as follows: Section 2 explains the research methodology and search criteria for the bibliometric analysis. Section 3 provides descriptive statistics of the literature and an overview of the current research field, including publication volume, publishing institutions, countries, and authors, as well as an econometric bibliometric analysis of keywords, illustrating trends in research topics and research hotspots over time. Section 4 covers the study highlights on CETP determinants, including principal theories and econometric models, trend analysis, and gaps and key factors. Finally, Section 5 concludes and proposes avenues for further DCETP study.

2. METHODOLOGY

This study employs systematic literature review (SLR) techniques and bibliometric analytic methods. The SLR constitutes an exhaustive search of literature related to the topic and a meticulous evaluation of the qualified research to address the specific research questions of the subject matter (Kitchenham et al., 2009; De Oliveira et al., 2018). The SLR consists of three phases: planning, implementation, and reporting, each of which consists of steps with a specific purpose.

The application of a scientific algorithm in bibliometric analysis enhances its capabilities by facilitating the visualisation and mapping of the knowledge graph. The advanced capabilities of bibliometric software applications like VOSviewer and CiteSpace have led to their widespread adoption (Ahsan et al., 2022). Compared to subjective narrative literature evaluation, bibliometric analysis eliminates author bias and the incompleteness of content, this is particularly important in complex research fields where extensive and intricate publications are common, as it eliminates authorial bias and gaps in content (Mukherjee et al., 2022). In addition, science mapping tools facilitate the presentation of collaborations, trends, and hotspots over time, improving their visual appeal (Romanelli et al., 2021; Zhang et al., 2022).

2.1. Study Framework and Data Sources

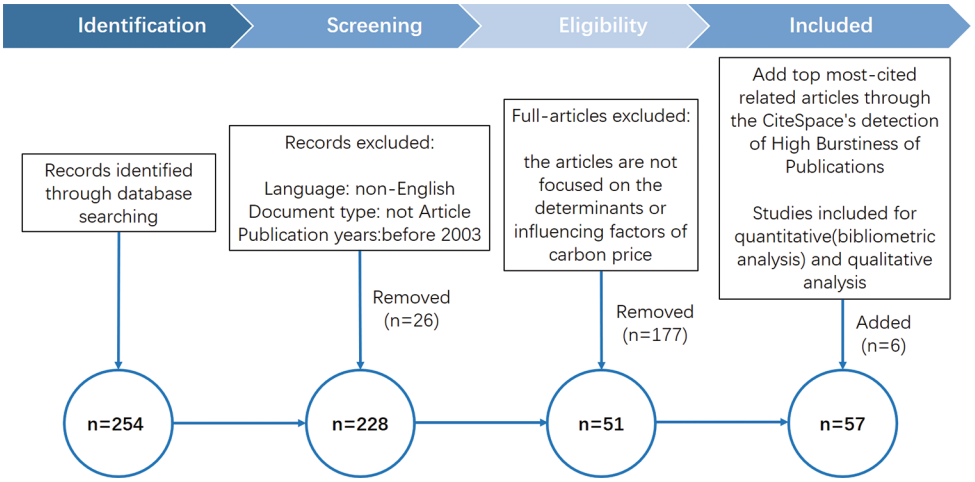
In this research, we created the research framework and described all the analysis processes and research contents, as shown in Figure 1.

2.2. Literature Retrieval Process

The Web of Science database is the largest and most comprehensive source of scholarly information worldwide. To identify germane literature, a search of the Web of Science Core Collection was conducted using pertinent keywords. Screening is an iterative process that involves skimming papers to identify the most accurate and relevant literature, followed by performing reliable analyses (Abdelmageed and Zayed, 2020). Due to the numerous terminologies related to CETP and determinants, a broad search for studies on "DCETP" necessitates the use of the following search terms:

TS = (("carbon price" OR "price of carbon" OR "carbon cost" OR "cost of carbon" OR "carbon emissions trading price" OR "carbon allowance trading price" OR "carbon market price" OR

Figure 1: Analytical process and study framework



"carbon trading price" OR "carbon pricing" OR "carbon pricing mechanism" OR "carbon quota price" OR "carbon allowance price" OR "carbon quota trading price" OR "CO2 price" OR "price of CO2" OR "carbon dioxide price") AND ("influencing factor*" OR "influential factor*" OR "impact factor*" OR "influence factor*" OR "effect factor*" OR "driving factor*" OR "factor* driving" OR "motivating factor*" OR "driving force*" OR "propelling factor*" OR "determinant*" OR "determining factor*" OR "decisive factor*" OR "key factor*" OR "crucial factor*" OR "critical factor*" OR "primary factor*" OR "major factor*" OR "main factor*"))

The publication language was set to "English" because integrating multiple languages poses a significant challenge to bibliometric analysis. The document type was selected as "Article" because it pertains to peer-reviewed research that undergoes rigorous review processes to guarantee robust research findings. We did not include "review" type materials as they provide an overview and summary of the published literature, including citation information. Our bibliometric analysis solely relied on citation data to produce valuable insights. Thus, integrating these reviews may result in the overlap of citation information, which could hinder the accurate representation of the research field's development (Wang et al., 2022).

The search period was initially set as "All years (1990–2023)". However, results indicated that papers before 2003 were not relevant to our research, as the earliest batch of carbon markets, such as the Chicago Climate Exchange (CCX) and the New South Wales Greenhouse Gas Abatement System (NEW GGAS), was established in 2003. Consequently, we adjusted the search period to "2003–2023" and conducted searches until May 25, 2023, resulting in 228 references.

Next, the titles, abstracts, and full texts were examined to eliminate irrelevant articles and to improve the credibility of the analysis results. Finally, we conducted a quantitative analysis of the remaining 57 articles. In the forthcoming chapter, we will present the descriptive statistics from the literature analysis, as illustrated in Figure 2.

3. LITERATURE DESCRIPTIVE STATISTICS

3.1. Number of Annual Publications

An important indicator of progress in a research field is the change in the volume of literature. The trend in article publication is evidenced by the increasing number of annual publications and citations.

Figure 3 illustrates the annual publication volume of scholarly articles on the topic of DCETP from 2005 to May 2023, totaling 57 articles. The chart reveals two notable research phases. From 2005 to 2017, despite sustained interest in this area, the relatively low amount of research output is in large part due to the small number of regions worldwide with carbon emissions trading markets and the difficulty of obtaining CETP data in the early stages of development.

The 2018 publications had been as high as five papers, in comparison with the previous years. In recent years, a positive trend further gained strength, and the number of publications almost tripled to 15 by 2022. As of mid-May 2023, five articles have been published, further demonstrating the growing interest in this area of research. This phase indicates a significant growth in research interest and output in the field of DCETP in recent years, driven by the emergence of carbon markets and the accumulation of carbon pricing data. Additionally, the yellow dots and lines in the chart represent a significant rise in interest in DCETP research and increasing contributions from Chinese researchers since 2017.

The 21st United Nations Climate Change Conference in December 2015 finally concluded with the adoption of the Paris Agreement, with the intention of achieving tangible moves to mitigate and adapt to the challenges of climate change. In November 2016, the Information Office of the State Council of China released the 2016 Progress Report on China's Policies and Actions to Address Climate Change. During this period, China also announced plans to launch its national carbon market in 2017 and has been actively preparing for its implementation. These significant events have prompted researchers worldwide, particularly in China, to focus more on the DCETP.

Figure 2: The Framework of literature descriptive statistics

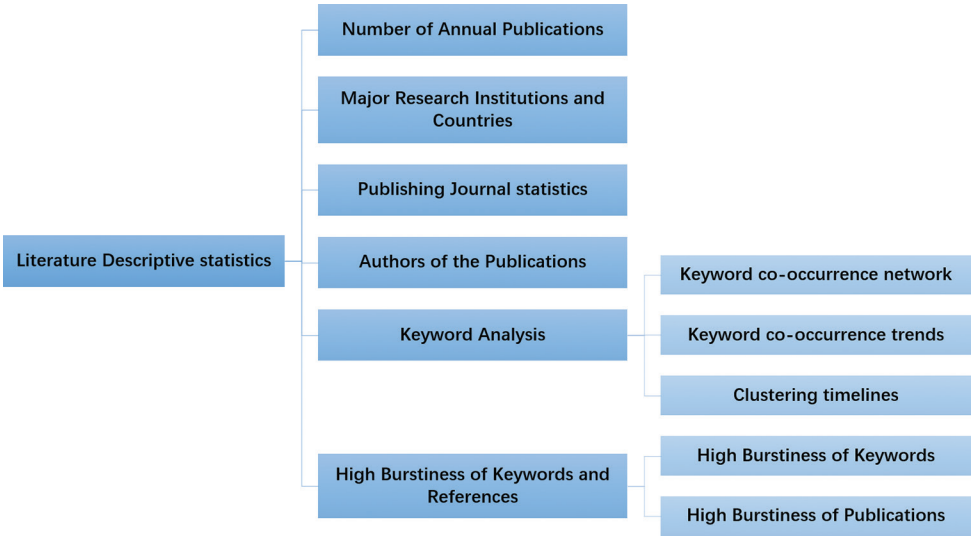
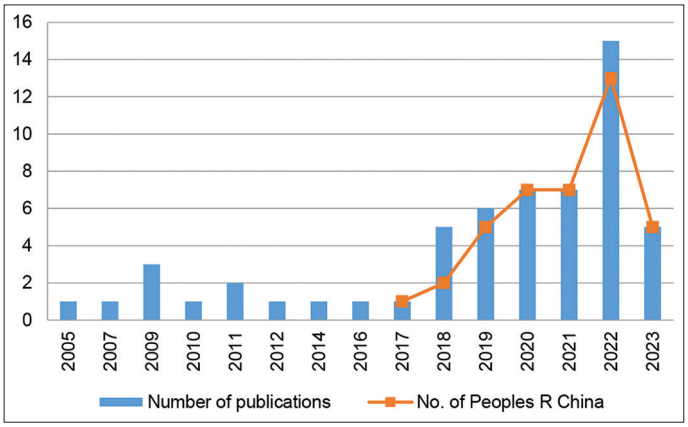


Figure 3: Annual publications on DCETP in web of science core collection



3.2. Major Research Institutions and Countries

Table 1 provides an overview of the key participating organizations in the field of global DCETP research, along with their country affiliations and the number of papers published by each. This field has seen extensive participation from several countries, including China, the United Kingdom (UK), France, and the United States (US). Notably, Chinese institutions have made significant contributions: two universities, North China Electric Power University and China University of Mining and Technology, have published at least three papers each, while 41 other institutions were actively engaging in this research area. Research institutions in the UK have also shown their activity, with three of the institutions published more than three papers and four participated in the research. Institutions from France and the US also exhibited enthusiasm, with 12 and 7 institutions publishing relevant papers, respectively. Additionally, there are 18 research institutions from other countries contributing to research in the field of DCETP.

The data highlights the internationalization of the DCETP research, with China, the UK, France, and the US have outstanding positions in this area. Such a distribution might be related to those countries actively participating in building a carbon market, conducting studies on factors influencing the price of carbon, having research capability, and getting involved in international cooperation.

Table 1: Major participating institutions

Research Institution	Country	No. of Publications
North China Electric Power University	China	8
RLUK- Research Libraries UK	United Kingdom	5
N8 Research Partnership	United Kingdom	3
University of Manchester	United Kingdom	3
China University of Mining and Technology	China	3
Other 41 Research Institutions	China	51
Other 12 Research Institutions	France	12
Other 7 Research Institutions	United States	7
Other 4 Research Institutions	United Kingdom	4
Other 18 Research Institutions	other countries	18
Total: 87	17	114

3.3. Publishing Journals Statistics

Table 2 presents the distribution of articles included in this study across different journals, indicating the percentage and number of articles in each journal. The table highlights the influence and recognition of seven prominent journals in the field. Energy Economics, Journal of Cleaner Production, Sustainability (Basel), as well as Environmental Science and Pollution Research (ESPR) were the top journals publishing relevant articles, each accounting for 10.5% of the total. They were closely followed by Carbon Management and Energy, and the Polish Journal of Environmental Studies, with 5.3% and 3% respectively.

In terms of citations, Energy Economics was considerably more popular than the rest of the field, with 742 citations, and the Journal of Cleaner Production a distant second at 190. In contrast, Sustainability (Basel) and ESPR had only 39 and 24 citations respectively, despite publishing six articles each. This suggests that articles published in Energy Economics hold significant influence and authority in advancing the research discourse and providing valuable insights for researchers and policymakers.

In addition, the distribution of these journals indicates the multidisciplinary nature of DCETP research, underscoring the importance of incorporating various disciplinary perspectives such as economics, environmental science, engineering, and policy analysis to comprehensively comprehend the DCETP. These journals serve as platforms for researchers to present their findings, engage in discussions, and disseminate knowledge. They are valuable resources for researchers new to the field.

3.4. Authors of the Publications

The collected data for analysis revealed that out of the 57 papers, Sun Wei from North China Electric Power University emerged as the most prolific author, having published 4 papers and being the first author on all of them. In contrast, the other first authors each published only 1 paper. Additionally, we utilized VOSviewer software to analyze the collaboration among all authors (Figure 4). This visualization presents a network of collaboration comprising 179 distinct authors. Each node in the network represents an author, while the connecting lines between nodes indicate the collaborative relationships between them. The different colors of the community structures in the figure represent clusters of authors based on shared research topics or collaboration styles. This visualization tool is instrumental in comprehending the structure of author collaborations, identifying key influencers, and exploring the overall architecture of the collaborative network through an economic lens.

Table 2: Top 7 journals on DCETP

Journal	Number	Percentage	Citations
Energy Economics	6	10.5	742
Journal of Cleaner Production	6	10.5	190
Sustainability (Basel)	6	10.5	39
Environmental Science and Pollution Research	6	10.5	24
Carbon Management	3	5.3	51
Energies	3	5.3	35
Polish Journal of Environmental Studies	3	5.3	14

By examining nodes, connections, and community structures, we can gain insights into collaboration patterns, key authors, and potential research opportunities within the network. As depicted in the figure, most research areas within DCETP exhibit small-scale author collaborations, the largest collaborative network is led by Zhang and Wen, involving nine participants. Notably, there appears to be limited collaboration between authors from different networks, suggesting a lack of effective communication and a preference among authors in the field to collaborate within their own groups.

3.5. Keyword Analysis

3.5.1. Keyword co-occurrence Network

Analyzing the frequency of keywords over different periods offers researchers a valuable perspective for understanding the research direction. Figure 5 illustrates the results of our keyword co-occurrence network analysis conducted using VOSviewer software. The analysis encompasses 329 keywords,

Figure 4: Collaborative relationship map of authors

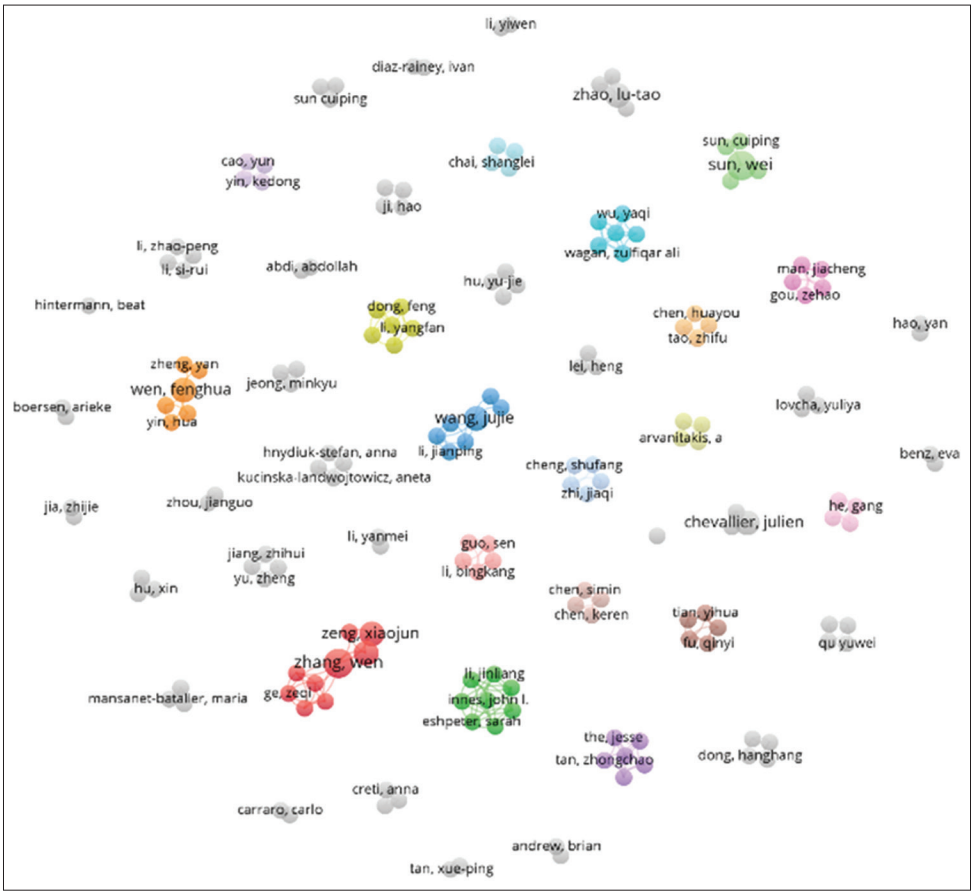
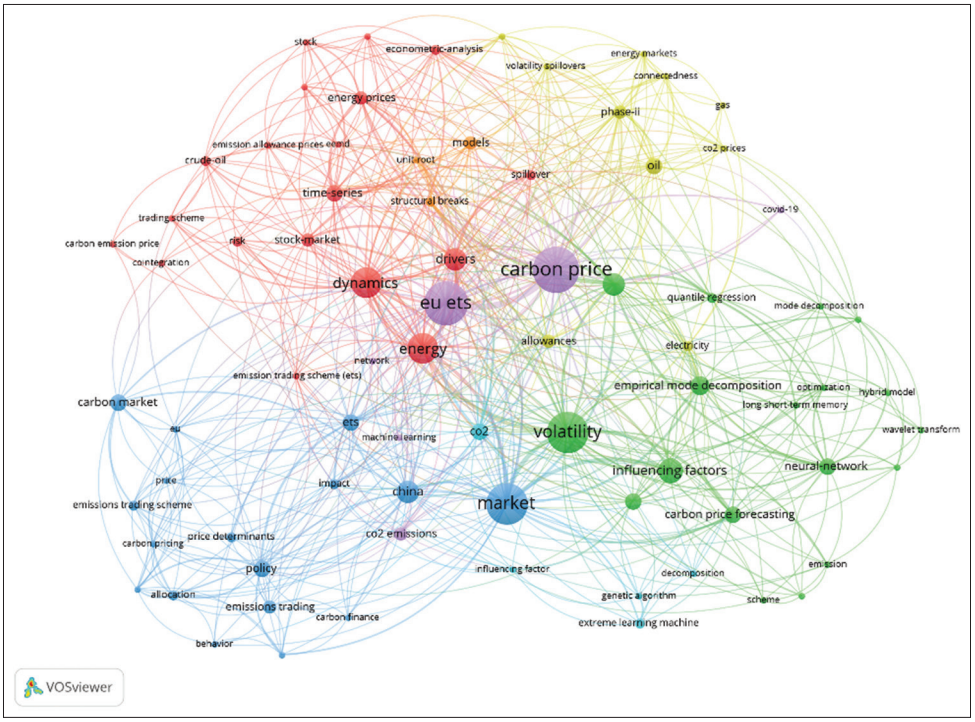


Figure 5: Keyword co-occurrence network



with a minimum occurrence set at 2. In this analysis, each node represents a keyword, and the size and color of the node indicate the importance of keyword, with larger nodes corresponding to higher frequency of occurrence. VOSviewer employs clustering based on keyword co-occurrence patterns, grouping together keywords with similar patterns.

From the Figure 5, it is evident that the network revolves around the central intersection of the purple node "carbon price." The network is primarily divided into three areas. Firstly, the blue area focuses on the analysis of different markets, with keywords such as market, EU ETS, China, and policy serving as the main connecting points. Secondly, the green area centers around volatility, incorporating keywords such as influencing factors, empirical model decomposition, carbon price prediction, and neural network. This area highlights various research models employed in the analysis of CETP volatility and forecasting. Lastly, the red area, with dynamics and energy as key connecting points, addresses different influencing factors, involving keywords such as drivers, stock markets, time series, energy price, and crude oil. This area emphasizes the exploration of diverse factors influencing CETP. Overall, the content of these three areas is closely interconnected, centered around CETP, and focused on price volatility, dynamics, influencing factors, and drivers in the European and Chinese carbon markets. Energy, as one of the determinants, has garnered significant attention from researchers.

3.5.2. Keyword co-occurrence trends

To comprehensively understand current research trends, it is essential to examine the evolution of keywords over time. The graph of keyword co-occurrence trends (Figure 6) generated by VOSviewer provides insights into the dynamics of keyword co-occurrence and highlights the shifts in research focus.

Analyzing Figure 6, it is evident that in the early stages of development prior to 2018, keywords such as carbon market, emissions trading, time series, and energy price received significant attention. The dominant keyword during this period was "EU ETS", represented by a darker color. This aligns with the focus on CETP in the European region, considering that the European carbon market has been active since 2005, as observed in the earlier section of data analysis.

From 2018 to 2020, researchers focused on keywords such as dynamics, model, drivers, and China, demonstrating a diversification of research perspectives and a wealth of theories. The rise of China's carbon market also attracted significant attention from researchers.

In the past 2 years, keywords such as volatility, influencing factors, stock-market, empirical mode decomposition, CETP forecasting, neural-network, and spillover have started to emerge. Although the frequency of these keywords is still relatively low due to the limitations of the time period, they indicate three key research trends. Firstly, researchers are beginning to employ relevant determinants for CETP forecasting. Secondly, they are exploring different factors for correlation analysis. Thirdly, they are adopting a variety of econometric methods to analyze the influencing factors of CETP.

3.5.3. Clustering timelines

Using Citespace software, we analyzed timelines through clustering and obtained similar results as depicted in Figure 7. The analysis revealed a total of seven clusters, each representing a distinct timeline. Typically, each cluster comprises a group of literature with similar topics or research directions. We derived the cluster labels from the keywords in the co-occurrence network,

Figure 6: Keyword co-occurrence trends

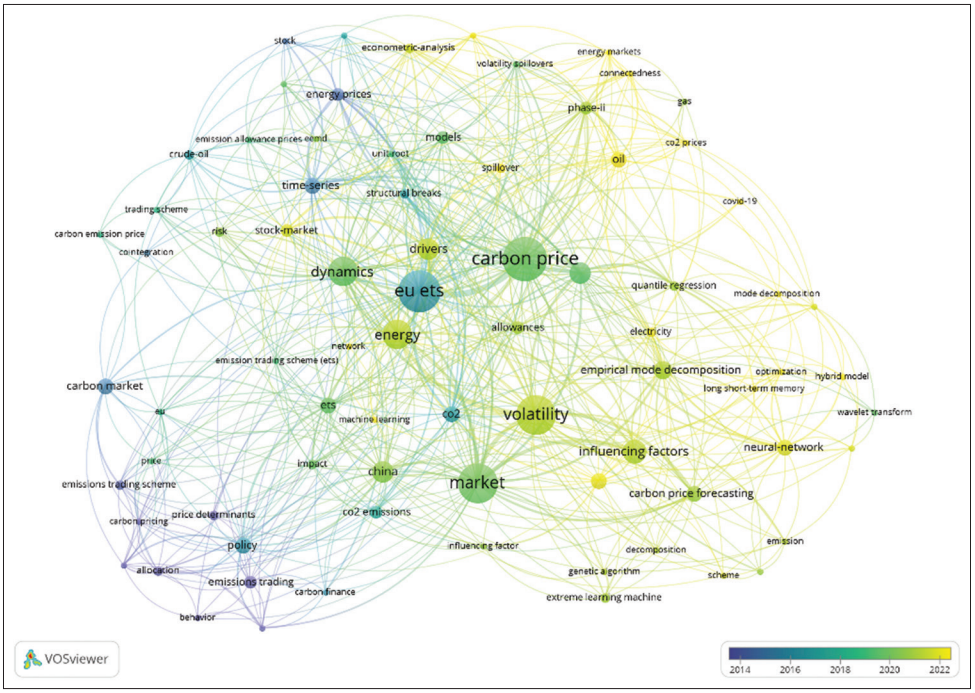
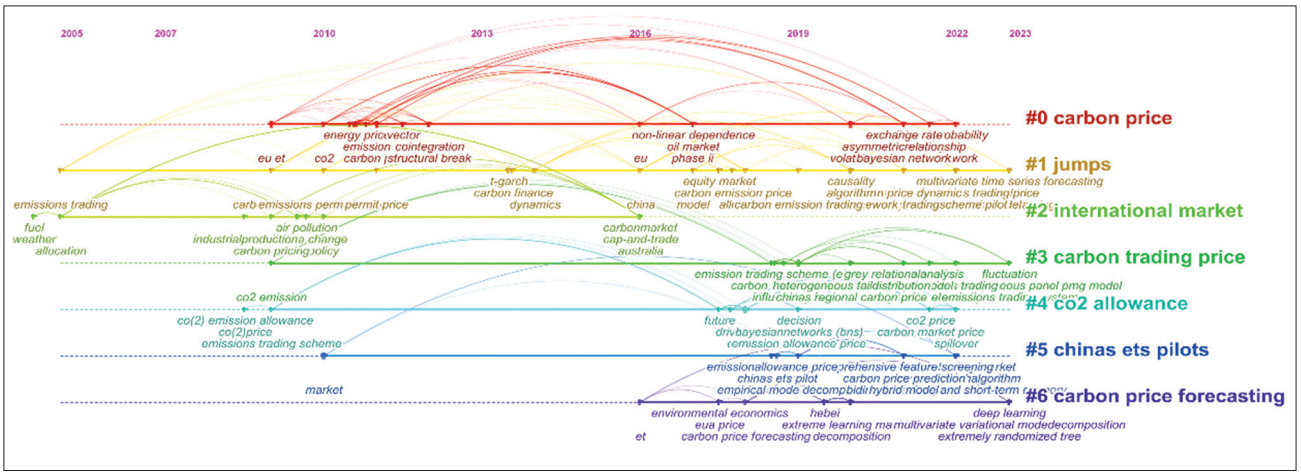


Figure 7: Clustering timelines of DCETP



which are distributed within corresponding time periods based on the year of occurrence. This approach enables us to infer the main research content and issues addressed by each cluster in different time periods, unveiling the focus and emphasis in literature research.

In accordance with our search criteria, the appearance of Cluster #0(carbon price), Cluster #3(carbon trading price) and Cluster #4(CO2 allowance) is expected and strongly linked to our topic. Cluster #1 (jumps) and Cluster #2 (international market) were the earliest clusters to appear, but Cluster #2 terminated in 2016, while Cluster #1 continues to be studied until 2023, indicating that "jumps" has been the focus of academic attention. Group 5 (Chinas ETS pilots) was mentioned in 2010, and the keywords in this cluster were re-activated in 2018 as China began to emphasize the development of its carbon market. From 2016, the number of related keywords in Cluster #6 (carbon price forecasting) began to rise, indicating a growing trend. This also suggests that research methods and models are becoming increasingly diverse and sophisticated, with researchers beginning to utilize various factors for CETP prediction.

3.6. High Burstiness of Keywords

CiteSpace's burst detection feature can identify fluctuations in keyword usage by analyzing the distribution of burst keywords within corresponding topics (Chen et al., 2010). In Figure 8, "volatility", "EU ET", and "emissions trading" are the three most intense burst keywords, with strength indicators of 2.83, 2.74, and 1.74, respectively. With 2017 as the dividing point, initially, people focused on "allocation", "eu et", "time series", "policy", and "energy price". Later on, the focus shifted towards "dynamics", "volatility", and "market" dynamics regarding price. In summary, the focus of the research was primarily on the EU ETS until 2017. However, since then, there has been a shift towards

studying new markets, indicating a growing interest in this area. Researchers have also begun to employ various econometric methods and explore different influencing factors to investigate the volatility and impacts of the CETP. This reflects the innovation in research methods and the application of relevant factors for CETP forecasting.

4. RESEARCH HIGHLIGHTS ON DCETP

4.1. Principal Theories and Econometric Models

In terms of theoretical foundations, only 4 of the 57 papers explicitly stated the relevant theories, including "Perfect Competition Theory" and the "Efficient Market Hypothesis" proposed by Maydybura and Andrew (2011), "Linking Theory" proposed by Diaz-Rainey and Tulloch (2018), "Equilibrium Price Theory" proposed by Ji et al. (2021), and "Externality Theory" and "Emission Trading Theory" proposed by Zeng et al. (2023). This suggests a consensus within the academic community regarding the theoretical foundations of the carbon trading market.

As for the econometric models, of the 57 papers, only the earliest one did not apply any econometric model: Christiansen et al. (2005) analyzed the facts and relevant data to propose three main influences affecting EU ETS prices during 2005-2007—political and regulatory issues, market fundamentals, and technical indicators. The models used in the other 56 articles can be categorized into two main types: relational models, which analyze how various determinants affect the price of carbon trading, and predictive models, which forecast CETP.

A total of 39 papers in the first category utilized various econometric models to explore relationships. As shown in Table 3, 10 papers focused on the VAR model and its related improved models, 5 papers utilized the GARCH model and its improved variations, and the remaining 24 papers implemented diverse relational models depending on the prevailing scenario. It is also apparent that scholars favored relatively uncomplicated regression models before 2017, with more refined versions of the relational model being utilized from that point onward. From the most recent 2022, 10 papers employed varied econometric relational models, out of which 3 utilized the VAR and its enhanced model, and 2 employed the Bai-Perron test and its hybrid model. Additionally, models such as the dynamic heterogeneous panel PMG model (Zeng et al., 2023), the dynamic connectedness measurement approach (Wen et al., 2022), the improved gray relational analysis model (Song et al., 2022), the Bai-Perron structural break test, the Johansen cointegration technique and the Newey-West regression estimation (Dong et al., 2022) were also employed in different papers. This shows a growing variety of relational models currently being used to analyze the factors influencing CETP.

Figure 8: High burstiness of keywords

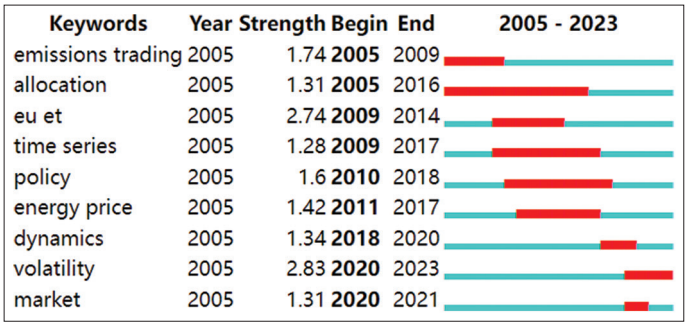


Table 3: The number of occurrences of different models

Model	Time
Relationship Model	
VAR and Improved Model	10
GARCH and Improved Model	5
Other Relationship Models	24
Predict Model	
ELM and Improved Model	6
Other Predict Models	16

The second category comprises 22 academic papers that analyze CETP trends using various forecasting models. Notably, only one paper conducted a predictive analysis before 2017. The remaining papers, which focused on influencing factors, indicate that all 21 predictive analyses were completed after 2017. Specifically, of the nine predictive analytics papers published since 2022, two papers utilized the long short-term memory network and its hybrid model, and two additional papers employed the neural network model and its hybrid model. The remaining papers present unique research models developed by the authors, such as the dynamic self-learning N-A MEMD-COSWOAELM model (Zhang et al., 2023); the ensemble empirical mode decomposition method (Xu et al., 2019); and a novel hybrid CETP forecasting framework (Xu et al., 2022); a CETP forecasting method based on multi-source information fusion; and hybrid multiscale decomposition (Wang et al., 2022); and a combination of the principal component analysis method and various methods of supervised machine learning (Rudnik et al., 2022). This indicates that researchers are not satisfied with existing predictive models and are continually developing innovative forecasting models to enhance prediction accuracy.

4.2. The Important Determinants

Table 4 provides a statistical count of determinant occurrences across 57 articles. Factors with higher occurrence rates are considered more significant and are worth further academic study. We assessed the individual impact of each determinant on the CETP. Moreover, several articles have not only explored the determinants" significant impacts on CETP but also provided econometric modelling results that highlight the direction of each determinant's influence, whether it is positive or negative. Furthermore, several articles have concentrated on utilizing determinants to forecast CETP, thereby enhancing prediction accuracy.

The table reveals that CETP is influenced by five primary categories: Market systems and associated policies (including 12 items), Energy (4 items), Economy (10 items), Environment (7 items), and Miscellaneous (2 items). According to the statistical analysis of major categories, Energy is deemed the most influential factor with a total of 141 occurrences, followed by Economy with 70 occurrences, Market System and Related Policies with 60 occurrences, Environment with 39 occurrences, and Others with 6 occurrences.

Table 4: Summary of determinants of CETP

Determinants	Times				
Main category and subdivision	**Positive**	**Negative**	**Uncertain direction of impact on relationships**	**Predict**	**Total**
Energy					141
Coal	3	6	21	13	43
Oil	8	1	17	15	41
Natural gas	4	-	21	15	40
Electricity	1	-	10	6	17
Economic					70
Finance markets	5	2	16	8	31
Industrial sectors and related index	-	1	8	5	14
Exchange rate	-	-	3	8	11
GDP			2	1	3
Macro economy risk (include COVID-19 pandemic)	-	1	2		3
Treasury bill yield or junk bond yield	-	-	3		3
Interest rate	-	1	-	1	2
CPI	-	-	1	-	1
Green industry	-	-	1	-	1
Proportion of tertiary industry	-	-	1	-	1
Market system and related policies					60
Offsets: Clean development mechanism (CERs) or Joint Implementation (ERUs)	4	-	8	5	17
Similar Carbon market	1	-	5	8	14
Carbon emission allowances	-	1	5	2	8
Cap	-	2	4	-	6
Auction	1	-	2	-	3
Transaction rules: Monitoring, reporting, verification, investment access, carbon forward	-	-	3	-	3
Coverage	1	1	1	-	3
Banking and borrowing	-	-	2	-	2
Emission reduction targets	-	-	1	-	1
Free allowance rate	1	-	-	-	1
Annual decline factor	1	-	-	-	1
Green recovery plan	-	-	1	-	1
Environment					39
Weather (temperatures)	-	-	12	7	19
Air quality index	-	1	6	4	11
Rainfall precipitation	-	-	3	1	4
Reservoir levels	-	-	2	-	2
Heating degree day	-	-	1	-	1
Humidity	-	-	-	1	1
Wind speed	-	-	-	1	1
Others					6
Web search index	-	-	1	4	5
Mobility trends data	-	-	1	-	1

The top nine determinants, when segmented specifically, are Coal, Oil, Natural Gas, Financial Markets, Weather (Temperatures), Electricity, Similar Carbon Markets, Industrial Sectors, and Related Indices, with frequency levels ranging from 14 to 43 occurrences.

In selecting determinants for carbon pricing, it's important to rely on three key principles: Logic, Measurability, and Accessibility. Logic means that the impact of the determinant on the CETP is consistent with basic factual or theoretical logical reasoning, rather than purely subjective conjecture. Measurability means that the factor has specific calculable proxies that can be analyzed using econometric models. Accessibility, as the name implies, means that the factor's proxy variables have specific access (Rabe, 2018). From Table 4, we can see that because the accessibility of DCETP in individual carbon markets is not easy, even though there are individual influences that are more logical, none or fewer of these articles choose these influences. For instance, when examining future CETP, researchers in the field of market systems and related policies only chose the first three factors from the various influences analyzed in the articles, without considering other aspects.

It is important to acknowledge that, despite the inherent subjectivity in selecting determinants, the inclusion of certain criteria suggests that authors regard these elements as having a substantial influence on CETP. Determinants that appeared only once in the literature include emissions reduction targets, free allowance rates, annual decline factors, green recycling schemes, consumer price indices, green industries, tertiary sector ratios, heating degree days, humidity, wind speeds, and mobility trend data. While the influence of these determinants on CETP may be specific to certain periods and particular carbon markets, their potential for broader applicability justifies continued research by scholars.

Importantly, studies show that the impact of various determinants on CETP differs across carbon markets, time frames, and models, resulting in varying effects. While one study finds a positive impact of the carbon emission trading system's coverage scope on CETP, another observes a negative impact. Similarly, the effects of coal (with 3 studies showing positive and 6 negative), fuel (8 positive, 1 negative), and financial markets (5 positive, 2 negative) are inconsistent. These conflicting results indicate that the precise influence of these factors on CETP remains inconclusive and necessitates further research. Moreover, the limited number of studies identified with the keywords used in this study implies that additional research may yield different insights.

4.3. Trend Analysis

Combined with the related analysis in the previous section, we can summarize the changing research trends in this research area. From 2005 to 2017, the scarcity of academic research in the field of carbon markets is attributed to its recent emergence and the lack of comprehensive data on CETP. Only 12 relevant articles have been published during this period. The majority of scholars have focused their research on identifying appropriate determinants for CETP in various markets and analyzing their specific impacts on the levels of CETP.

Since 2017, the global carbon market has entered a new stage, leading to a significant increase in related studies. In particular, there has been a gradual increase in the number of studies utilizing determinants to forecast CETP. Out of 45 papers, 21 specifically focused on CETP forecasting. This trend reflects the consensus among academics that the five major categories of factors mentioned earlier have a decisive impact on CETP. Additionally, there is a strong belief that applying these determinants can enhance the accuracy of CETP forecasts. However, as the global carbon market continues to evolve and research in this area deepens, researchers have come to realize that there are additional factors that can influence the volatility of CETP. In the economic domain, the Consumer Price Index was highlighted in 2018; the share of the tertiary industry in 2021; and both the green industry and COVID-19 in 2022. In the market system and related policies, the free allowance rate and the annual decline factor were both noted in 2019, while the emission reduction target and the EU Green Recovery Plan emerged in 2021 and 2022, respectively. In the environmental domain, wind speed and humidity became pertinent factors in 2021 and 2023, respectively. The emergence of these determinants is likely influenced by specific historical contexts and regional policy factors.

Meanwhile, the selection of determinants has become increasingly diversified in recent years, from the initial subjective manual selection to screening out the determinants by using the average influence value method (Li et al., 2020), to selecting the key determinants by using the Least Absolute Shrinkage and Selection Operator method (Li et al., 2022), and some researchers have also specially designed a feature screening technique that combines the advantages of Principal Component Analysis, Random Forest and Gradient Boosted Decision Tree methods to extract determinants (Wang et al., 2021). During research on the impact of determinants on CETP, researchers have progressively employed more sophisticated econometric models, from the simplest comparative analysis of data at the beginning, to general regression analysis (Maydybura and Andrew, 2011), to a Quantile Regression Model (Tan and Wang, 2017), to Structural Breaks Test, VAR Models and Granger Causality Tests (Diaz-Rainey and Tulloch, 2018) and the Difference-in-Differences model (Yang et al., 2018), to Autoregressive Distributed Lag Model (Ji et al., 2021), to explore the degree of correlation between factors in both spatial and temporal dimensions using an improved Gray Correlation Analysis Model (Song et al., 2022), to the more complex integrated system (including a Noise-Assisted Multivariate Empirical Mode Decomposition method and the Lempel-Ziv Complexity Algorithm (Wu et al., 2022). There are numerous intricate econometric models, suggesting that researchers with diverse foci will persist in discovering or building models that more accurately depict the relationship between determinants and the CETP.

Regarding the selection of research subjects, most articles have focused on the Chinese carbon market and the European Union (EU) ETS, while few others have analyzed other carbon markets. Based on the statistics, out of the 57 published articles, 31 were dedicated to the China's ETS, and 26 to the EU ETS. The remaining two articles examined the Korea ETS, the Western Climate Initiative market, and the New Zealand ETS. Additionally, an article examines the trading price in the aforementioned markets as well as in the following carbon markets: RGGI, the Japanese ETSs, Kazakhstan ETS, the Swiss ETS, CCX, and the Pacific Carbon Trust. China's leading position in global carbon emissions underscored the significance of its pilot carbon markets for study. Additionally, EU ETS was one of the earliest carbon trading markets opened, with the greatest market maturity. The rules of many carbon trading markets are based on EU ETS as a reference, resulting in numerous studies on the factors influencing the European CETP. It is foreseeable that with the growing concern over climate warming and the expansion and maturation of the global carbon market, research on regional carbon markets will proliferate. Scholars are expected to continue to focus on the carbon markets in China and Europe.

5. CONCLUSIONS AND FUTURE RESEARCH

We conducted a systematic review and bibliometric analysis of 57 studies focusing on the DCETP. Using the Web of Science Core Collection database, we conducted an extensive search of literature published between 2003 and 2023 for DCETP. Using tools such as Excel, Citespace, and VOSviewer, we conducted a bibliometric analysis and network mapping to reveal the research dynamics in the field. This analysis covered dimensions such as the number of publications, authors" affiliations, relevant journals, and keywords. Additionally, we thoroughly reviewed the literature, focusing on the types and impacts of determinants, theories from related studies, econometric models, and emerging research trends. This comprehensive examination enabled us to trace the trajectory of studies on the DCETP over the past two decades.

Since 2005, academic interest in the DCETP has been steadily increasing. Although the growth was relatively slow during the first decade, the number of relevant publications has seen a significant

surge since 2018. As of May 2023, China has emerged as the leading country in this research field, with substantial contributions also coming from European countries and the US. Notably, Sun Wei from North China Electric Power University has demonstrated remarkable innovation. However, collaborations between authors tend to be limited to small-scale partnerships, lacking large-scale or cross-network collaborations. Relevant papers are most frequently published in journals such as Energy Economics, Journal of Cleaner Production, Sustainable Development (Basel), and Environmental Science and Pollution Research.

Keyword analysis plays a crucial role in our study, allowing us to identify trends and patterns in the research landscape. By examining keyword co-occurrence networks, we have found that over the past 20 years, research has primarily focused on the volatility, dynamics, impact, and drivers of carbon market prices, with the markets of study mainly centered in Europe and China. Through the analysis of keyword co-occurrence trends, timeline clustering, and keywords with high impact, we have identified four main directions of recent research: the application of determinants for CETP forecasting, the emergence of novel and diverse determinants, the advancement of research methodologies and modelling techniques, and the shift in focus from the EU ETS to new markets.

An in-depth analysis of 57 articles reveals a notable phenomenon in the field: while authors frequently select, derive, and interpret econometric models to understand the impact of determinants on CETP. The econometric models employed by scholars can be categorized into two types: influence relationship models and forecasting models. In recent years, both types have seen significant progress and innovations. However, scholars have not engaged in in-depth exploration of relevant theories, nor have they attempted to conduct research using new theoretical frameworks.

A central question in our study is: What are the determinants of CETP and how do they impact CETP? Our analysis indicates that energy is the most critical determinant, followed by economic, market system, and policy-related factors, as well as environmental factors. The impact of determinants on CETP varies across studies, potentially due to differences in econometric models, research subjects, and data sources. As the global carbon market continues to develop and new markets emerge, we anticipate the emergence of novel and diverse determinants. We expect that future research will refine the identification of the most appropriate determinants for different markets. Additionally, further exploration of new relationships and forecasting models for these determinants is warranted. It is also important to explore other economic theories and models that may better explain and assess the impact of these determinants on CETP, thereby stimulating more academic research in this area.

Furthermore, it is important to acknowledge the limitations of this study. Firstly, although the Web of Science Core Collection database is highly representative, it is possible that some marginal or emerging research findings were not included. Secondly, the search strategy and filtering criteria used may have limited our access to comprehensive information. Given these limitations, we encourage future studies to adopt a more comprehensive and scientifically rigorous literature review methodology. This would provide robust theoretical support and practical guidance for optimizing the global carbon market, predicting CETP stability, and achieving low-carbon goals.

REFERENCES

Abdelmageed, S., Zayed, T. (2020), A study of literature in modular integrated construction-Critical review and future directions. Journal of Cleaner Production, 277, 124044.

Ahsan, M.M., Cheng, W., Hussain, A.B., Chen, X., Wajid, B.A. (2022), Knowledge mapping of research progress in vertical greenery systems (VGS) from 2000 to 2021 using CiteSpace based scientometric analysis. Energy and Buildings, 256, 111768.

Chen, C., Ibekwe-SanJuan, F., Hou, J. (2010), The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. Journal of the American Society for Information Science and Technology, 61(7), 1386-1409.

Christiansen, A.C., Arvanitakis, A., Tangen, K., Hasselknippe, H. (2005), Price determinants in the EU emissions trading scheme. Climate Policy, 5(1), 15-30.

De Oliveira, U.R., Espindola, L.S., da Silva, I.R., da Silva, I.N., Rocha, H.M. (2018), A systematic literature review on green supply chain management: Research implications and future perspectives. Journal of Cleaner Production, 187, 537-561.

Diaz-Rainey, I., Tulloch, D.J. (2018), Carbon pricing and system linking: Lessons from the New Zealand emissions trading scheme. Energy Economics, 73, 66-79.

Dong, F., Gao, Y., Li, Y., Zhu, J., Hu, M., Zhang, X. (2022), Exploring volatility of carbon price in European Union due to COVID-19 pandemic. Environmental Science and Pollution Research, 29(6), 8269-8280.

Egenhofer, C. (2007), The making of the EU Emissions trading scheme: Status, prospects and implications for business. European Management Journal, 25(6), 453-463.

Fan, Y., Jia, J.J., Wang, X., Xu, J.H. (2017), What policy adjustments in the EU ETS truly affected the carbon prices? Energy Policy, 103, 145-164.

Hao, Y., Tian, C., Wu, C. (2020), Modelling of carbon price in two real carbon trading markets. Journal of Cleaner Production, 244, 118556.

Hu, X., Yang, Z., Sun, J., Zhang, Y. (2020), Carbon tax or cap-and-trade: Which is more viable for Chinese remanufacturing industry? Journal of Cleaner Production, 243, 118606.

Hua, Y., Dong, F. (2019), China's carbon market development and carbon market connection: A literature review. Energies, 12(9), 1663.

ICAP. (2023), ICAP Emissions Trading Worldwide 2023 Status Report. Pakistan: International Carbon Action Partnership.

Ji, C.J., Hu, Y.J., Tang, B.J. (2018), Research on carbon market price mechanism and influencing factors: A literature review. Natural Hazards, 92(2), 761-782.

Ji, C.J., Hu, Y.J., Tang, B.J., Qu, S. (2021), Price drivers in the carbon emissions trading scheme: Evidence from Chinese emissions trading scheme pilots. Journal of Cleaner Production, 278, 123469.

Ji, C.J., Li, X.Y., Hu, Y.J., Wang, X.Y., Tang, B.J. (2019), Research on carbon price in emissions trading scheme: A bibliometric analysis. Natural Hazards, 99(3), 1381-1396.

Kitchenham, B., Pearl Brereton, O., Budgen, D., Turner, M., Bailey, J., Linkman, S. (2009), Systematic literature reviews in software engineering-A systematic literature review. Information and Software Technology, 51(1), 7-15.

Li, H., Huang, X., Zhou, D., Cao, A., Su, M., Wang, Y., Guo, L. (2022),

Forecasting carbon price in China: A multimodel comparison. International Journal of Environmental Research and Public Health, 19(10), 6217.

LI, M.F., Hu, H., Zhao, L.T. (2022), Key factors affecting carbon prices from a time-varying perspective. Environmental Science and Pollution Research, 29(43), 65144-65160.

Li, Z.P., Yang, L., Li, S.R., Yuan, X. (2020), The long-term trend analysis and scenario simulation of the carbon price based on the energy-economic regulation. International Journal of Climate Change Strategies and Management, 12(5), 653-668.

Lin, B., Jia, Z. (2019), What are the main factors affecting carbon price in Emission trading scheme? A case study in China. Science of the Total Environment, 654, 525-534.

Maydybura, A., Andrew, B. (2011), A study of the determinants of emissions unit allowance price in the European union emissions trading scheme. Australasian Accounting Business and Finance Journal, 5(4), 123-142.

Mukherjee, D., Lim, W.M., Kumar, S., Donthu, N. (2022), Guidelines for advancing theory and practice through bibliometric research. Journal of Business Research, 148, 101-115.

Rabe, B.G. (2018), Can We Price Carbon? United States: MIT Press.

Romanelli, J.P., Gonçalves, M.C.P., de Abreu Pestana, L.F., Soares, J.A.H., Boschi, R.S., Andrade, D.F. (2021), Four challenges when conducting bibliometric reviews and how to deal with them. Environmental Science and Pollution Research, 28(43), 60448-60458.

Rudnik, K., Hnydiuk-Stefan, A., Kucińska-Landwójtowicz, A., Mach, Ł. (2022), Forecasting day-ahead carbon price by modelling its determinants using the PCA-based Approach. Energies, 15(21), 8057.

Song, X., Zhang, W., Ge, Z., Huang, S., Huang, Y., Xiong, S. (2022), A Study of the influencing factors on the carbon emission trading price in China based on the improved gray relational analysis model. Sustainability, 14(13), 8002.

Tan, X.P., Wang, X.Y. (2017), Dependence changes between the carbon price and its fundamentals: A quantile regression approach. Applied Energy, 190, 306-325.

Wang, J., Cui, Q., Sun, X. (2021), A novel framework for carbon price prediction using comprehensive feature screening, bidirectional gate recurrent unit and Gaussian process regression. Journal of Cleaner Production, 314, 128024.

Wang, J., Zhou, Y., Cooke, F.L. (2022), Low-carbon economy and policy implications: A systematic review and bibliometric analysis. Environmental Science and Pollution Research, 29(43), 65432-65451.

Wang, P., Liu, J., Tao, Z., Chen, H. (2022), A novel carbon price combination forecasting approach based on multi-source information fusion and hybrid multi-scale decomposition. Engineering Applications of Artificial Intelligence, 114, 105172.

Wen, F., Zhao, H., Zhao, L., Yin, H. (2022), What drive carbon price dynamics in China? International Review of Financial Analysis, 79, 101999.

Wu, Z., Zhang, W., Zeng, X. (2022), Exploring the short-term and long-term linkages between carbon price and influence factors considering COVID-19 impact. Environmental Science and Pollution Research, 30(22), 61479-61495.

Xu, J., Tan, X., He, G., Liu, Y. (2019), Disentangling the drivers of carbon prices in China's ETS pilots-An EEMD approach. Technological Forecasting and Social Change, 139, 1-9.

Xu, W., Wang, J., Zhang, Y., Li, J., Wei, L. (2022), An optimized decomposition integration framework for carbon price prediction based on multi-factor two-stage feature dimension reduction. Annals of Operations Research, 345, 1-38.

Yang, B., Liu, C., Gou, Z., Man, J., Su, Y. (2018), How will policies of China's CO_2 ETS affect its carbon price: Evidence from Chinese pilot regions. Sustainability, 10(3), 605.

Zeng, S., Fu, Q., Yang, D., Tian, Y., Yu, Y. (2023), The influencing factors of the carbon trading price: A case of China against a "double carbon" background. Sustainability, 15(3), 2203.

Zhang, W., Wu, Z., Zeng, X., Zhu, C. (2023), An ensemble dynamic self-learning model for multiscale carbon price forecasting. Energy, 263, 125820.

Zhang, Z., Liu, Y., Han, Z., Liao, X. (2022), Green finance and carbon emission reduction: A bibliometric analysis and systematic review. Frontiers in Environmental Science, 10, 929250.