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Current trends in carbon emission trading: Theoretical perspectives, research methods and emerging themes

Zhang Xiaoping[1], Nur Syuhada Jasni[2*], Rina Fadhilah Ismail[3]
[1]Faculty of Accountancy, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia & Faculty of Accountancy, Hebei Finance University, Baoding, Hebei Province, China; 2022273108@student.uitm.edu.my (Z.X.)
[2,3]Faculty of Accountancy, Universiti Teknologi MARA Cawangan Selangor, Kampus Puncak Alam, Selangor, Malaysia; nursy168@uitm.edu.my (N.S.J.) rinafadhilah@uitm.edu.my (R.F.I.)

Abstract: Since the inception of the EU carbon emissions trading market, it has experienced substantial growth. However, there is a shortage of comprehensive analysis on the policy implications of carbon emissions trading in the context of the low-carbon economy. The article utilizes bibliometric and content analytic methodologies to thoroughly examine the features and content of 116 relevant pieces of literature. Based on this analysis, a research model on the carbon emissions trading schemes is constructed. The study findings indicate a significant surge in the quantity of published material since 2021, with a predominant focus on terms related to the low carbon economy, such as environmental regulation and carbon emission. The research hotspots are related to transformation and upgrading and enterprise performance, etc. The research theory involves compliance cost theory, Porter's hypothesis theory, emissions trading theory and green innovation theory, empirical research is the main method of carbon emissions trading research. Emerging theme analyses are summarized in terms of the economic, environmental, technological and social effects of carbon trading. Finally, there are research conclusions and future research trends.

Keywords: *Carbon emissions trading, Carbon emission reduction, Technological innovation.*

1. Introduction

The escalating accumulation of global greenhouse gases will exacerbate environmental issues, emphasizing the critical need for advancing energy conservation and emissions reduction within a low-carbon economy (Zhu et al., 2019). Carbon emissions trading is a highly effective approach to regulating and reducing CO_2 emissions. It involves creating a market where CO_2 is treated as a commodity, allowing for better control and management of CO_2 emissions. (Hua & Dong, 2019). Various carbon trading systems were implemented across four continents from 2002 to 2023. The worldwide carbon emissions trading system includes the European Union Emissions Trading System (EU-ETS), which was the first of its kind worldwide, as well as the U.S. Regional Greenhouse Gas Initiative (RGGI), the U.S. California Cap-and-Trade Scheme (CCAT), and the Australian Carbon Pricing System (ACPM), Japan's Tokyo Metropolitan Cap-and-Trade Scheme (Tokyo-CAT), New Zealand's Carbon Trading System (NZ-TS), and China's carbon emissions trading market, among others (Perdan & Azapagic, 2011).

Recently, researchers have done thorough theoretical and empirical studies on the subject of carbon emissions trading. Yu & Xu (2017) conducted scientometric analyses to thoroughly evaluate the present state of carbon emissions trading and investigate its prospective developments. Narassimhan et al. (2018) thoroughly analyze the implementation of the Emissions Trading System (ETS) in eight jurisdictions. Shen et al.(2020) provide a comprehensive analysis of the historical development of carbon

* Correspondence: nursy168@uitm.edu.my

emissions trading. Tang et al.(2020)present a thorough examination of quantitative modeling in research on Emissions Trading Systems (ETS), whereas Wei et al. (2022) provide a comprehensive analysis of peak carbon and carbon neutrality, with a specific emphasis on policy and managerial considerations.

Huang (2023) investigates the impact of carbon emissions trading markets on the shift to more environmentally friendly energy sources. These literature reviews offer a limited and specific synthesis of studies on carbon emissions trading methods, focusing on a single perspective, a specific location, or a fixed timeframe. However, they do not provide a comprehensive overview of the literature about the policy impacts of carbon emissions trading. This paper aims to address this gap by utilizing the Cite Space visualization tool and content analysis method to systematically categorize the policy impacts of carbon emissions trading across four dimensions: economic, environmental, technological, and social. The goal is to offer valuable insights for future researchers and policymakers.

This study aims to provide a thorough assessment, bibliometric analysis, and content analysis of the literature on the effects of carbon emissions trading policies. The paper will explore the following research inquiries.

a. What are the patterns in the quantity of publications within the research field?

b. Who are the most prominent writers, publications, and subject areas in the current study area?

c. What are the primary areas of current research focus in this field?

The paper is organized in the following way. The second part of the study focuses on the collection of data and the methodology used for research. The third part analyzes the metrics that characterize the literature. The fourth part examines the content metrics of the literature, as well as the analysis of the research theory and methodology. The fifth part conducts a thematic analysis of the literature content. Finally, the sixth part concludes the study and provides insights into future research directions.

2. Data Collection and Research Methodology

2.1. Data Collection

The process of conducting a literature search and screening for this work is outlined in Table 1. To ensure the inclusion of high-quality and scientifically rigorous material, only English literature from the Web of Science and Scopus databases was selected for this study. The literature consisted exclusively of journal articles, eliminating conferences, reviews, monographs, and other forms of literature. In particular, a total of 445 pages were obtained from the Web of Science Core Collection database by employing the search word ALL=("Carbon trading*" OR "carbon market mechanism" OR "carbon emission trading" OR "carbon market*") AND ("Company value" OR "productivity" OR "financial performance" OR "carbon reduction* " OR "Environment, society, governance*" OR "technological innovation " OR "innovation*" OR "employment" OR "Social equity" OR "resident income") AND ("enterprise" OR "business" OR "company" OR "corporation" OR "organization" OR "Company"). Similarly, the identical search phrases were utilized in Scopus, leading to the retrieval of a total of 428 articles based on title, abstract, and keywords. To ensure the pertinence of the literature, this work meticulously examined each retrieved article individually.

During the literature screening process, we utilized the relevance ranking feature of the Web of Science database and Mendeley Literature Management Software to eliminate literature that had low relevance and non-academic research. This was done by carefully reading and analyzing the titles, abstracts, keywords, and body contents of the literature. For instance, literature that does not address or delve into the ramifications of carbon emissions trading policies. The bibliometric analysis utilized a total of 116 English-language documents from the years 2000 to 2024.

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Table 1.
Literature screening process.

Literature search	**Databases**	
	Web of science	**Scopus**
Last retrieval time	16st July 2024	16st July 2024
Document type	Article	Article
Search topics	("Carbon trading*" OR "carbon market mechanism" OR "carbon emission trading" OR "carbon market*") AND ("company value" OR "productivity" OR "financial performance" OR "carbon reduction* " OR "Environment, society, governance*" OR "technological innovation " OR "innovation*" OR "employment" OR "social equity" OR "resident income") AND ("enterprise" OR "business" OR "company" OR "corporation" OR "organization" OR "company")	
Number of searches	445	428
Literature screening	Excluding literature that is not relevant to the impacts of carbon emissions trading policies	
Number of post-screening literature	69	47
Literature period	1 January 2000-16 July 2024	
Final number of literature	116	

2.2. Research Methods

This work employs both bibliometric and content analysis methodologies. Bibliometric is the application of mathematical and statistical principles, along with computer analysis, to statistically examine the exterior features of literature. Its purpose is to investigate the structure of knowledge and the progression of research topics and to visually portray this information. By examining literature publications, core authors, and keyword clustering, this method can provide a comprehensive and objective summary of a specific research topic's evolutionary lineage and research layout. However, it is limited in its ability to deeply analyze the specific research content of the literature.

Content analysis is a widely employed qualitative method that involves examining and evaluating the existing state of more specific studies by categorizing, condensing, and summarizing the fundamental content of the literature. It also aims to reveal the inherent qualities of literature that are relevant to a particular study issue. The method combines the comprehensive content of the literature to provide a clear understanding of the present state of development in connected research fields. However, its effectiveness is constrained by the limited data from the literature samples and its subjectivity. This report employs a mixed research method that integrates quantitative and qualitative approaches to examine the impacts and future directions of the carbon emissions pricing scheme.

3. Analysis of Literature Characteristics

3.1. Analysis of Year of Publication

The quantity of papers published on a specific subject is indicative of the level of societal interest in that particular discipline. Furthermore, the popularity of a study topic can be assessed by examining the temporal distribution of these publications. Figure 1 displays the year of publication for the literature that was obtained. The study on the effects of carbon emissions trading programs was first published in 2008. Starting from 2021, there has been a substantial surge in the quantity of pertinent publications and the frequency of citations. More precisely, there are a total of 28 articles published in 2021 and prior, 27 pieces published in 2022, 40 articles published in 2023, and 21 papers published in the first half of 2024. Recent years have seen a surge of interest in the research on carbon emissions trading legislation, with researchers closely examining its impact on several facets of society.

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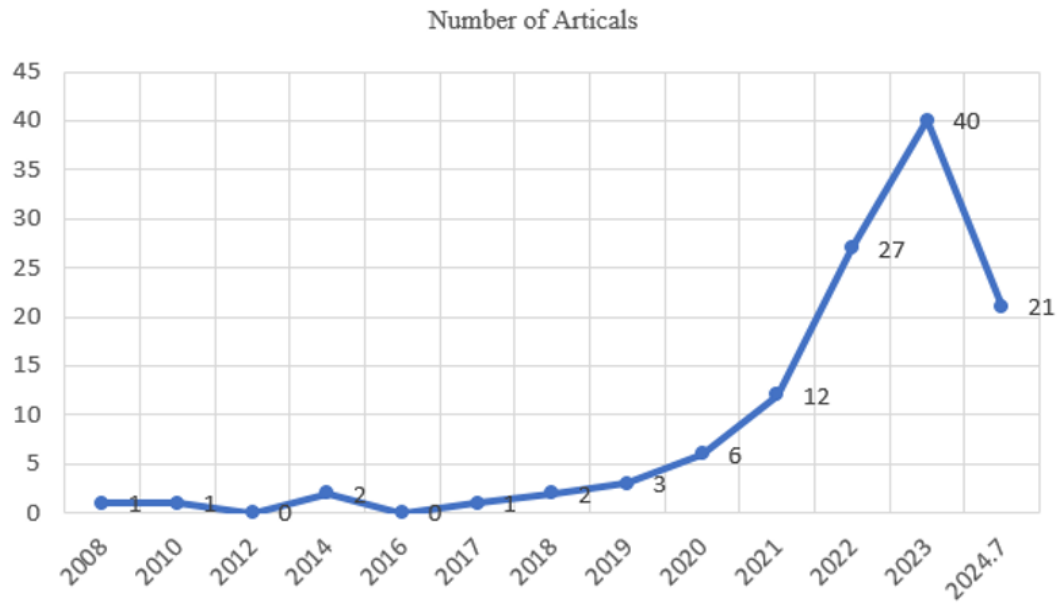

Figure 1.
Number of articles from 2000 to 2024.7.

3.2. Literature Published in Journals

A comprehensive examination of 116 papers indicated that a total of 58 periodicals contributed to the literature. Overall, a substantial volume of literature is dedicated to examining the impacts of carbon emissions trading legislation. However, these journals are not concentrated in one specific region. It is worth mentioning that 40 journals, which accounts for 68.97 per cent, published only one article on this topic. The periodicals encompass several fields such as energy economics, environmental management, environmental science, and ecology. Top journals in the field include the Journal of Cleaner Production, Energy Policy, Energy Economics, and Journal of Environmental Management. The journal that had the greatest number of publications was Sustainability, with a total of 12 articles, accounting for 21.1% of the total. Environmental science and pollution research had the second-highest number of articles, totaling 11, which accounted for 19.3% of all publications. Table 2 displays the statistics of journal publishing.

Table 2.
Journal publications.

No.	Core area journal name	Research area	Number of publications	Impact factor 2023-2024	Proportion of publications (%)
1	Sustainability	Environmental sciences & ecology	12	3.3	0.211
2	Environment science and pollution research	Environmental sciences	11	5.9	0.193
3	Journal of cleaner production	Environmental sciences & ecology	7	9.7	0.123
4	Frontiers in environmental science	Environmental Science	6	3.3	0.105
5	Energy economics	Energy management	5	13.6	0.088
6	Journal of environmental	Environmental science and management	4	8.0	0.070

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No.	Core area journal name	Research area	Number of publications	Impact factor 2023-2024	Proportion of publications (%)
	management				
7	Energy policy	Energy economics and management	4	9.3	0.070
8	Environment, development and sustainability	Environment and sustainability	4	4.7	0.070

3.3. Author Co-occurrence Analysis

This article examines the incidence of authors in 116 papers on the subject of carbon emissions trading policy effects, utilizing Cite space and other technologies. The space software identifies the network of collaboration among cited authors, specifically through co-citation analysis. By utilizing author co-occurrence analysis, it is feasible to identify influential authors (those with the greatest citation weights) and their associated articles in the research field. Additionally, it is possible to illustrate author co-citation relationships and determine which authors share similar and closely related research topics.

Based on the co-citation analysis of the writers mentioned in the literature (Fig. 2), Cheng Silu, Tang Maogang, Feng Chen, Hu Fengxia, Ma Weibiao, and Guo Wenqing are the authors who have a relatively large number of publications, with two articles each. The top scholars mentioned above engage in more frequent and intimate partnerships with one another. The co-citation relationships have a limited structural hierarchy, indicating that most writers operate independently and there are fewer research collectives. The authors who have the highest citation frequency demonstrate a significant level of centrality in the collaborative network, further accompanying their importance and commitment to the advancement of research on carbon emissions trading.

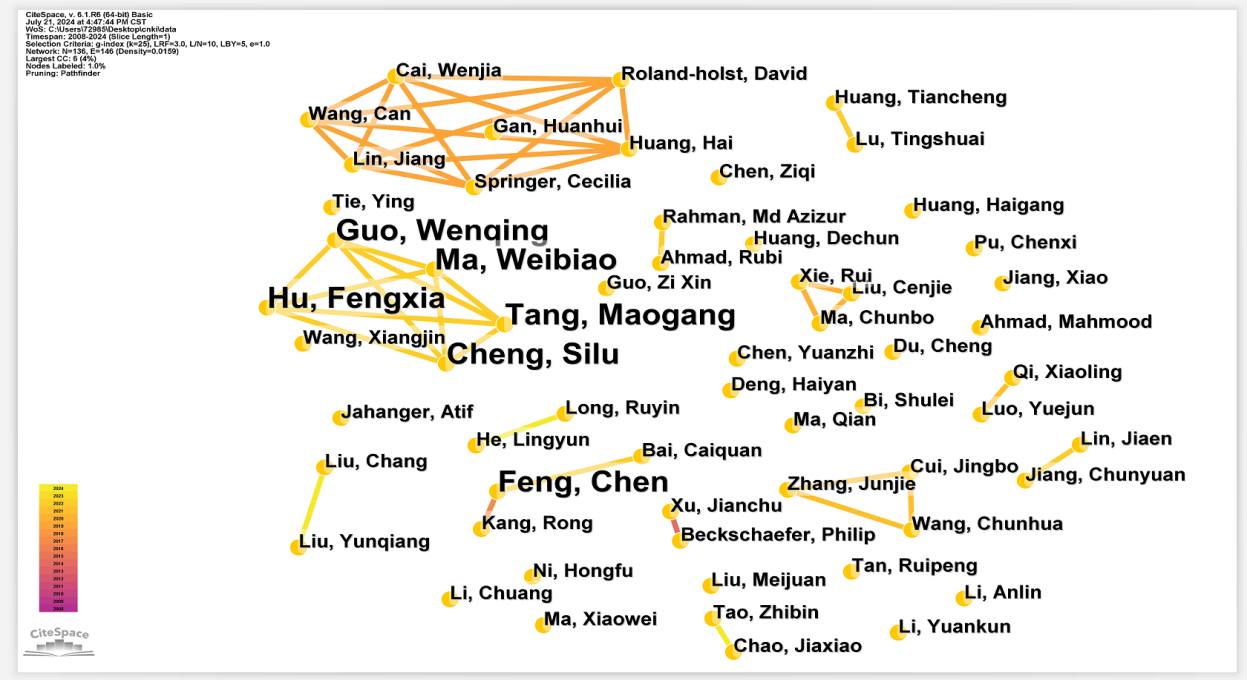

Figure 2.
Author co-occurrence analysis.

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4. Literature Content Measurement Analysis

4.1. Keyword Co-occurrence Analysis

Keywords serve as a concise literature overview, encapsulating its essential material. They are valuable for analyzing literature's themes and focal points. Upon completion of the analysis, this study acquires the mapping of keyword co-occurrence and the intensity of co-occurring words in English literature. Subsequently, it analyzes the research trajectory and historical evolution in the realm of carbon emissions trading policy impact. Figure 2 displays the level of co-occurrence of keywords in English literature. Nodes represent high-frequency keywords, with the size of each node indicating the intensity of co-occurrence. Keywords are connected by lines. This study employed Cite Space software to conduct keyword clustering analysis to ascertain the frequency and centrality of different phrases in the retrieved publications. Table 3 shows the top ten English terms in terms of keyword co-occurrence intensity, including carbon emission trading, environmental regulation, carbon emission, impact, emission control, emissions trading, innovation, green innovation, carbon emission trading scheme, and so on.

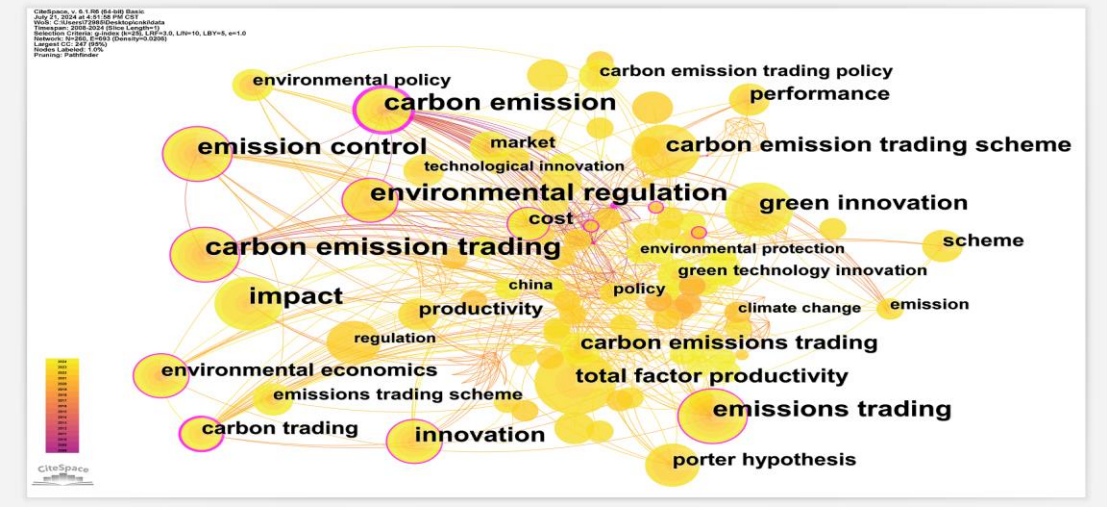

Figure 3.
Keyword co-occurrence analysis.

Table 3.
Keywords with a high frequency.

No.	English literature		
	Keywords	**Frequency**	**Centrality**
1	Carbon emission trading	28	0.17
2	Environmental regulation	25	0.19
3	Carbon emission	23	0.57
4	Impact	22	0.04
5	Emission control	21	0.12
6	Emissions trading	20	0.12
7	Innovation	15	0.11
8	Green innovation	15	0.05
9	Carbon emission trading scheme	15	0.06
10	Carbon emission trading	28	0.17

Based on the analysis of keyword co-occurrence patterns, as well as the research methodologies and data sources employed by researchers, the study of carbon emissions trading schemes may be categorized into four distinct topics. a) The impact of carbon trading programs on economic growth can be determined by analyzing important indicators such as productivity and total factor productivity. b) The environmental impacts of carbon emissions trading schemes are determined by the application of concepts from environmental economics and emission control. c) The effects of carbon pricing regimes on innovation can be assessed by examining the terms green technological innovation and green innovation. d) The societal effects of carbon trading regimes are assessed by examining crucial factors such as market dynamics and policy performance.

4.2. Keyword Clustering Analysis

The keywords of English literature are primarily organized into 9 groups (refer Figure 4), which are cluster #0 environmental policy, cluster #1 government, cluster #2 transition and upgrading, cluster #3 carbon trading, cluster #4 market-based regulation, cluster #5 agriculture, cluster #6 carbon price, cluster #7 company performance, and cluster #8 carbon dioxide. Based on the study of keyword clusters, this paper presents a concise assessment of the significant literature associated with each cluster theme and its main substance. The findings of this analysis are outlined in Figure 4.

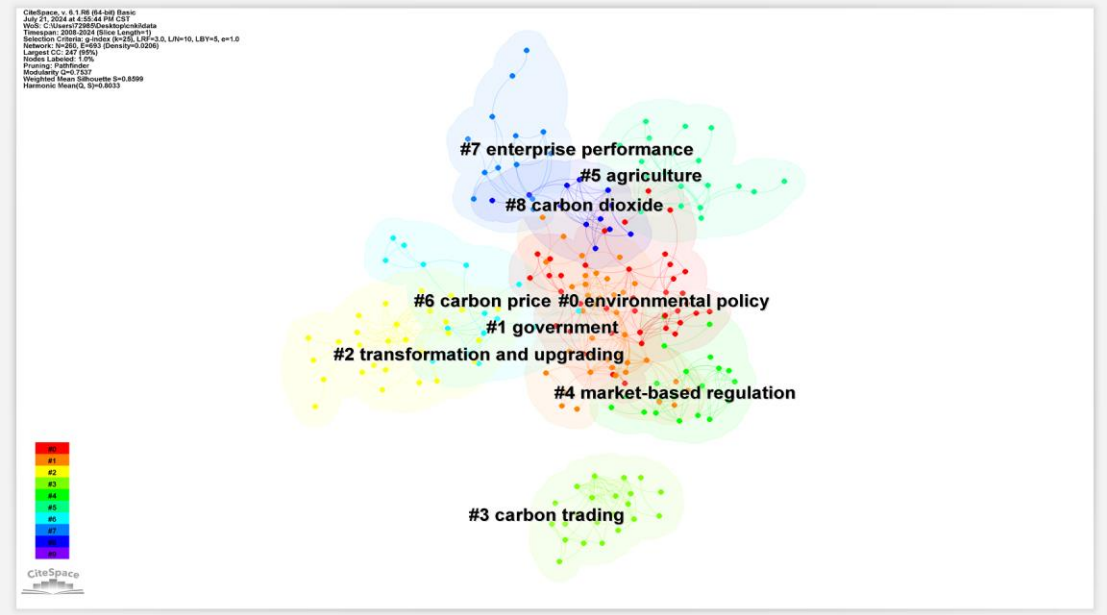

Figure 4.
Keywords clustering analysis.

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Table 4.
Significant studies related to carbon trading policies effects.

Cluster-ID	Cluster name	Authors	Title	Source title	Findings
#0	Environmental policy	Ren et al.(2023)	Can China's carbon trading policy improve the profitability of polluting companies: a retest of Porter's hypothesis	Environmental Science and Pollution Research	The introduction of carbon emissions trading as a quasi-natural environmental policy provides support for the weak form of Porter's theory. Nevertheless, it has been seen that the robust version of Porter's hypothesis is not stable.
#1	Government	Pan et al.(2022)	Effect of Chinese pilot's carbon emission trading scheme on enterprises' total factor productivity: The moderating role of government participation and carbon trading market efficiency	Journal of Environmental Management	This study highlights the substantial impact of government involvement and the effectiveness of the carbon trading market on the overall productivity of firms, specifically about China's carbon emission trading system (CETS) pilot policy.
#2	Transformation and upgrading	Dai et al.(2018)	Can China's Carbon Emissions Trading Rights Mechanism Transform its Manufacturing Industry? Based on the Perspective of Enterprise Behavior	Sustainability	The implementation of China's carbon trading pilot strategy has not led to the transformation and advancement of China's manufacturing sector.
#3	Carbon trading	Deng et al.(2023)	Does the carbon emission trading system induce enterprises' green innovation?	Journal of Asian Economics	The implementation of China's carbon trading pilot policy stimulates the development of environmentally friendly inventions and innovations within companies.
#4	Market-based regulation	Wang et al.(2023)	The policy evaluation of China's carbon emissions trading scheme on company employment: A channel from industrial automation	Energy Policy	Market-based environmental legislation, such as CETS, plays a key role in influencing employment levels in both cities and enterprises.
#5	Agriculture	Hua et al.(2022)	Research on the policy effect	International	Agribusinesses have a large boost in total

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			and mechanism of carbon emission trading on the total factor productivity of agricultural enterprises	Journal of Environmental Research and Public Health	factor productivity as a result of carbon trading rights.
#6	Carbon price	Song & Liu(2024)	Empirical analysis of the relationship between carbon trading price and stock price of high carbon emitting companies based on the VAR model - evidence from Chinese listed companies	Environmental science and pollution research	The correlation between carbon trading prices and stock prices in China's high-carbon-emitting businesses has weakened over time across different stages.
#7	Enterprise performance	Chen et al.(2022)	Does the carbon emission trading scheme boost corporate environmental and financial performance in China?	Journal of Cleaner Production	Carbon emissions trading programs enhance enterprises' market-based financial success, but they do not have a major impact on accounting-based financial performance.
#8	Carbon dioxide	Chen et al.(2022)	Low-Carbon city construction and corporate carbon reduction performance: Evidence from a quasi-natural experiment in China	Journal of Business Ethics	Constructing low-carbon cities enhances the performance of business carbon reduction.

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4.3. Further Analyses Based on the Content of the Literature

4.3.1. Analysis of Literature Theory Perspectives

The study of the impacts of carbon emissions pricing policies is based on four main theories: the theory of compliance costs (also known as the traditional hypothesis theory) and the theory of Porter's hypothesis (also referred to as the innovation compensation theory). The third theory pertains to emissions trading, whereas the fourth theory relates to green innovation.

Neoclassical economics posits that stricter environmental regulations increase companies' expenses, hinder their capacity to innovate in an environmentally friendly manner, diminish their competitiveness, and adversely affect their economic growth (Ramanathan et al., 2010). This view is known as the compliance cost theory. Based on the compliance cost hypothesis, the researcher found that carbon emissions rights in the carbon emissions trading pilot zones of China have a significant positive impact on the company's financial performance, but a significant negative impact on the company's long-term value (Jafarinejad & Jory, 2022). After examining a subset of non-financial companies in the UK between 2009 and 2018, the research found that the actual carbon efficiency of these firms did not influence their financial or market success (Adu et al., 2023).

In 1995, Porter and van der Linde conducted a case study that supported the idea that well-designed and stringent environmental regulations can motivate companies to innovate. They argued that the benefits gained from innovation can help offset the expenses of complying with environmental regulations, ultimately enhancing the competitiveness of companies. This creates a mutually beneficial situation for both the environment and the economy (Porter & van der Linde, 1995), academics refer to their view as the Porter hypothesis. Following the Porter hypothesis, Wen et al.(2020) argued that China's carbon emissions pricing system favorably affects both the excess returns of pilot enterprises and the carbon premium in stock returns. According to Xiao et al. (2021), the carbon emissions trading system led to a significant improvement of around 14% in total factor productivity in pilot zones, when compared to non-pilot regions. Pilot carbon emissions trading policies have the potential to enhance the effectiveness of the agribusiness GTFP greatly (Yu et al., 2022).

The concept of emissions trading was formulated in 1968 by economist Dales in his book "Pollution, Wealth, and Prices." Dales proposed that a company's emissions should be considered a property right that can be freely traded in the market, to optimize the utilization of this resource (Dales, 1968).In 1972, Montgomery expanded upon the hypothesis by conducting a more comprehensive analysis, which involved comparing market-based emissions trading with mandated environmental regulation. The study demonstrated that market-based emissions trading is more effective in managing the overall expenses associated with environmental governance. (Dales, 2002).

In 1911, the renowned economist Joseph Alois Schumpeter, who held dual Austrian-American citizenship, presented the concept of innovation in his monograph titled "The Theory of Economic Development"(Schumpeter, 1911). The theory of green innovation is rooted in the broader theory of innovation and specifically emphasizes the ecological and environmental advantages (Kemp & Foxon, 2007). Grounded in the principles of green innovation, Razzaq et al. (2021) employed a comprehensive range of non-linear modeling techniques to examine the inherent connection between green technological advancements and carbon emissions. They utilized monthly data from the BRICS countries spanning from 1990 to 2017. The study demonstrated that green technological advancements have a substantial impact on decreasing carbon emissions. Research conducted by Qi et al. (2021) found that the introduction of the pilot carbon emissions pricing program had a beneficial impact on the low-carbon innovation of enterprises inside the pilot area. Furthermore, when evaluating other quota distribution strategies, it was concluded that the benchmarking method had a greater influence on fostering low-carbon innovation.

In summary, the current study on carbon emissions trading policy predominantly involves the comprehensive application of concepts from several disciplines. However, it lacks in-depth study of theoretical viewpoints and innovation.

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4.3.2. Analysis of Literature Research Methods

The analysis of the effects of carbon emissions trading on policy has garnered considerable interest in recent years and is a vital topic within the discipline of economics. The current study on this topic primarily focuses on quantitative methods and lacks the utilization of theoretical research methodologies. This study presents a summary of the existing literature from a quantitative research perspective.

The current study on carbon emissions trading policies primarily focuses on quantitative analysis. The introduction of carbon emissions trading pilots can be seen as a quasi-natural experiment in policy. Recently, researchers have predominantly employed Difference-in-Difference (DID), a blend of Propensity Score Matching and Difference-in-Difference Method (PSM-DID), and Difference-in-Difference-in-Difference (DDD) to evaluate the impacts of policies. Yang et al.(2020) employed the DID model and examined it through conventional least squares and least squares dummy variable methods. Their investigation discovered the existence of employment double dividends and the impact of Porter's impacts on China's carbon emissions trading plan. Liu et al. (2021) utilized the DID methodology and found that the implementation of carbon emission trading (CET) reduces the value of the current capital market. However, it does effectively raise the overall gearing ratio of the company and does not encourage the company to enhance its research and development (R&D) expenditure. The utilization of the DID technique to assess the influence of carbon emissions trading policy on company ESG performance reveals a significant positive connection between ESG performance and this policy (Zhang et al., 2023).

Wang & Liu (2021) employed the PSM-DID technique. It has been found that the company's financial performance is affected by carbon emissions trading policy in a U-shaped manner. Furthermore, the task of encouraging the company's sustainable technological innovation in the long run through the implementation of carbon emissions trading legislation poses significant difficulties. The study, done utilizing the PSM-DID approach, found that the carbon emissions trading mechanism significantly improves the degree of green governance in the pilot firms (Yao et al., 2023).

Niu et al. (2022) utilize DID and DDD panel regression models to illustrate that CET has a substantial and favorable effect on the market value of companies. This discovery suggests that CET aligns with the Porter theory. Yu & Li(2021) constructed a DDD model to assess the impact of carbon emissions trading schemes on labor demand in firms. They utilized synthetic control methods to analyze the variations in employment effects resulting from carbon emissions trading policies across various pilot locations in China. The results suggest that China's method of pricing carbon emissions has a positive effect on employment in the nearby provinces located inside the designated pilot zones, leading to a spillover effect of around 10%. Cui et al.(2018) utilized the DDD technique to comprehensively examine the influence of the carbon emissions trading system on the progress of low-carbon innovation. The study's findings revealed that the carbon emissions trading system successfully incentivized the advancement of low-carbon technological innovation.

In summary, the study methodology for carbon emissions trading policy includes many approaches such as DID, PSM-DID, and DDD, among others. The primary focus of this research is on quantitative analysis. The existing literature predominantly relies on established methodologies and theories to statistically assess the efficacy of carbon emissions pricing programs. However, there is a relative scarcity of material that focuses on extracting the fundamental principles behind this phenomenon.

5. Emerging Themes in Carbon Emissions Trading Policies Effects Research

5.1. Theme 1: Economic Effects of Carbon Emissions Trading Policies

The focus of the study primarily centres on carbon market mechanisms in the European Union (EU) and Chinese markets. The divergent designs of each nation's carbon emissions trading mechanisms have resulted in contrasting research findings.

The two perspectives are outlined below:

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a) Based on the compliance cost theory, the researcher concludes that carbon trading rules negatively impact companies' value and productivity. The company's involvement in carbon emissions trading could potentially diminish the company's worth. This could result in increased operating costs, production costs, labor costs, certification costs, and other transaction costs in the short term. Additionally, it may asymmetrically affect the company's competitiveness in the market, leading to changes in its market value. Ma et al. (2020) created a model that establishes a connection between China's carbon emissions trading market, energy market, and capital market. A negative dynamic correlation coefficient has been discovered between China's carbon emissions trading market and the capital market. The negative connection is due to the illogical distribution of quotas in the carbon emissions market. In the article by Liu et al. (2021), the analysis found that implementing carbon emissions pricing in China will result in a decrease in the existing market values of capital, while simultaneously enhancing the total firm gearing.

b) According to Porter's premise, the researcher concludes that implementing a carbon trading program improves the value and productivity of a corporation. Multiple academics have employed various competitiveness criteria, including carbon premium, profitability, and productivity, to analyze the impact of emission trading schemes (ETSs) on corporate performance. According to Wang et al.(2020), the carbon emissions and degree of financial development have a significant impact on China's gross domestic product (GDP). Nevertheless, there exists an inverse relationship between carbon emissions and the utilization of renewable energy, as well as advancements in technology. The introduction of the ETS pilot had a significant and favorable impact on the financial performance of firms. The financial performance of non-state enterprises improved more significantly than that of state-owned corporations as a result of the ETS experiment (Yu et al., 2022).

According to research conducted by Huang & Chen (2022), China's CET substantially raised the levels of green total factor production (GTFP) in the pilot cities. Pan et al. (2022) discovered that CET has a significant impact on the overall productivity of companies. Moreover, it was discovered that the efficiency of the carbon emissions trading market and the extent of government intervention had a substantial influence on the contribution of carbon emissions trading to enterprises' overall factor productivity. In the article by Feng et al. (2021), on a nationwide scale, the CET has successfully increased China's GTFP. However, at the regional and municipal levels, the impact varies across different areas. Initially, the CET policy did not have a notable impact on the enhancement of GTFP. However, it did stimulate technological advancement once GTFP was broken down. CET regulations yield an environmental benefit and stimulate the development of eco-friendly technologies (Li et al., 2022).CET can significantly increase a company's total factor productivity TFP (Cheng & Meng, 2023).

Overall, the economic consequences of carbon trading regimes are a subject of debate, but most research indicates that these policies have yielded favorable economic outcomes.

5.2. Theme II: Environmental Effects of Carbon Emissions Trading Policies

According to the Porter hypothesis, most academics have found that the carbon emissions trading approach has significant environmental effects and may effectively achieve the reduction of carbon emissions and improvement of environmental performance. The carbon emissions trading mechanism plays a vital role in regulating markets and managing the environment. It efficiently and cost-effectively minimizes greenhouse gas emissions, hence helping the accomplishment of society's overall goals for green and low-carbon development (Li et al., 2020). Research has demonstrated that carbon emissions trading policies have made substantial contributions to the reduction of global greenhouse gas emissions. These policies involve implementing environmental rules that aim to regulate CO_2 emissions by utilizing the carbon market (Yuan et al., 2019). The carbon market trading mechanism actively facilitates the reduction of carbon emissions and pollutants emitted by extremely polluting enterprises (Zhou, 2023). The carbon trading program will incentivize enterprises to modify their industrial composition, adopt clean energy technology, allocate resources to environmental infrastructure, and efficiently advance carbon emission reduction through economic mechanisms (Tian et al., 2022).

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The carbon trading program facilitates the logical and efficient distribution of resources (Clarkson et al., 2015). Companies that have effective corporate governance frameworks can effectively comply with carbon trading policies and promote environmentally friendly and sustainable development ideals both inside the company and in the wider community (Yu et al., 2022). According to Guo et al.(2022), carbon trading programs have a significant impact on lowering carbon emissions, and the impacts of these policies in pilot zones extend to nearby non-pilot regions. Tang et al. (2021) found that China's ETS has had a substantial and ongoing impact in reducing carbon intensity. The trading profits of EU ETS Phase I and Phase II participating enterprises were found to have contributed to the reduction of carbon emissions by Guo et al.(2020).

Zhang et al.(2023) highlighted that carbon market trading substantially impacted reducing carbon emissions of carbon trading pilot enterprises due to the external influence of environmental legislation. According to Gu et al. (2022), The application of difference-in-difference and trajectory equilibrium methodologies demonstrated that carbon trading programs exert a substantial influence on reducing energy consumption and carbon emissions.

5.3. Theme III: Technical Effects of Carbon Trading Policies

The current research on carbon trading and green technology innovation can be categorized into two primary divisions.

a) Based on the compliance cost theory, the researcher concludes that environmental regulations, specifically the carbon emissions trading system, impede firms' investment in research and development and the advancement of green technologies. Several researchers argue that the carbon market has not effectively boosted R&D investment and the development of green technology innovation. In the article by Feng et al. (2017), the introduction of the CET has significantly diminished the company's research and development (R&D) and innovation capabilities. Germà and Stephan (2018) noted that environmental legislation not only impedes the development of green technical innovation but also has a detrimental impact on innovation indicators, such as the number of patents.

The introduction of the carbon emissions pricing pilot plan led to a significant reduction of around 9.26 percent in the proportion of green patents (Chen et al., 2021). Government-led innovation in carbon trading programs did not have an immediate positive impact on energy efficiency in the short term, whereas company-led innovation is associated with a decrease in energy efficiency (Liu et al., 2020). Carbon emissions trading mechanisms and green technology innovation exhibit a negative association. Nevertheless, both elements significantly influence diminishing carbon emissions and carbon intensity. The inhibitory impact is especially prominent in the eastern area (Zhang et al., 2022).

b) The researcher concludes that the carbon emissions trading system, which is a form of environmental regulation, motivates enterprises to invest in research and development (R&D) and innovate in green technology, according to Porter's hypothesis. Several researchers have discovered that the carbon trading programs implemented by both the European Union and China have effectively stimulated investment in research and development, as well as the innovation of environmentally friendly technologies. In the article by Zhu et al. (2019), The ETS in China provides increased incentives for investment in R&D and the promotion of environmentally friendly technologies. This benefits both companies that are subject to regulations and those that are not. The logistic regression study of selected financial data from publicly traded corporations indicated a statistically significant and positive association between China's carbon emissions trading plan and the advancement of eco-friendly technology by companies (Zhang et al., 2019). Zhou & Wang (2022) demonstrated that the implementation of carbon emissions trading pilot rules in China directly and positively influences the advancement of green technology innovation in the designated cities. However, there is significant diversity among regions, with limited advancement in creating environmentally friendly technology innovation in the western regions and areas with well-established industrial infrastructure. Liu & Sun (2021) established a significant correlation between China's carbon emissions trading mechanism and

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the advancement of low-carbon technological innovation. Moreover, this favorable link has consistently increased gradually over time. Hasan et al. (2021) found that reducing carbon emissions and profit is directly proportional to the investment in green technology under carbon regulation.

Overall, most studies on the impact of carbon trading regimes on technological progression and innovation suggest that these policies promote and stimulate progress and innovation. Nevertheless, there remains a lack of agreement on this issue.

5.4. Theme IV: Social Effects of Carbon Emission Trading Policies

There is a lack of study on the societal effects of carbon trading policies. Prior studies predominantly analyze the impacts of carbon trading systems on employment, social equity, and individual income. Certain academics contend that carbon emissions trading schemes yield a benefit in terms of employment. Following research conducted by Yang et al.(2020), the carbon emissions trading scheme has a significant influence on both employment and carbon emissions. More precisely, it provides a dual advantage by creating more job prospects and, at the same time, decreasing carbon emissions in the carbon emissions trading pilot scheme. Jia(2023) employed an energy-environment-economy analytical model and found that carbon trading policies have significant societal value and stimulate employment growth in energy-intensive, low-carbon industries. The ETS has made a substantial contribution to the labor demand of regulated enterprises, resulting in favorable employment impacts when companies increase their production(Ren et al., 2020)

Some claim that carbon trading has led to a decrease in employment in industries that consume a lot of energy but has contributed to a fair distribution of revenue. According to Huang et al.(2019), With employment in China's coal sector set to fall by 75 percent by 2030, the distribution of benefits generated by a national carbon emissions trading market could help achieve greater social equity.

Regarding the effect on individuals' earnings, numerous studies have indicated that implementing carbon emission reduction measures has contributed to an increase in people's incomes and a decrease in poverty. In the article by Zhang & Zhang(2020), The exchange of carbon permits in China's carbon market has increased the average net income of farmers in seven pilot provinces and cities by RMB 752.6 per person.

5.5. Research Framework for Carbon Emissions Trading Policy Effects

Creating a research framework for the effects of carbon emissions trading systems helps establish the essential research characteristics in this area. Based on an analysis of literature characteristics and content, along with the integration of theoretical perspectives and research methods, a model that summarizes the carbon emissions trading policies studies is presented in Figure 5. By analyzing a variety of theoretical perspectives, researchers have investigated the policy implications of carbon emissions trading, including compliance cost theory, Porter's hypothesis theory, emissions trading theory, and innovation theory. They have also used quantitative research models such as DID, PSM-DID, and DDD. Their studies have mainly focused on analyzing carbon emissions trading programs' economic, environmental, technological, and social consequences.

The carbon emission trading policy impacts research framework offers a succinct summary of the current research on the subject matter, highlighting the present state of knowledge. Simultaneously, using the established framework, it is feasible to accomplish the integration of all pertinent material, coherent analysis and interpretation, and standardized categorization. Consequently, the efficiency and uniformity of evaluating literature on the impact of carbon emissions trading regimes have greatly improved.

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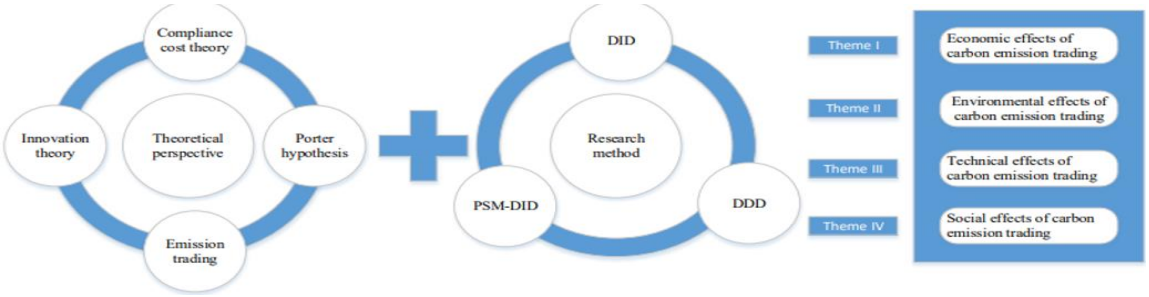

Figure 5.
Carbon emission trading model.

6. Conclusion

Carbon emissions trading programs have multifaceted impacts on the economy, environment, technology, and society, which all contribute to sustainable development. The economic effect serves as the foundation for the carbon emissions trading strategy to encourage green development. The environmental effect is the underlying condition, while the technical effect is a significant approach. The social effect is the primary objective.

This study aims to analyze the literature on carbon emissions trading studies that are included in the Web of Science and Scopus databases. The technique of integrating bibliometric and knowledge mapping is employed to examine the characteristics of literature and the focal points of study on carbon emissions trading policy. Additionally, a research framework is established, with the primary findings outlined as follows: a) Since 2021, there has been a significant surge in the volume of publications in the field of literature. b) The literature encompasses a diverse selection of periodicals, including prominent worldwide publications like Sustainability, which focus on topics such as environmental protection, ecological management, and environmental research. c) Regarding author co-occurrence analyses, the literature shows a disorganized hierarchy of co-citation links among scholars, with most individual research. d) The co-occurrence analysis diagram indicates that research in the carbon emissions trading policy field mostly focuses on issues such as green innovation and carbon emission reduction. e) The literature on keyword clustering reveals that the prevailing areas of research in the field of carbon emissions trading are mostly focused on environmental policy, market-based environmental regulation, and business performance. f) The literature primarily addresses compliance cost theory, Porter's hypothesis theory, emissions trading theory, and innovation theory. However, it lacks theoretical advancements that apply to emerging environmental settings, such as carbon neutrality and carbon peaking. The literature mainly employs quantitative research methodologies, utilizing research models such as DID, PSM-DID, and DDD. Currently, every nation on Earth is confronted with the significant issue of environmental deterioration and pollution. In the context of dual-carbon, carbon emissions trading is a specific method of promoting environmental sustainability. Given the rapid expansion of research interest, it is crucial for carbon emissions trading research to avoid becoming superficial and confined to empirical or formalistic approaches. Eagerly anticipating forthcoming research: a) Strengthen the importance of various research areas related to carbon emissions trading and promote the overall uniformity and scientific rigor of research in this field. b) Elaborate on theoretical ideas about bicarbonate and construct a cohesive theoretical research framework. c) The macro and micro settings heavily impact the carbon trading market. Research on carbon emissions trading should align more closely with the actual context, utilize operational data from enterprises effectively, advance academic theoretical research, and provide guidance for the sustainable development of businesses.

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