“Bibliometric analysis of research trends and networks in carbon tax studies: Insights into environmental and economic policy implications”

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ARTICLE INFO	Andi Kusumawati, Suhanda Suhanda, Darmawati, Andi Iqra Pradipta Natsir and Indira Syakira Kirana Juanda (2025). Bibliometric analysis of research trends and networks in carbon tax studies: Insights into environmental and economic policy implications. *Environmental Economics*, *16*(1), 43-58. doi:10.21511/ee.16(1).2025.04
DOI	http://dx.doi.org/10.21511/ee.16(1).2025.04
RELEASED ON	Wednesday, 29 January 2025
RECEIVED ON	Wednesday, 10 July 2024
ACCEPTED ON	Friday, 06 December 2024

JOURNAL	"Environmental Economics"
ISSN PRINT	1998-6041
ISSN ONLINE	1998-605X
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
44	8	5

BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine

www.businessperspectives.org

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BIBLIOMETRIC ANALYSIS OF RESEARCH TRENDS AND NETWORKS IN CARBON TAX STUDIES: INSIGHTS INTO ENVIRONMENTAL AND ECONOMIC POLICY IMPLICATIONS

Received on: 10th of July, 2024
Accepted on: 6th of December, 2024
Published on: 29th of January, 2025

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Conflict of interest statement:
Author(s) reported no conflict of interest

Abstract

Carbon taxes are increasingly recognized as a critical tool in mitigating climate change by reducing carbon emissions. This study analyzes research trends in carbon tax studies using bibliometric techniques and social network analysis to explore their environmental and economic impacts and policy implications. By analyzing 922 documents from 308 sources published between 1968 and 2024, the study identifies key topics, emerging trends, and collaboration patterns among researchers. The results show a significant increase in carbon tax publications and citations, particularly from 2000 to 2019, peaking around 2017–2019, followed by a decline after 2021. The most frequently studied topics include carbon tax effects on emissions reduction, economic balance, and environmental sustainability. Social network analysis reveals influential researchers and institutions driving the discourse on carbon taxes, highlighting the importance of interdisciplinary collaboration in shaping effective policies. These findings provide insights into the evolution of carbon tax policies and underscore the need for continued research on specialized themes such as the role of carbon taxes in supply chain management, social equity, and energy policy.

Keywords carbon footprint reduction, climate change mitigation, economic impacts, environmental economics, environmental policy, taxation, sustainability

JEL Classification Q58, D85, H23, Q54

INTRODUCTION

The global urgency to address climate change has positioned carbon taxation as a pivotal tool in environmental and economic policy discourse. Carbon taxes play a vital role in improving Water-Energy-Food (WEF) efficiency by balancing economic output and emissions (Barrédy, 2023; J. Wang et al., 2023; T. Zhang et al., 2024). As countries strive to meet their emission reduction targets while sustaining economic growth, carbon taxation emerges as a balanced mechanism to internalize the social costs of carbon emissions. Solar and wind energy subsidies can also reduce emissions, they come with higher economic costs, leading to GDP losses of 0.53%-0.58% (Alegoz, 2024; Hu et al., 2021; Timilsina et al., 2024). This dual role (mitigating climate change and preserving economic stability) places carbon taxation at the center of policy debates.

Despite its growing relevance, the adoption and effectiveness of carbon taxes are met with significant challenges, including political resistance, economic trade-offs, and the need for equitable implementation across diverse socio-economic contexts. These challenges underscore the need to comprehensively examine research trends to identify the gaps and emerging patterns in the field. Furthermore, understanding the global research network and its contributions is critical for aligning academic efforts with practical policy-making.

This study situates itself within the broader scientific discourse on climate policy, aiming to elucidate the role of carbon taxes as both an economic and environmental instrument. This paper brings novelty through a bibliometric approach to identify research trends and global collaboration networks in carbon tax studies, providing new insights into environmental and economic policy implications that have not been widely explored. By exploring the interconnectedness of research trends and networks, this work contributes to formulating robust and informed strategies to address the complexities of carbon taxation.

1. LITERATURE REVIEW

A carbon tax is an economic policy tool designed to reduce carbon dioxide emissions generated from burning fossil fuels. Internalizing the negative externalities of carbon emissions ensures that market prices reflect the actual environmental costs associated with these emissions (Matsumura et al., 2024). For instance, in China's propylene sector, the carbon tax rate ranges from 86 to 600 Chinese Yuan (CNY), or approximately 12 to 84 US dollars (USD) per ton of carbon dioxide equivalent (CO2e), representing 1-10% of the typical propylene price in the Chinese market (Lv et al., 2024). By imposing a price on carbon emissions, the tax creates an incentive for companies and individuals to reduce their reliance on fossil fuels and transition to cleaner energy alternatives (Gonçalves & Menezes, 2024; W. Jiang et al., 2024; Kim et al., 2024).

The environmental impact of implementing a carbon tax can be profound. By raising the cost of fossil fuel use, the tax is intended to reduce greenhouse gas emissions and promote the adoption of clean technologies and energy efficiency (Allers & Rienks, 2024). Moreover, carbon taxes are widely regarded as one of the most effective solutions for mitigating climate change (Msefula et al., 2024; Naef, 2024). However, higher per capita CO2 emissions correlate with a decline in renewable energy supply (Mideksa, 2024; Przychodzen, 2024). As carbon dioxide emissions are reduced, the mitigation of climate change is achieved, resulting in fewer extreme weather events and less damage to ecosystems and human health (Linden et al., 2024; Uddin et al., 2023; M. Wang et al., 2024; Wiskich, 2024).

The economic impact of carbon taxes depends mainly on their design and implementation. While some sectors may experience higher production costs, these taxes also incentivize energy efficiency and innovation, which can ultimately boost productivity and create new economic opportunities (Ding & Li, 2024; Roche et al., 2022; Shapir-Tidhar et al., 2023; Yu et al., 2024). The revenue generated from carbon taxes can be used to fund environmental initiatives, support renewable energy transitions, or offset other taxes (D. C. Li & Yang, 2024; Sun et al., 2024). For domestic firms, carbon taxes can be applied in a way that promotes sustainability without compromising long-term economic growth (Akkemik et al., 2024; C. Jiang, 2021; Mardones & Alvial, 2024). Furthermore, higher carbon prices can increase social welfare, particularly when combined with cross-regional production strategies (Guan et al., 2024; Hua et al., 2024).

The optimal policy mix is most effective when carbon emissions are significantly reduced, indicating that combining abatement policies can drive further carbon reductions (Y. Li et al., 2024, p. 1). Pre-existing reward-based climate policies can enhance public support for carbon taxes, especially when the connection between the two policies is clear and people view the reward as compensation for the tax (Campos & Serra, 2020; Gong et al., 2024). Furthermore, transparency in how carbon tax revenues are used can bolster public trust and support (Ewald et al., 2022, p. 1). Local governments have the potential to improve citizens' quality of life, promote local economic development, and address regional disparities by implementing effective policies, strategic planning, and sound financial management (Darmawati et al.,

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2024). When environmental tax revenues are utilized wisely, they can contribute to environmental protection and economic growth (Liu & Ge, 2023; Xie et al., 2023). Additionally, aligning carbon tax policies with international regulations is crucial for preventing carbon leakage, which occurs when production shifts to countries with weaker environmental laws (de Bruin & Yakut, 2024, p. 1).

Bibliometric studies and network analysis of carbon tax have been widely conducted. Zhang et al. (2016) identified key themes in carbon tax literature, such as climate change policies, carbon emissions trading, socio-economic impacts, renewable energy, and carbon capture and storage. Similarly, Patel and Jhalani (2023) highlighted that policy formation and the effects of environmental taxes dominate keyword trends in the literature. Additionally, Bima et al. (2023) found that carbon tax discussions in nationally accredited Indonesian journals and Scopus-indexed journals focus on business management and accounting, with VOSviewer analysis revealing trends in carbon emission accounting. Furthermore, Bima and Alim (2024) identified 182 Scopus-indexed articles on green taxes, emphasizing innovative designs and distribution effects, while network analysis showed a broad disciplinary focus. Moreover, Nazari et al. (2024) categorized public acceptance of carbon pricing into themes of resistance, public attitudes, policy implementation, and distributional impacts. Previous studies highlight the policy and regulatory importance of carbon and green taxes. However, differences in emphasis on socio-economic impacts, public acceptance, and research trends in emissions accounting and innovative tax design indicate a need for harmonizing methodology and research focus.

Overall, the literature underscores the multifaceted impacts of carbon taxes, emphasizing their role in mitigating climate change, fostering economic opportunities through innovation and efficiency, and the necessity of transparent and well-coordinated policies to gain public support and prevent carbon leakage. There is a consensus on harmonizing methodologies to address socio-economic impacts and public acceptance comprehensively.

This study aims to analyze the research trends on carbon taxes using social networks and bibliometric analysis, identifying key themes and their interconnections. By focusing on the environmental and economic impacts of carbon tax policies, this paper explores the underlying relationships within the academic discourse. The study also aims to offer insights into policy implications, providing a framework for designing effective and sustainable carbon tax policies that address economic and environmental challenges. The analysis helps fill existing literature gaps and guide policymakers by uncovering unresolved issues and clarifying contradictory findings.

2. METHODS

This study utilizes two primary methodologies: bibliometric analysis and social network analysis. The bibliometric approach tracks publication performance by analyzing trends in research output, keyword occurrences, and citation networks within carbon tax studies. Specifically, bibliometric analysis is employed to:

1. Identify relevant literature on carbon taxes;
2. Collect the data from academic databases such as Scopus and Google Scholar;
3. Clean and process the data to remove duplicates and irrelevant records; and
4. Analyze the data to identify key research areas, dominant themes, and emerging trends.

Bibliometric analysis was selected because it can uncover long-term research trends, highlight the most frequently studied topics, and analyze the economic and environmental impacts discussed in the literature. This technique also helps reveal existing research gaps, providing insights into policy recommendations and future research directions.

The social network analysis complements the bibliometric approach by mapping relationships between authors, institutions, and research topics, particularly in the context of environmental and economic policy implications. Network metrics such as betweenness, closeness, and PageRank measure the relative importance and influence of critical topics and actors within the research community.

Data were collected from Scopus and Google Scholar databases using a systematic search process. The search query included terms such as *"carbon tax" OR "carbon pricing" OR "carbon taxation" OR "carbon levy" OR "carbon fee" OR "carbon charge"* using Publish or Perish 8 (PoP) software. The search identified 1,200 literature sources, which were then processed as follows:

1) removing 92 duplicate documents, resulting in 1,108 records for initial screening;

2) excluding 154 non-research articles and non-English documents, resulting in 954 articles for detailed eligibility screening;

3) excluding 32 articles not aligned with the carbon tax research scope, resulting in a final sample of 922 articles.

The final sample of articles was exported in Research Information Systems (.ris) format for analysis in VOSviewer and in BibTex (.bib) format for analysis in Biblioshiny R. The data normalization process involved correcting typographical errors, filling in empty fields, and adjusting the Biblioshiny R database format to prevent data bias. The filtering process is detailed in Figure 1.

This study employs two primary methods to address the research questions (RQ1-RQ5): bibliometric and social network analysis. The bibliometric analysis focuses on metrics such as total citations, average citations per document, publication trends, and keyword co-occurrence. These metrics help identify central themes frequently appearing in carbon tax research, allowing the study to pinpoint the most researched topics and the economic and environmental impacts highlighted in the literature.

Meanwhile, social network analysis provides deeper insights into the structure of the research community, identifying influential nodes and developing clusters in economic and environmental policy. This study maps the relationships between actors, individuals, and institutions who play key roles in carbon tax research using metrics such as betweenness, closeness, and PageRank. It also uncovers topics that are likely to become future research focuses. Through the

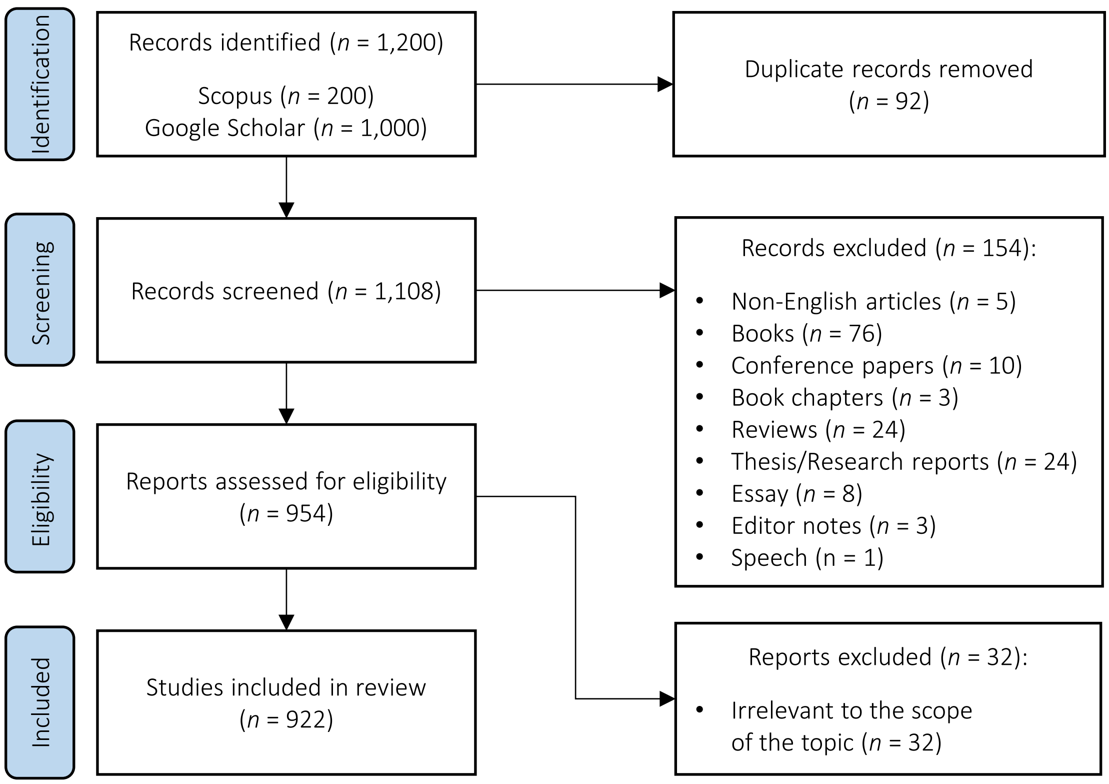

Figure 1. Data filtering strategy through PRISMA protocol

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combination of these two methods, this study not only identifies key trends in carbon tax research but also explores policy implications and offers future research directions based on patterns of collaboration and thematic development.

3. RESULTS AND DISCUSSION

Table 1 shows carbon tax research from 1968 to 2024, with 922 documents published by 308 sources. The carbon tax research field has experienced an average annual growth rate of 5.5%, indicating a steady increase in academic interest over time. Each document, averaging 9.74 years old and receiving approximately 118.8 citations, reflects earlier studies' long-term relevance and impact on developing carbon tax policies. These citation patterns suggest that foundational works continue to influence contemporary research and policy discussions. The 1,781 unique keywords used by 2,110 contributing authors highlight the diversity of topics explored in the field, ranging from environmental impacts to economic and social equity considerations. Of particular note, 141 authors individually produced 166 documents, while the remaining documents averaged 3.13 authors each, underscoring the collaborative nature of carbon tax research. These collaborative efforts, revealed through social network analysis, demonstrate how interdisciplinary partnerships are critical in advancing the understanding of carbon taxes and shaping effective, sustainable policy frameworks.

Table 1. Statistical description of carbon tax research

Description	Results
Timespan	1968:2024
Sources	308
Documents	922
Annual Growth Rate %	5.5
Document Average Age	9.74
Average citations per doc	118.8
References	0
Author's Keywords	1,781
Authors	2,110
Authors of single-authored docs	141
Single-authored docs	166
Co-Authors per Doc	3.13

Figure 2 shows the trend of publications and citations related to carbon tax research from 1968 to 2024. The blue line represents the number of documents published each year, while the orange line is the number of citations received by these documents. The number of documents and citations has increased significantly since 2000, with the peak number of publications and citations occurring around 2017 to 2019. This pattern indicates a growing interest in and attention paid to carbon taxes in the scientific literature. The discontinuous exponential line shows a long-term increasing trend in the number of documents and citations, although there is a sharp decline after 2021.

Based on Table 2, "Carbon Tax" is the most frequent keyword with 291 occurrences, followed by "Climate Change" (71 occurrences) and "Carbon Pricing" (56 occurrences). Other common key-

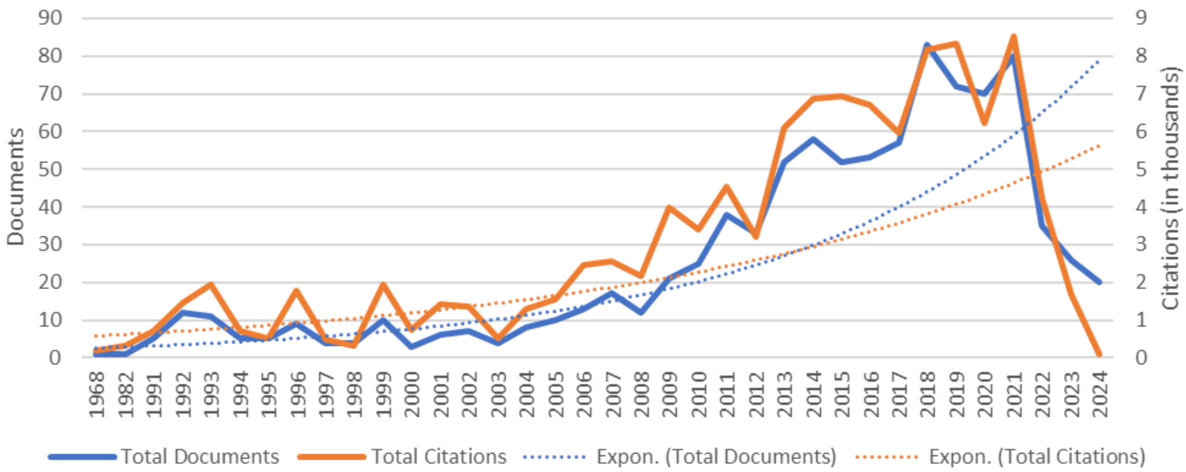

Figure 2. Carbon tax research trends (1968–2024)

words include "Climate Policy," "Carbon Emission," and "CGE Model." Figure 3, created using VOSviewer, visualizes this keyword network, showing strong linkages between "Carbon Tax" and related topics like "Climate Policy," "Carbon Pricing," and "Carbon Emission." The network map also highlights clusters such as distributional effects, emissions trading, and environmental sustainability, emphasizing the centrality and interconnectedness of carbon tax research in the literature.

Table 2. Keyword occurrences in carbon tax research literature

Keywords	Occurrences
Carbon Tax	291
Climate Change	71
Carbon Pricing	56
Climate Policy	43
Carbon Emission	40
CGE Model	31
Cap-and-Trade	24
Greenhouse Gas Emissions	23
CO2 Emissions	22
China; Global Warming	19
CGE	18
Environment; Renewable Energy; Sustainability	14
Climate Change Mitigation	13
Carbon Policy; Climate Change Policy; Energy	12
Carbon Price; Carbon Taxation	11
Double Dividend; Energy Efficiency; Environmental Policy; General Equilibrium; Paris Agreement; Supply Chain Management	10
Distributional Effects; Emissions Trading; Optimization; Social Welfare	9
Carbon Footprint; CGE Modelling; Economic Growth; Energy Policy; Inequality; Policy	8
Carbon Emission Reduction; Carbon Trading; Covid-19; Economics; Energy Tax; Environmental Regulation; Fairness; Remanufacturing; Subsidy; Uncertainty; Willingness to Pay	7
Carbon Dioxide Emissions; Carbon Market; Closed-Loop Supply Chain; Energy Consumption; Income Distribution; Wind Power	6
Bioenergy; Biofuel; Carbon Capture; Carbon Leakage; CCS; Decarbonization; Distribution; Distributional Impacts; Employment; Energy System; Environmental Tax; Green Paradox; Greenhouse Gases; Inventory; Markal; Political Economy; Poverty; Power Sector; Public Opinion; Revenue Recycling; South Africa; Supply Chain; Tax Incidence; Transportation	5
Acceptability; Air Travel; Australia; British Columbia; Carbon Capture and Storage; Climate; Developing Countries; Emission Reduction; Environmental Economics; Environmental Regulations; Environmental Sustainability; Environmental Tax Reform; Environmental Taxation; Europe; Fiscal Policy; Green Growth; Greenhouse Gas; India; Integrated Assessment; Ireland; Mexico; Optimal Carbon Tax	4

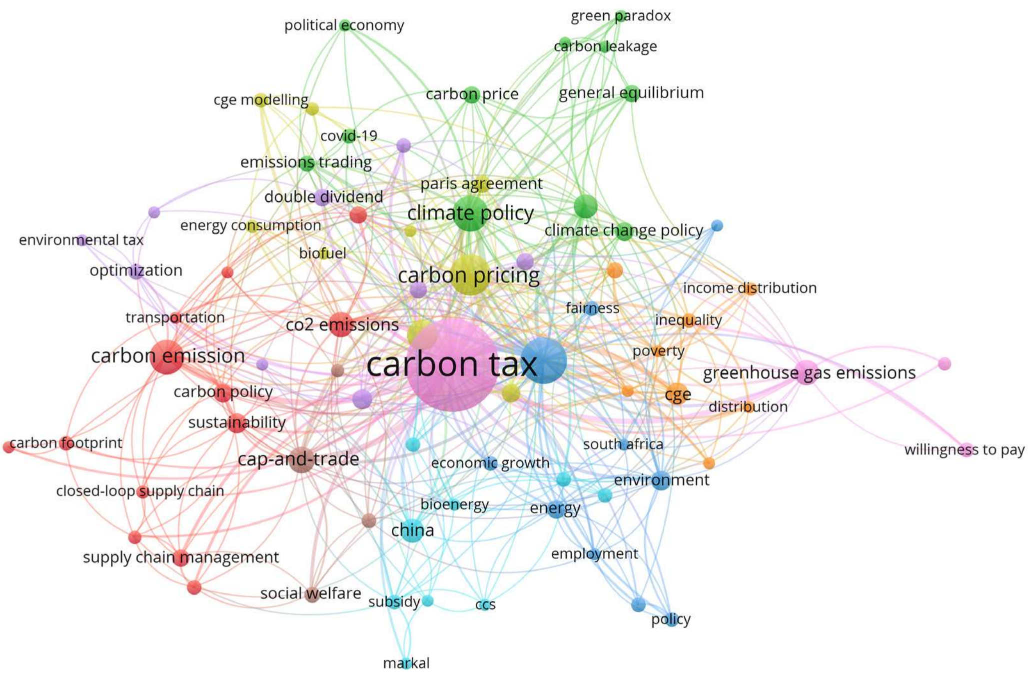

Figure 3. Network visualization of keywords in carbon tax research literature

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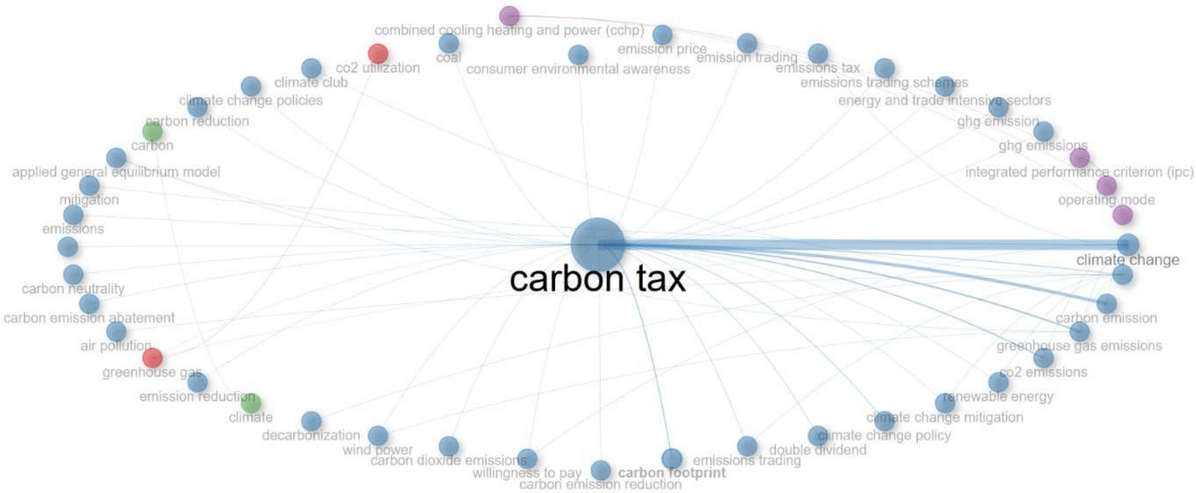

Figure 4. Network visualization of environmental impacts and effectiveness of carbon tax in reducing emissions

The cluster division in carbon tax-related research reveals key focus areas. Cluster 1 (red) covers carbon emissions reduction and sustainable supply chain management. Cluster 2 (green) focuses on climate change policy and emissions trading. Cluster 3 (blue) addresses climate change, economic growth, and social justice. Cluster 4 (yellow) emphasizes CGE models and energy consumption. Cluster 5 (purple) covers carbon trading and environmental policy. Cluster 6 (cyan) relates to energy policy and uncertainty. Cluster 7 (orange) focuses on distributional effects and poverty. Cluster 8 (brown) addresses environmental regulation. Cluster 9 (pink) covers carbon taxes and public revenue. This division highlights the distribution of research across various themes.

The network analysis parameters include the "Star" layout, normalization by "association," and the "Walktrap" clustering algorithm. Figure 4 illustrates that carbon taxes significantly affect environmental aspects, particularly climate change and emission reduction. The carbon tax node has the highest betweenness (618.104777), closeness (0.022222222), and

Table 3. Clustering and centrality measures of key nodes in carbon tax research network (environmental impact)

Cluster	Node	Betweenness	Closeness	PageRank
1	Greenhouse Gas	37	0.013157895	0.01638015
1	CO2 Utilization	0	0.008849558	0.007974376
2	Carbon Tax	618.104777	0.022222222	0.302994442
2	Climate Change	115.4538425	0.015151515	0.102911064
2	Carbon Pricing	111.0524917	0.014705882	0.065828563
2	Carbon Emission	0	0.012820513	0.035196492
2	Greenhouse Gas Emissions	3.388888889	0.013888889	0.043368513
2	Renewable Energy	0	0.012820513	0.013069456
2	Climate Change Mitigation	0	0.012820513	0.01631483
2	Climate Change Policy	0	0.012195122	0.016130614
2	Double Dividend	0	0.012195122	0.014530954
2	Emissions Trading	0	0.012820513	0.017822382
2	Carbon Footprint	0	0.012195122	0.006532654
2	Carbon Emission Reduction	0	0.012195122	0.009731974
2	Willingness to Pay	0	0.012820513	0.012801251
2	Wind Power	0	0.012345679	0.00960459
2	Decarbonization	0	0.00952381	0.006624761

Table 3 (cont.). Clustering and centrality measures of key nodes in carbon tax research network (environmental impact)

Cluster	Node	Betweenness	Closeness	PageRank
2	Air Pollution	0	0.00952381	0.006624761
2	Carbon Emission Abatement	0	0.012195122	0.006532654
2	Carbon Neutrality	0	0.012195122	0.006532654
2	CO2 Abatement	0	0.012195122	0.006532654
2	Applied General Equilibrium Model	0	0.012345679	0.00960459
2	Climate Change Policies	0	0.012195122	0.006532654
2	Coal	0	0.012195122	0.006532654
2	Consumer Environmental Awareness	0	0.012195122	0.006532654
2	Emission Price	0	0.012195122	0.006532654
2	Emissions Tax	0	0.009708738	0.006402611
2	Emissions Trading Schemes	0	0.012195122	0.006532654
2	Energy and Trade intensive sectors	0	0.012195122	0.006532654
2	GHG Emission	0	0.012195122	0.006532654
3	Climate	0	1	0.022222222
3	Carbon	0	1	0.022222222
4	Combined Cooling Heating and Power (CCHP)	0	0.333333333	0.022222222
4	Integrated Performance Criterion (IPC)	0	0.333333333	0.022222222
4	Operating Mode	0	0.333333333	0.022222222
4	Optimal Operational Strategy	0	0.333333333	0.022222222

PageRank (0.302994442), confirming its central role. Keywords like "carbon emission," "greenhouse gas emissions," and "CO2 emissions" are closely linked to "carbon tax." Cluster 2 highlights connections to "climate change mitigation" and "renewable energy," indicating carbon taxes drive the transition to renewable energy and climate strategies. The network emphasizes carbon taxes' role in reducing emissions and promoting environmental sustainability.

The network map in Figure 5 and Table 4 highlights the economic impact of carbon taxes through node and cluster analysis. The "carbon tax" node in Cluster 4 has the highest betweenness, closeness, and PageRank values, closely linked to nodes like the "CGE model," "cap-and-trade," and "income distribution," emphasizing economic and distributional effects. Clusters 1 and 2 focus on "supply chain management" and "general equilibrium," showing the impact on supply chains and economic equilibrium. Cluster 3 includes "inequality" and "distribution," adding a dimension of social justice. These relationships underscore the comprehensive impact of carbon taxes on economic equilibrium and social justice.

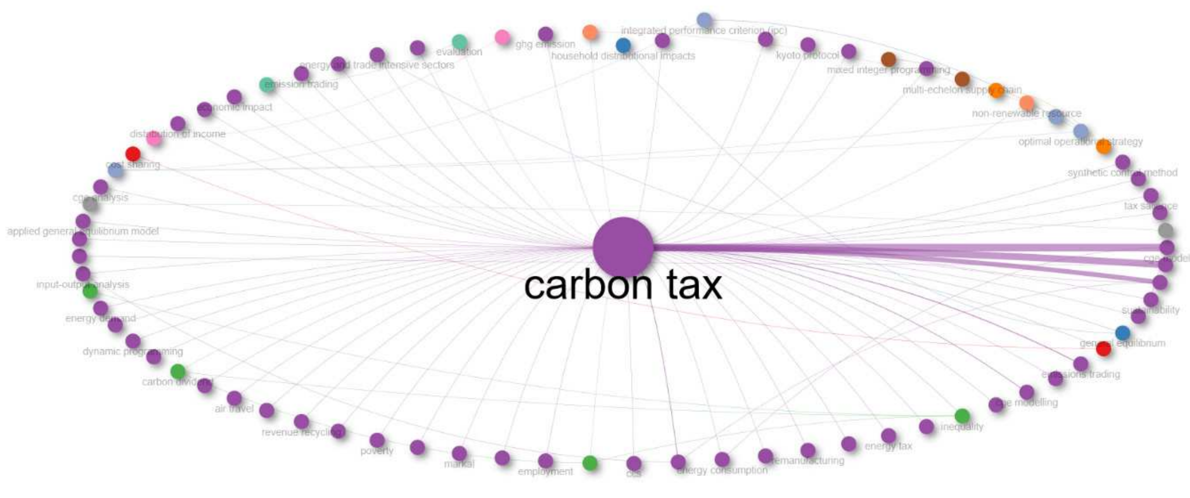

Figure 5. Network visualization of economic impacts and distributional effects in carbon tax research

http://dx.doi.org/10.21511/ee.16(1).2025.04

Table 4. Clustering and centrality measures of key nodes in carbon tax research network (economic impact)

Cluster	Node	Betweenness	Closeness	PageRank
1	Supply Chain Management	64	0.007633588	0.013041357
1	Cost Sharing	0	0.005128205	0.005090264
2	General Equilibrium	64	0.007633588	0.013041357
2	Household Distributional Impacts	0	0.005128205	0.005090264
3	Inequality	64	0.007751938	0.019655214
3	Distribution	0	0.007692308	0.012977361
3	Carbon Dividend	0	0.007692308	0.011540188
3	Households	0	0.005181347	0.004707566
4	Carbon Tax	2062.632353	0.014492754	0.341974813
4	CGE Model	0	0.007575758	0.030612896
4	Cap-and-Trade	64	0.007692308	0.032979817
4	Sustainability	0	0.007633588	0.009904762
4	Carbon Price	0	0.007518797	0.004639699
4	Emissions Trading	0	0.007518797	0.011431255
4	Optimization	0	0.007518797	0.00599801
4	CGE Modelling	0	0.007518797	0.010072944
4	Economic Growth	0	0.007518797	0.007356322
4	Energy Tax	0	0.007518797	0.007356322
4	Fairness	0	0.007518797	0.007356322
4	Remanufacturing	0	0.007518797	0.007356322
4	Closed-Loop Supply Chain	0	0.007518797	0.004639699
4	Energy Consumption	0	0.007575758	0.008476197
4	Income Distribution	0.117647059	0.007633588	0.01568324
4	CCS	0	0.007518797	0.004639699
4	Employment	0	0.007518797	0.007356322
4	Inventory	0	0.007518797	0.004639699
4	Markal	0	0.007518797	0.00599801
4	Political Economy	0	0.007518797	0.00599801
4	Poverty	0	0.007518797	0.004639699
4	Public Opinion	0	0.007518797	0.00599801
4	Revenue Recycling	0	0.007518797	0.007356322
4	Supply Chain	0	0.007518797	0.00599801
4	Air Travel	0	0.007518797	0.004639699
4	Developing Countries	0	0.007518797	0.004639699
4	Choice Experiment	0	0.007518797	0.00599801
4	Dynamic Programming	0	0.007518797	0.004639699
4	Economic Instruments	0	0.007518797	0.00599801
4	Energy Demand	0	0.007518797	0.004639699
4	Input-Output Analysis	0	0.007575758	0.00730585
4	Market-Based Instruments	0	0.005154639	0.004471517
4	Applied General Equilibrium Model	0	0.007518797	0.004639699
4	CGE Analysis	0	0.007518797	0.004639699
4	Distribution of Income	0	0.007518797	0.004639699
4	Dynamic CGE Model	0	0.007518797	0.004639699
4	Economic Impact	0	0.007518797	0.004639699
4	Emissions Trading Schemes	0	0.007518797	0.004639699
4	Energy and Trade Intensive Sectors	0	0.007575758	0.007145009
4	EOQ	0	0.007518797	0.004639699
4	GHG Emission	0	0.007518797	0.004639699
4	Incidence	0	0.007518797	0.004639699
4	Inter-Fuel/Inter-Factor Substitution	0	0.007518797	0.004639699
4	Kyoto Protocol	0	0.007518797	0.004639699
4	Manufacturing	0	0.007518797	0.004639699
4	Synthetic Control Method	0	0.007518797	0.004639699

Table 4 (cont.). Clustering and centrality measures of key nodes in carbon tax research network (economic impact)

Cluster	Node	Betweenness	Closeness	PageRank
4	System Dynamics	0	0.007518797	0.004639699
4	Tax Salience	0	0.007518797	0.004639699
4	Tax Swap	0	0.007518797	0.004639699
5	Net Present Cost	0	1	0.012820513
5	Optimisation Software	0	1	0.012820513
6	Mixed Integer Programming	0	1	0.012820513
6	Multi-Echelon Supply Chain	0	1	0.012820513
7	Decision Making Under Uncertainty	0	1	0.012820513
7	Fat-Tailed Risk	0	1	0.012820513
8	Bottom-Up	0	1	0.012820513
8	Top-Down	0	1	0.012820513
9	Emission Price	0	0.007575758	0.008069042
10	Hotelling Rule	0	0.007575758	0.008069042
10	Non-Renewable Resource	0	0.007575758	0.008069042
11	Combined Cooling Heating and Power (CCHP)	0	0.333333333	0.012820513
11	Integrated Performance Criterion (IPC)	0	0.333333333	0.012820513
11	Operating Mode	0	0.333333333	0.012820513
11	Optimal Operational Strategy	0	0.333333333	0.012820513

The network map in Figure 6 and Table 5 highlights carbon tax studies' policy implications and recommendations. The "carbon tax" node in Cluster 1 shows high betweenness, closeness, and PageRank values, indicating its central role. Closely connected nodes like "climate policy," "cap-and-trade," and "carbon taxation" underscore the integration of climate policy with market mechanisms. The cluster includes energy policy and environmental regulation nodes, suggesting that carbon taxes drive environmental tax and energy policy reforms. Policy recommendations emphasize supporting carbon tax implementation, recycling revenues, and strengthening environmental regulation. Additionally, nodes like "Paris Agreement" and "UNFCCC" in Cluster 2 highlight the role of international agreements in global climate mitigation.

The thematic map in Figure 7 identifies future carbon tax research opportunities by dividing topics based on relevance and development level. Core topics with high relevance and development include "carbon tax," "climate change," and "CGE model." Rapidly developing motor themes like "climate policy," "carbon pricing," and "climate change mitigation" require further research and policy implementation. Niche themes such as "bioenergy," "carbon capture and storage," and "environmental regulations" have high development

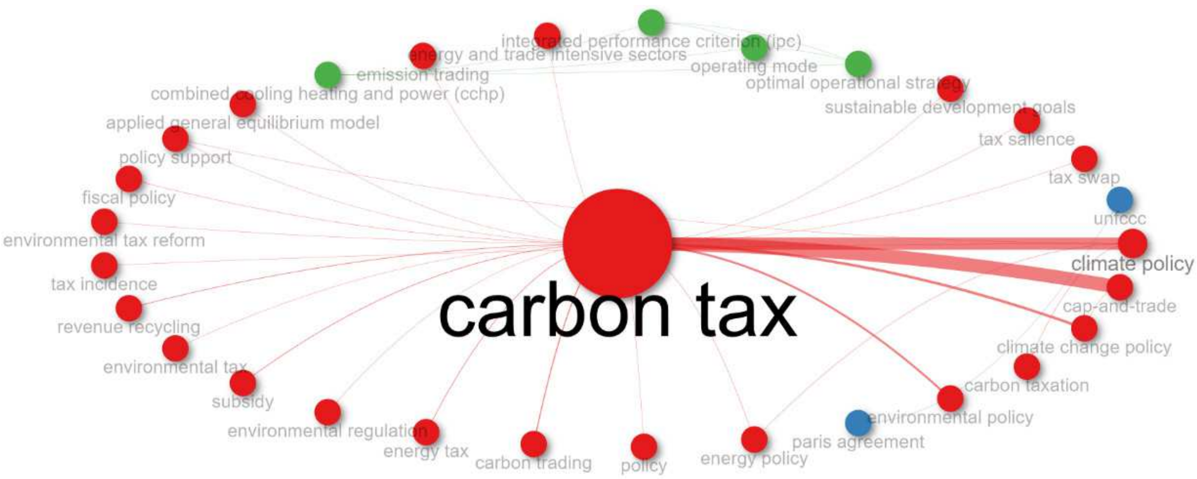

Figure 6. Network visualization of policy implications in carbon tax research

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Table 5. Clustering and centrality measures of key nodes in policy implications of carbon tax research

Cluster	Node	Betweenness	Closeness	PageRank
1	Carbon Tax	239.2142857	0.04	0.323223925
1	Climate Policy	43.7	0.025	0.096346589
1	Cap-and-Trade	0.085714286	0.023255814	0.068385428
1	Climate Change Policy	0	0.02173913	0.033420357
1	Environmental Policy	0	0.021276596	0.025244025
1	Energy Policy	0	0.022727273	0.022147866
1	Carbon Trading	0	0.021276596	0.019460018
1	Energy Tax	0	0.021276596	0.016568014
1	Environmental Regulation	0	0.021276596	0.010784007
1	Subsidy	0	0.021276596	0.016568014
1	Environmental Tax	0	0.021276596	0.010784007
1	Revenue Recycling	0	0.021276596	0.016568014
1	Tax Incidence	0	0.016129032	0.010647903
1	Environmental Tax Reform	0	0.021276596	0.010784007
1	Fiscal Policy	0	0.021276596	0.013676011
1	Policy Support	0	0.022727273	0.016431911
1	Applied General Equilibrium Model	0	0.021276596	0.010784007
1	Emission Trading	0	0.021276596	0.010784007
1	Energy and Trade Intensive Sectors	0	0.021276596	0.010784007
1	Sustainable Development Goals	0	0.021276596	0.010784007
1	Tax Salience	0	0.021276596	0.010784007
1	Tax Swap	0	0.021276596	0.010784007
2	Paris Agreement	0	1	0.033333333
2	UNFCCC	0	1	0.033333333
3	Combined Cooling Heating and Power (CCHP)	0	0.333333333	0.033333333
3	Integrated Performance Criterion (IPC)	0	0.333333333	0.033333333
3	Operating Mode	0	0.333333333	0.033333333
3	Optimal Operational Strategy	0	0.333333333	0.033333333

but lower relevance, suggesting specific areas for deeper exploration. Emerging themes like "wind power" indicate areas needing new approaches or re-evaluation.

The thematic evolution in Figure 8 illustrates the development of carbon tax research from 1968 to 2024, showing shifts in focus and future opportunities. Early research (1968–2010) centered

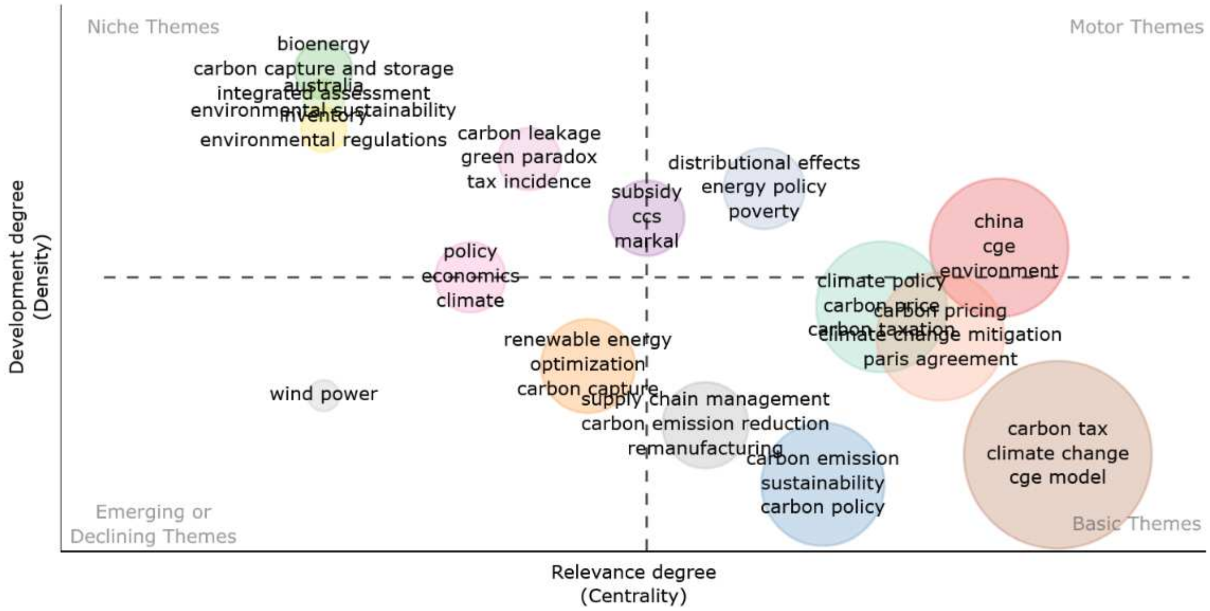

Figure 7. Thematic map on carbon tax research

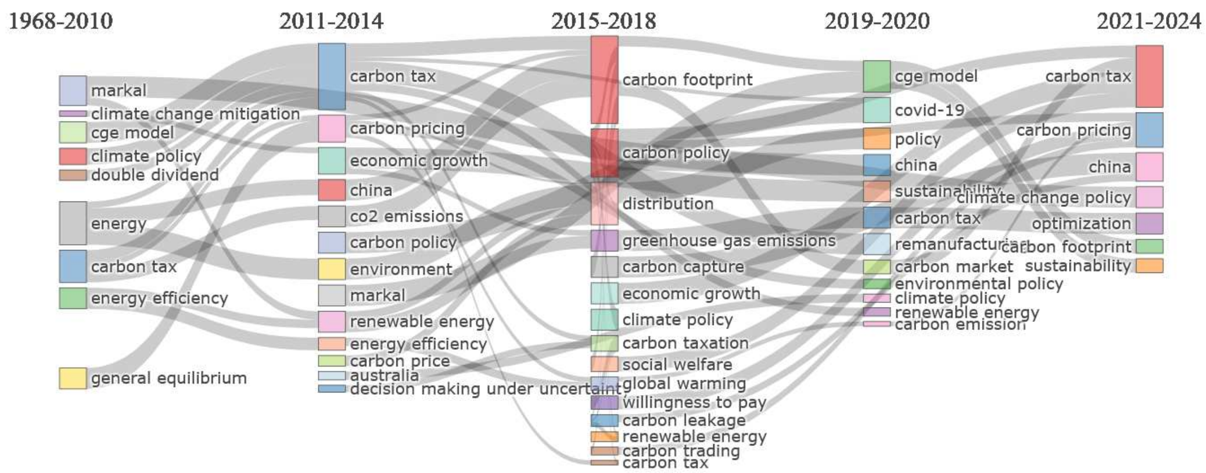

Figure 8. Thematic evolution of carbon tax research

on "general equilibrium," "energy efficiency," and "carbon tax." From 2011 to 2014, "carbon pricing," "economic growth," and "China" became prominent, expanding economic and geographic analysis. In the 2015–2018 period, they emphasized "carbon footprint," "distribution," and "greenhouse gas emissions," reflecting distributional and environmental concerns. From 2019–2020, research addressed COVID-19's impact on sustainability. The 2021–2024 period highlights "carbon pricing," "optimization," and "sustainability," suggesting future research should explore policy optimization and integration for practical sustainability.

The findings indicate a rising trend in carbon tax publications and citations since 2000, with a peak observed between 2017 and 2019. This upward trend underscores the growing global focus on climate change and the urgent need for effective policy responses. Key terms such as "Carbon Tax," "Climate Change," and "Carbon Pricing" highlight the central themes of environmental challenges being addressed in the literature. The network map reveals clusters related to emissions, climate policy, economics, and social justice, consistent with the findings of Zhang et al. (2016) and Patel and Jhalani (2023). In China, carbon tax rates for the propylene sector, which range from 86 to 600 CNY per ton of CO2e, encourage the adoption of cleaner energy sources and demonstrate the flexibility of regional policies (Gonçalves & Menezes, 2024; W. Jiang et al., 2024; Kim et al., 2024; Lv et al., 2024). This regional flexibility further stimulates research into practical carbon tax implementations that align with global sustainability objectives.

The findings show that carbon taxes significantly influence climate change and emissions reduction, with the carbon tax node having the highest centrality value. It highlights the policy's crucial role in renewable energy transition and climate change mitigation. The centrality value suggests carbon taxes are pivotal in environmental policy discussions, emphasizing their effectiveness in reducing emissions (Bima et al., 2023). Bima et al. (2023) study on evolving methodologies reflects these findings. Additionally, carbon taxes effectively reduced carbon emissions (Msefula et al., 2024; Naef, 2024). Increasing CO2 per capita decreases the renewable energy supply (Mideksa, 2024; Przychodzen, 2024), suggesting higher emissions lead to greater fossil fuel reliance. Carbon taxes counter this by making fossil fuel use more expensive, thus promoting renewable energy adoption.

The findings reveal that carbon taxes have significant economic impacts, with the "carbon tax" node holding the highest centrality value and being closely linked to the "CGE model" and "income distribution." This indicates that carbon taxes are central to discussions on economic modeling and income distribution, influencing areas such as supply chain management, economic balance, and social justice (Bima & Alim, 2024). Nazari et al. (2024) further highlighted the importance of public acceptance and policy effectiveness, which aligns with these findings. When properly implemented, carbon taxes can stimulate economic growth without compromising long-term prospects by incentivizing innovation and improving efficiency (Akkemik et al., 2024; C. Jiang,

http://dx.doi.org/10.21511/ee.16(1).2025.04

2021; Mardones & Alvial, 2024). This approach not only fosters economic growth but also supports social justice by optimizing economic outcomes and ensuring more equitable income distribution.

The findings suggest that carbon taxes are central to climate policy, closely linked to "climate policy" and "cap-and-trade," and play a critical role in driving environmental tax and energy policy reforms. This centrality highlights the importance of carbon taxes in achieving climate goals within broader policy frameworks. Key policy recommendations include supporting the implementation of carbon taxes, recycling tax revenues, and strengthening environmental regulations to enhance their effectiveness. These recommendations align with Nazari et al. (2024), who emphasized the importance of public support for carbon tax policies. Y. Li et al. (2024) demonstrated that effective abatement policies, including carbon taxes, can significantly reduce carbon emissions. This finding is consistent with de Bruin and Yakut's (2024) conclusion that aligning carbon tax policies with international regulations helps prevent carbon leakage. Complementary policies, such as renewable energy subsidies and social safety nets, can address the regressive impacts of carbon taxes on lower-income households. The effectiveness of carbon taxes lies in making fossil fuel use more costly while generating revenue for sustainable projects, with their success dependent on public acceptance, which is strengthened through transparent communication and the visible funding of environmental initiatives.

The findings highlight promising opportunities for future carbon tax research, focusing on core topics such as "carbon tax" and "climate change," as well as emerging themes like "climate policy" and "carbon pricing." These findings underscore the need for continued exploration to develop practical sustainability solutions, which aligns with Nazari et al. (2024) on the critical role of carbon pricing policies for economic and environmental sustainability. Similar to the conclusions of Allers and Rienks (2024), the findings suggest that carbon taxes reduce emissions by increasing the cost of fossil fuels, thereby encouraging the adoption of clean technologies. While higher production costs can result in increased prices, they also incentivize energy efficiency and innovation, ultimately boosting productivity and creating new economic opportunities (Ding & Li, 2024; Roche et al., 2022; Shapir-Tidhar et al., 2023; Yu et al., 2024). This dual effect – reducing reliance on fossil fuels while driving technological advancements – illustrates the central role of carbon taxes in discussions on sustainable development.

CONCLUSION

This study aims to analyze carbon tax research trends, their environmental and economic impacts, and policy implications through bibliometric methods and social network analysis. Carbon tax publication and citation trends are increasing, suggesting the topic is worthy of further study. Carbon taxes significantly impact climate change and emission reduction and play an essential role in environmental and sustainability strategies. Carbon taxes impact supply chain management, economic balance, and social equity and are climate policy, driving environmental tax reform and energy policy. Future research should focus on foundational and emerging themes to enhance the effectiveness and equity of sustainability efforts. Key areas for future exploration in carbon tax research include established topics like "carbon tax" and "climate change," as well as newer topics such as "climate policy" and "carbon pricing." The increasing trend in carbon tax publications and citations underscores the significant role carbon taxes play in addressing critical issues such as climate change mitigation, emissions reduction, supply chain management, economic stability, and social equity. Additionally, this paper highlights the importance of carbon taxes in shaping environmental tax reform and advancing energy policies aimed at sustainability.

This study contributes significantly by identifying key trends, impacts, and policy implications of carbon taxes through bibliometric and social network analyses. The findings show that carbon taxes play a central role in reducing carbon emissions and promoting sustainability policies and have significant economic impacts, including supply chain management and income distribution. The results can be used practically by policymakers to design more effective and equitable carbon tax policies, support the transition to renewable energy, and strengthen environmental regulation. In addition, this research opens up opportunities for academics to further explore carbon tax-related topics, such as distributional impacts and policy optimization, that help global efforts to address climate change.

The main limitation of bibliometric research is that it tends to provide a quantitative overview without necessarily reflecting the depth of qualitative analysis of individual studies. Bibliometric analysis can also overlook specific contexts and nuances in research that can only be captured through in-depth literature reviews or case studies. Future research could deepen the understanding of carbon taxes by combining bibliometric methods with more in-depth qualitative analysis, such as expert interviews or country case studies. In addition, further exploration could be done on the socio-economic impacts of carbon taxes across different sectors and regions and the development of policy models that consider dynamic variables in a changing global economy.

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Investigation: Suhanda, Darmawati, Andi Iqra Pradipta Natsir.
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Resources: Suhanda, Darmawati, Andi Iqra Pradipta Natsir, Indira Syakira Kirana Juanda.
Software: Indira Syakira Kirana Juanda.
Supervision: Andi Kusumawati.
Validation: Andi Kusumawati, Suhanda.
Visualization: Darmawati, Indira Syakira Kirana Juanda.
Writing – original draft: Andi Kusumawati, Suhanda, Darmawati, Andi Iqra Pradipta Natsir, Indira Syakira Kirana Juanda.
Writing – review & editing: Andi Kusumawati, Suhanda, Darmawati, Andi Iqra Pradipta Natsir, Indira Syakira Kirana Juanda.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to the Rector and the Dean of the Faculty of Economics and Business, Hasanuddin University for their unwavering support and invaluable assistance in this analysis. Their commitment to advancing academic research and community service has been instrumental in completing this study.

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