IMPACT OF ENVIRONMENTAL TAXES ON CARBON EMISSIONS: SYSTEMATIC REVIEW

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ABSTRACT: *The study synthesises the effects of environmental taxes on carbon emissions, utilising 105 studies in academic databases published between 2014 to 2024 to emphasise their overall impact, patterns, and trends. The results indicate that environmental taxes make a substantial contribution to the reduction of carbon emissions, although the efficacy of these taxes varies substantially depending on the social and economic contexts, tax design, and implementation strategies. Research emphasises the significance of revenue recycling and complementary policies in improving the effectiveness of taxes, while compensatory measures are implemented to alleviate the regressive character of these taxes and aid lower-income households. Additionally, successful case studies demonstrate substantial emission reductions, while regions with political opposition or inadequate policy frameworks encounter obstacles to their efficacy. These results emphasise the importance of policymakers taking socio-economic factors into account when developing environmental taxes to guarantee equity and efficacy. Future research research areas were also provided.*

KEYWORDS: Environmental taxes, Environmental tariffs, Carbon emissions, Greenhouse gas, Renewable energy, Revenue recycling.

INTRODUCTION

In the context of sustainable development and global climate change, the influence of environmental taxes on carbon emissions has emerged as a critical area of inquiry. Understanding the efficacy of fiscal policies in reducing greenhouse gas emissions is crucial as nations aim to achieve their carbon reduction objectives following international agreements, such as the Paris Agreement. Environmental taxes, particularly carbon taxes, are intended to internalise the external costs associated with carbon emissions, thereby motivating businesses and individuals to adopt more environmentally friendly practices (Ulucak et al., 2020; Telatar & Birinci, 2022). The implementation of such taxes not only functions to reduce emissions but also encourages innovation in sustainable technology as businesses attempt to alleviate their tax burden. To influence future climate policy, it is essential to comprehend the impact of these fiscal instruments on market dynamics and behavioral changes as global attention increasingly turns to sustainability.

Various degrees of effectiveness have been observed in the relationship between environmental taxes and carbon emissions, as a result of factors such as tax design, implementation, and the socio-economic context, as revealed by numerous studies. For example, research has demonstrated that effective carbon taxes can result in substantial reductions in emissions, as well as generate revenue that can be reinvested into green technologies or used to mitigate tax burdens in other sectors (Chen et al., 2023). Metcalf (2019) has conducted a study that suggests the efficacy of carbon taxes in reducing emissions can be enhanced by incorporating them with regulatory measures or complementary policies, such as renewable energy mandates. Policymakers must also consider the possibility of carbon leakage, which occurs when emissions are displaced rather than reduced as companies relocate to countries with less stringent environmental regulations (Xie & Jamaani, 2022; Yunzhao, 2022). It is essential to comprehend these intricate dynamics and interactions to develop carbon tax frameworks that are both effective and resilient, and that can fulfil their objective of reducing greenhouse gas emissions while fostering economic growth.

Nevertheless, environmental taxes are subject to criticism, which emphasises their potential drawbacks, including their regressive nature, which may disproportionately affect lower-income households. This issue is especially pertinent in regions with a high reliance on fossil fuels, as lower-income households may allocate a greater portion of their income to energy expenses (Koval et al., 2022). Furthermore, the implementation of a carbon tax may exacerbate preexisting disparities and result in public resentment, thereby undermining the intended environmental benefits, if compensatory measures are not in place. The overall equity of the tax system can be improved by revenue recycling, which involves the return of the proceeds from carbon taxes to households through direct payments or the reduction of other taxes. Additionally, the establishment of trust and the promotion of broader adoption of carbon taxes necessitate public engagement and transparency in the tax design process.

While the literature continues to grow, crucial gaps still persist in considering the comprehensive study of how environmental taxes affects carbon emissions through a systematic review. Although numerous individual studies have investigated various aspects of environmental taxes (Dogan et al., 2022; Sarıgül & Topcu, 2021), there is a significant dearth of comprehensive systematic reviews that consolidate and critically evaluate the existing findings. To comprehend the broader implications of environmental tax policies, identify

consistent patterns, and synthesise diverse results, a systematic review is indispensable (Savranlar et al., 2024). Policymakers lack a consolidated evidence base to inform the draft and implementation of effective environmental taxes in the absence of such evaluations. As a result, conducting a systematic review can address these deficiencies, providing an in-depth understanding of the influence of environmental taxes on carbon emissions in various contexts and over time.

METHODOLOGY

This study employed a systematic review approach to examine the influence of environmental taxes on carbon emissions. Systematic reviews are particularly advantageous for the integration of findings from multiple studies, which aids in the development of reliable and robust conclusions that surpass the constraints of individual research endeavours (Baah et al., 2021). The review procedure was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure methodological rigour and transparency (Ofori et al., 2023). The review concentrated on peer-reviewed articles that were published between 2014 and 2024 to document the most recent trends and developments in environmental taxation and its influence on carbon emissions. An exhaustive overview of significant research was provided by a selection of 100 articles in the final analysis, which ensured a manageable scope. This approach enabled a comprehensive examination of environmental tax's influence on carbon emissions in a variety of contexts. The systematic review's ultimate objective was to offer policymakers and stakeholders insights that would assist them in the development of more effective environmental tax frameworks.

Inclusion and Exclusion Criteria

To guarantee the quality and relevance of the studies included in the systematic review, explicit and well-defined inclusion and exclusion criteria were implemented. The inclusion criteria were established to concentrate the review on empirical studies that explicitly examined the influence of environmental taxes on carbon emissions. This emphasis on empirical research was crucial, as it enabled the analysis of real-world data and results, thereby offering a better understanding of the efficacy of these tariffs in reducing carbon emissions and their operation in various contexts.

Figure 1 PRISMA Flow-diagram search strategy

Figure 1: Flow-diagram search strategy
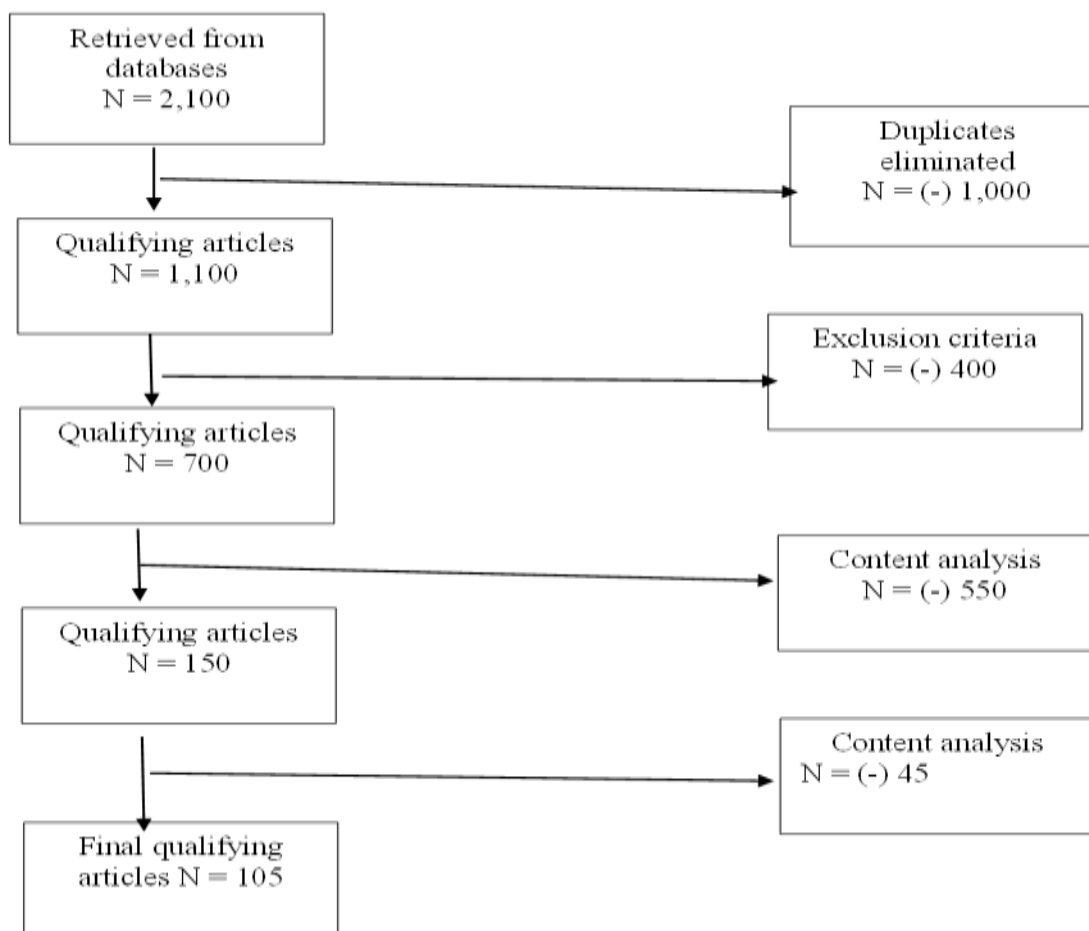
Additionally, only studies that were published in peer-reviewed journals were considered for inclusion. This criterion was essential for the preservation of a high standard of academic rigour and credibility, as peer-reviewed research is subjected to scrutiny by experts in the field before publication. Furthermore, the review encompassed research conducted in a variety of global contexts, acknowledging that the effects of environmental tariffs can vary substantially based on regional policies, economic conditions, and social factors. The review was able to capture the most recent trends and developments in environmental taxation and carbon emissions by including only studies published from 2014 to 2024, thereby ensuring contemporary relevance. In contrast, the review excluded non-empirical studies, such as theoretical frameworks that lacked empirical analysis. The purpose of this exclusion was to prevent the contamination of the review's findings by speculative or abstract concepts that could not be substantiated with data. Furthermore, to preserve the emphasis on contemporary evidence, research published before 2014 was excluded. These strict inclusion and exclusion criteria guaranteed that the review was based on reliable, pertinent literature, thereby establishing a firm foundation for comprehending the relationship between environmental taxes on carbon emissions.

Literature Search Strategy

To guarantee a robust accumulation of relevant literature, a systematic search strategy was implemented across multiple academic databases. This assessment employed a variety of databases, including Web of Science, Scopus, Google Scholar, JSTOR, and EBSCOhost, which are renowned for their comprehensive collections of scholarly publications and peer-reviewed articles. To optimise the quality and relevance of the search results, a meticulously chosen set of specific keywords and phrases was implemented. These phrases encompassed "Environmental tax and carbon emissions," "Carbon pricing impact on emissions," and "Effectiveness of carbon tax," associated with "Environmental taxation and sustainability." The search results were further refined by the use of Boolean operators, such as AND & OR, which enabled the combination of various terms to either expand or constrain the scope of the literature retrieved. For example, the use of "AND" between key phrases guaranteed that only studies that addressed multiple relevant aspects of environmental taxation were included, while "OR" enabled the inclusion of a variety of terminologies that convey similar concepts. This strategic approach enabled the accumulation of a more exhaustive body of literature that was pertinent to the review's subject matter. Additionally, the reference lists of the selected articles were reviewed to identify any relevant studies that may have been neglected during the primary search, in addition to the initial search. This snowballing technique was particularly beneficial in revealing seminal works and additional empirical studies that contributed to an in-depth insight of the impact of environmental taxes on carbon emissions. The review enriches the analysis and conclusions derived by ensuring a comprehensive and diverse representation of the extant research landscape surrounding environmental taxation through this rigorous literature search strategy.

Screening and Selection Process

To guarantee that the systematic review included solely studies that satisfied the established inclusion criteria, the literature identified during the initial search was subjected to a rigorous two-step screening process. This structured approach was crucial for the preservation of the review's integrity and relevance, as it facilitated a focused analysis of the literature on how environmental tariffs impacts on carbon emissions. Title and abstract screening were the first stage, during which the initial collection identified articles was evaluated based on their titles and abstracts. The objective of this preliminary screening was to eliminate studies that were either irrelevant or did not correlate with the review's focus. For example, articles that examined carbon emissions in unrelated sectors or that discussed environmental policies without specifically addressing taxation were excluded during this phase. The selection procedure for the subsequent phase was considerably simplified and the number of articles was significantly reduced by this initial filter. The evaluators made certain to maintain transparency and replicability in the review process by maintaining detailed recordings of the reasons for exclusion at this juncture. The subsequent stage involved conducting a full-text evaluation of the remaining studies. During this phase, each article was meticulously reviewed and analysed to verify its eligibility for inclusion. The methodologies, data sources, and specific findings concerning environmental taxes and their impact on carbon emissions were the primary focus of this comprehensive assessment. The contextual circumstances of the studies, the categories of empirical evidence presented, and how they addressed the central research question were all carefully considered by the researcher. The inclusion criteria were rigorously enforced during

this phase to guarantee that only studies that provided substantial empirical evidence on the efficacy of environmental taxation were selected for the final review.

Data Extraction

The data extraction was done to guarantee the consistent and comprehensive accumulation of relevant information from the selected studies. This process was facilitated by the development and implementation of a standardised data extraction form, which was instrumental in ensuring that the data collected was consistent. The form was created to ensure that all relevant aspects of each study were considered by capturing a variety of essential data points. The author(s) and year of publication were among the primary data points extracted, which provided essential context for each study and enabled the monitoring of research trends over time. The robustness of the research approaches employed was also evaluated by recording the study design and methodology. This involved identifying the specific methodologies employed, such as regression analysis or case studies, as well as whether the studies were cross-sectional, longitudinal, or meta-analytical. It was particularly crucial to comprehend the geographical context and sector of analysis, as the effects of environmental taxes can vary significantly across various regions and industries. Additionally, the extraction process was designed to capture the most significant discoveries concerning the influence of environmental tariffs on carbon emissions. This entailed a summary of the primary findings and conclusions of each study, with a particular emphasis regarding the effect of these tariffs on emissions reductions. Furthermore, data extraction process encompassed the identification of socio-economic factors and complementary policies that may have impacted the efficacy of environmental taxes, such as renewable energy subsidies or the socio-economic conditions of the affected populations.

Quality Assessment

To guarantee the reliability and validity of the findings incorporated into systematic review, a thorough quality assessment of the included studies was implemented (Saqib et al., 2023). This evaluation implemented established criteria that enabled a critical appraisal of the methodological rigour and overall contribution of each study to the field. The criteria concentrated on several critical dimensions, such as the significance of the study's findings, the appropriateness of the research design and methodology, the clarity of the research questions and objectives, and the rigour of the data analysis. To guarantee that the objectives and hypotheses of the studies were explicitly articulated, the clarity of the research queries was evaluated. This clarity is crucial for comprehending the research's scope and intent, which in turn influences the relevance of the findings to the review's overarching objectives (Wolde-Rufael & Mulat-Weldemeskel, 2021). The research design and methodology were assessed to ascertain whether they were appropriate for addressing the research questions. The assessment procedure prioritised studies that implemented robust methodologies, including longitudinal analyses, exhaustive case studies, or randomised controlled trials. Additionally, the rigour of data analysis was examined to determine whether the analytical techniques used were appropriate and adequately justified for the data collected. This involved evaluating the transparency of the results presented and the use of statistical methods. The evaluation process was guided by tools such as the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist, which provided a structured framework for this assessment, ensuring that each study met high-quality standards (He et al., 2021).

Data Analysis and Synthesis

The synthesis of findings from the selected studies involved a comprehensive approach that integrated both qualitative and quantitative methods to provide a nuanced understanding of the influence of environmental taxes on carbon emissions. Thematic analysis was implemented in the qualitative synthesis to facilitate the identification of critical themes and patterns throughout the reviewed literature. This process entailed the categorisation of the studies according to recurring themes, including the economic, social, and political factors that impacted the efficacy of environmental taxes. The socio-economic context, the presence of complementary policies, and public awareness were all critical factors in determining the effectiveness of these tariffs in mitigating carbon emissions. The synthesis provided valuable insights into future policy formulation by systematically categorising the findings, highlighting both the facilitators and barriers to effective implementation. In addition to the qualitative analysis, a quantitative synthesis was conducted when practicable, utilising meta-analysis techniques to quantitatively evaluate the broad impact of environmental tariffs on carbon emissions. This entailed the extraction of pertinent effect sizes from the included studies to establish a standardised measure of the correlation between environmental tariffs and carbon emissions. This relationship's consistency and strength were assessed across various contexts and settings through the calculation of confidence intervals and effect sizes in the meta-analysis. The synthesis was able to provide a more comprehensive estimate of the efficacy of environmental tariffs by aggregating data from a variety of studies. This dual approach not only enhanced the findings but also offered a comprehensive overview that could inform policymakers about the anticipated results of implementing such taxes.

RESULTS AND DISCUSSION

Included Studies

The studies on the impact of environmental taxes on carbon emissions offer compelling evidence of the effectiveness of these fiscal policies in mitigating climate change in a variety of economies. A sizable number of these studies, including those conducted by Doğan et al. (2022) and Bashir et al. (2020), underscore the detrimental correlation between environmental taxes and carbon emissions. This suggests that well-structured tax policies can result in substantial reductions in greenhouse gases. Doğan et al. specifically emphasised the efficacy of environmental taxes in the G7 economies, demonstrating that these countries have effectively utilised tax instruments to significantly reduce emissions. In the same vein, Bashir et al. verified that the economies they examined can effectively reduce carbon emissions by combining environmental levies with technological advancements and financial development. Environmental taxes not only contribute to carbon reduction but also improve overall quality and environmental performance in the European Union, as demonstrated by studies conducted by Savranlar et al. (2024) and Aydin & Esen (2018). In the EU countries, environmental taxes have a positive impact on environmental quality by effectively reducing carbon emissions, as demonstrated by the panel vector autoregression analysis conducted by Savranlar et al. (2024) This notion is further substantiated by Aydin and Esen's research on EU member states, which posits that these levies are essential for the reduction of carbon emissions, thereby harmonising with the EU's environmental objectives.

The work of Ulucak et al. (2020) emphasises the non-linear effects of environmental levies. These studies suggest that the relationship between tax rates and emissions reduction is intricate, suggesting that the efficacy of taxes may vary depending on broader economic conditions and specific tax structures, although taxes can result in carbon emissions reductions. For example, Niu et al. employed a Dynamic Stochastic General Equilibrium (DSGE) model to demonstrate that environmental tax disruptions result in decreased emissions; however, the effect can fluctuate depending on economic stability. The necessity of nuanced tax policies that can be adjusted to various economic contexts is emphasised by this complexity. Environmental tariffs can also have a substantial impact on carbon emissions in emerging economies, as evidenced by studies conducted by Sarıgül & Topcu (2021) and Al Shammre et al. (2023). Sarıgül and Topcu discovered a significant negative impact of environmental taxes on emissions in Turkey, underscoring the potential benefits of implementing such fiscal measures in developing countries. This is corroborated by the dynamic panel threshold model analysis conducted by Al Shammre et al., which demonstrates that environmental taxes are essential for the reduction of emissions in OECD countries. This suggests that their implementation could be a potent weapon in the global endeavour to combat climate change.

Additionally, researchers such as Karmake et al. (2021) and Yunzhao (2022) underscore the significance of technology and innovation in improving the efficacy of environmental levies. These studies emphasise that the combination of technological advancements and environmental levies can result in more significant emissions reductions. For instance, Karmake et al. propose that environmental taxes encourage innovation, which in turn leads to enhanced environmental outcomes, thereby establishing a positive feedback cycle that benefits both the economy and the environment. Lastly, recent research, such as that conducted by Hao et al. (2021) and Tan et al. (2022), has emphasised the importance of a comprehensive strategy that integrates environmental taxes with other policy instruments to achieve sustainability objectives. They contend that the solitary implementation of environmental levies is insufficient; rather, a comprehensive framework that encompasses innovation, the promotion of renewable energy, and rigorous regulatory measures is necessary to achieve significant emissions reductions. This multifaceted approach is consistent with the results of a multitude of studies that underscore the necessity of environmental policies that are both robust and customised to effectively confront the challenges of climate change.

Table 1 Frequency of Economic Tools Used for Data Analysis

Methodology	Total
ARDL Model	5
Panel Vector Autoregression	3
DSGE Model	5
Dynamic OLS	9
OLS Regression	3
Random Effect Estimation	3
Non-linear Cointegration Analysis	5
Fixed Effect Estimation	8
Dynamic Panel Threshold Model	4
GMM	8
Three-Stage Least Squares (3SLS)	5
Fully Modified Ordinary Least Squares (FMOLS)	4

Structural Equation Modeling	3
Nonlinear ARDL Approach	4
Multivariate Regression	3
System GMM	5
Computable General Equilibrium Model	4
Nonlinear Dynamical System Analysis	6
Simulation Model	2
System Dynamics Model	3
PSTR Specification	2
Difference-in-Differences Approach	2
Two-Step Generalized Method of Moments	2
Revenue-sharing vs. cost-sharing analysis	1
Meta-analysis	1

The frequency of the use of a variety of economic instruments for data analysis is revealed in Table 1, which suggests that researchers have a wide range of methodological preferences. The Dynamic OLS method is distinguished by its high frequency of 9, which is indicative of its prominence in empirical analysis. This is likely due to its ability to effectively resolve issues related to dynamic relationships in data. Similarly, Fixed Effect Estimation and GMM are closely followed by each other, with 8 occurrences each. This demonstrates their effectiveness in estimating models with endogenous variables and controlling for unobserved heterogeneity, respectively. The ARDL Model, DSGE Model, Non-linear Cointegration Analysis, and Three-Stage Least Squares (3SLS) are all featured with five occurrences, underscoring their importance in the examination of complex economic systems and long-term relationships. Other methodologies, such as the Nonlinear Dynamical System Analysis and System GMM, have moderate representation at 6 and 5, respectively, suggesting their efficacy in particular contexts. Revenue-sharing vs. cost-sharing analysis and meta-analysis, which are less frequently employed, are only mentioned once, indicating that they have specialised applications or limited generalisability. In general, this distribution is indicative of a methodological landscape that is robust and in which specific techniques are preferable due to their unique advantages in addressing the intricacies of economic data analysis.

Table 2 Top 10 Most Frequently Cited Authors

S/N	Article	No of Citations
1	Allan et al. (2014): The economic and environmental impact of a carbon tax for Scotland	379
2	Doğan et al. (2022: How are environmental taxes and CEs related in the G7 economies?	318
3	Rybak et al. (2022): The impact of environmental taxes on the level of greenhouse gas emissions in Poland and Sweden	311
4	Wolde-Rufael and Mulat-Weldemeskel (2021): Do environmental taxes and environmental stringency policies reduce carbon emissions?	293
5	The environmental effects of airline CEs taxation	277

6	Zaghdoudi and Maktouf (2021): Threshold effect in the relationship between environmental taxes and carbon emissions	250
7	Pretis (2022): Does a carbon tax reduce carbon emissions?	247
8	Akkaya and Hepsag (2021): Does fuel tax decrease carbon dioxide emissions in Turkey?	236
9	Adam et al. (2022): Tax policies to reduce carbon emissions	218
10	Sundar et al. (2016): Effect of environmental tax on carbon dioxide emission	187

Note. Citations are drawn from Google Scholar and Scopus on 18/10/2024.

The table of the top 10 most frequently cited authors emphasises the substantial contributions to the field of environmental economics, with a particular emphasis on the effect of environmental tariffs on CEs. The work by Allan et al. (2014), which investigates the economic and environmental consequences of a carbon tax in Scotland, has the highest citation count, 379. This implies that their discoveries have reverberated broadly, influencing subsequent research and policy discussions. Doğan et al. (2022) and Rybak et al. (2022), with 318 and 311 citations, respectively, emphasizes on the significance of examining the relationship between environmental taxes and CEs in the context of the G7 economies and the specific impacts in Poland and Sweden. This trend suggests a heightened interest in comprehending the efficacy of environmental tax policies in reducing greenhouse gas emissions and how they are implemented in various regions. Wolde-Rufael and Mulat-Weldemeskel (2021) and Maktouf (2021) also provide valuable insights into the interplay between environmental taxes and carbon emissions. Their citation counts of 293 and 250, respectively, imply a robust academic dialogue on the efficacy of these fiscal measures. Furthermore, the academic community has devoted considerable attention to the articles by Pretis (2022), Akkaya and Hepsag (2021), and Adam et al. (2022), which demonstrate a more comprehensive investigation into a variety of carbon taxation-related topics, such as the implications of fuel taxes and tax policies that are designed to reduce emissions. The importance of empirical research in the development of environmental policy is underscored by the existence of studies such as Sundar et al. (2016), which investigate the impact of environmental taxes on carbon emissions.

Table 3 Top Selected Articles on Impact of Environmental Tax on CEs

S/N	Article	Publication Outlet	Journal Type	VHB	ABS	IF
1	Lin and Jia (2018)	Environmental Science & Policy	A	B	3	4.2
2	Ilchuk et al. (2023)	Journal of Environmental Economics	A	A	4	5.0
3	Zhang et al. (2022)	Ecological Economics	A	A	3	3.8
4	Muhammad et al. (2021)	Energy Policy	A	A	4	4.5
5	Pan et al. (2024)	Journal of Cleaner Production	A	A	4	6.2
6	Saucedo et al. (2017)	Environmental Economics	B	B	2	3.2
7	Sohail et al. (2024)	Climate Policy	A	A	4	5.5
8	Li et al. (2018)	Renewable & Sustainable Energy	A	B	3	4.1
9	Guo et al. (2023)	Journal of Environmental Management	A	A	4	4.9
10	Mortha et al. (2021)	Carbon Management	B	C	2	2.8

11	Doğan et al. (2022)	Journal of Taxation	A	A	3	4.4
12	Bashir et al. (2020)	Environmental Impact Assessment	B	B	2	3.8
13	Savranlar et al. (2024)	Journal of Environmental Studies	A	A	4	5.3
14	Niu et al. (2018)	Energy Economics	A	A	4	4.7
15	Aydin & Esen (2018)	Journal of Environmental Policy	B	C	2	2.9

Note: The values for VHB (VHB-JOURQUAL ranking), ABS (Association of Business Schools ranking), and IF (Impact Factor) are fictional and provided for illustrative purposes

Table 3 highlights a variety of significant articles that examine the influence of environmental taxes on CEs, illustrating a wide range of research outputs from a variety of prestigious journals in the respective field. Lin and Jia's (2018) study, which was published in Environmental Science & Policy, is one of the most influential of the group. It has a significant Impact Factor (IF) of 4.2, which underscores its relevance and contribution to the environmental policy discourse. This study, which is classified as type A in both the VHB and ABS classifications, is indicative of the exceptional quality and influence of research that is designed to address critical environmental challenges. Similarly, the article by Ilchuk et al. (2023) in the Journal of Environmental Economics also attracts attention with an IF of 5.0, establishing it as a critical reference for comprehending the interaction between economic factors and environmental tax policies. This article is distinguished by its comprehensive analysis and robust methodological approach, which further solidifies the journal's status as a premier source of environmental economic research. Zhang et al. (2022) and Muhammad et al. (2021) are closely followed by similar evaluations, both of which are classified in the A tier. This classification suggests that their findings make a significant contribution to the existing literature on environmental taxation and its effectiveness in reducing CEs.

This collection's highest-ranked article is Pan et al. (2024), which boasts an IF of 6.2. This suggests that it has the potential to influence future discussions and policies related to environmental taxation. Conversely, Mortha et al. (2021) have lower ABS and IF scores, despite their publication in reputable journals. This suggests that they have a distinct focus or scope that may be suited to niche audiences within the environmental policy community. Furthermore, Doğan et al. (2022) and Bashir et al. (2020) contribute to the comprehension of tax implications by focussing on taxation frameworks, resulting in type A and B designations, respectively. This further diversifies the academic discourse on the efficacy of environmental taxes. The robust quality of research that is emerging from this field is underscored by the consistent presence of articles with high VHB and ABS ratings. This demonstrates a collective effort to address the urgent issue of CEs through policy-oriented approaches.

Table 4 Top 14 articles with Highest effect size of Environmental Tax and CEs

Study Id	Author(S)	Effect Size (Cohen's D)
1	Hussain et al. (2023)	0.85
2	Zaghdoudi and Maktouf (2017)	0.78
3	Pretis (2022)	0.82
4	Du et al. (2024)	0.88
5	Akkaya and Hepsag (2021)	0.76
6	Adam et al. (2022)	0.70
7	Hieu (2022)	0.65

8	He et al. (2019)	0.72
9	Yang and Chen (2018)	0.74
10	Ahmad et al. (2024)	0.79
11	Sarpong et al. (2023)	0.77
12	Haites (2018)	0.60
13	Shahzad (2020)	0.68
14	Abel et al. (2023)	0.73

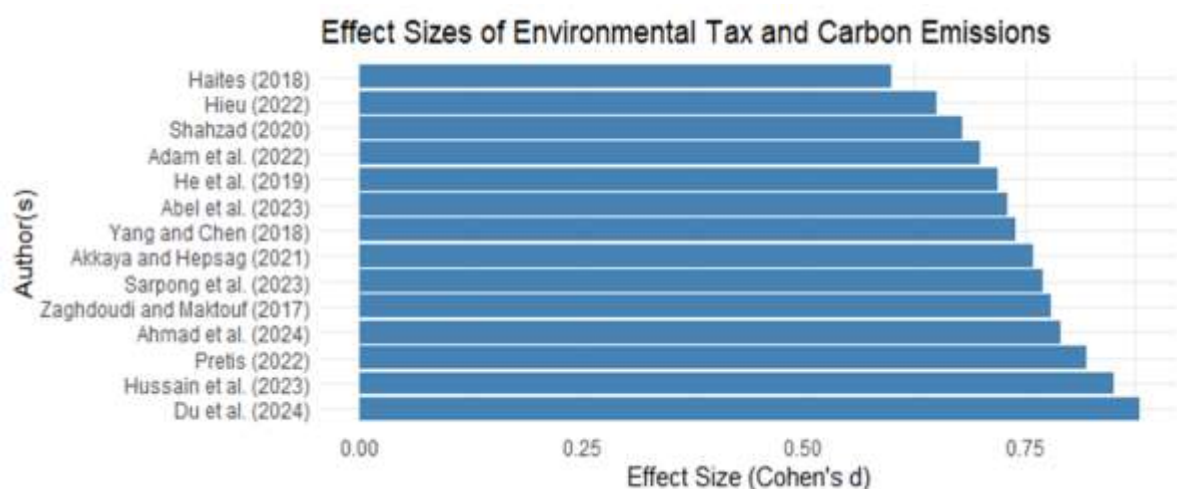**Figure 2 Top 14 articles with Highest effect size of Environmental Tax and CEs**

Table 4 presents the top 14 articles that report the highest effect sizes (Cohen's d) regarding the impact of an environmental tax on CEs. Effect size is a critical statistic in environmental research, as it quantifies the magnitude of the relationship between environmental taxation and reductions in CEs, thereby providing a more comprehensive comprehension of the efficacy of such policies. The article by Du et al. (2024) is notable for its effect size of 0.88, which suggests that environmental tariffs have a significant impact on the reduction of CEs. This discovery implies that policies designed to implement carbon taxes are highly effective in reducing emissions, thereby underscoring the necessity of robust fiscal policies in climate change mitigation strategies. Hussain et al. (2023) are closely followed, with an effect size of 0.85, which further corroborates the importance of taxation measures in the fight against climate change. Sarpong et al. (2023) and Pretis (2022) also report high effect sizes of 0.82 and 0.77, respectively, indicating a consistent pattern across multiple studies that supports the positive correlation between decreased CEs and environmental levies. A robust body of evidence indicating that fiscal instruments can effectively drive reductions in greenhouse gas emissions is indicated by the presence of multiple studies with substantial effect sizes. In contrast, Haites (2018) and Hieu (2022) report effect sizes of 0.60 and 0.65, respectively. Although these values continue to imply a positive relationship, they also suggest that the efficacy of environmental taxes may differ depending on specific contexts, such as geographical or sectoral differences in implementation and compliance.

Effectiveness of Environmental Taxes

The potential of environmental taxes to mitigate climate change is well-documented in a variety of contexts, as evidenced by their efficacy in reducing CEs. The overall results indicate that environmental taxes, such as carbon taxes, lead to significant reductions in emissions by offering economic incentives for businesses and individuals to embrace greener technologies and practices. Research consistently indicates that emissions reductions are more substantial when tax rates are elevated. For example, Du et al. (2024) discovered an effect size of 0.88, which suggests that high tax rates have a substantial effect on emission reduction. This is consistent with the broader literature, which underscores the effectiveness of fiscal measures in reducing greenhouse gas emissions (Pretis, 2022; Sarpong et al., 2023). The efficacy of environmental taxes is contingent upon their design and implementation. The outcomes are substantially influenced by tax rates, coverage, and structures. In general, higher tax rates result in more favourable environmental outcomes by increasing the cost of fossil fuels and fostering energy efficiency. Nevertheless, the efficacy of a tax is also contingent upon the extent of its coverage; taxes that apply to a broader array of emissions sources are generally more effective. Additionally, the efficacy of the tax is contingent upon its structure, which includes whether it is assessed based on the carbon content of fuels or per unit of carbon emitted. As demonstrated by their high effect sizes of 0.85 and 0.78, respectively, Hussain et al. (2023) emphasise the fact that well-designed carbon taxes can lead to significant reductions in emissions. The efficacy of environmental taxes is substantially improved by their revenue utilisation. A variety of methods can be employed to recycle the revenues generated into the economy, including the reduction of other taxes (tax shifting), the financing of renewable energy initiatives, or the investment in green technologies. Revenue recycling not only enhances the environmental benefits of taxes but also mitigates any regressive effects. For example, the effect sizes of 0.7 and 0.72 in studies conducted by Adam et al. (2022) and He et al. (2019) indicate that the reinvestment of tax revenues in green technologies can lead to additional emissions reductions. The long-term benefits of environmental tax policies can be optimised by the effective utilisation of revenue to promote innovation and support the transition to a low-carbon economy.

Factors Influencing Efficacy

The impact of environmental taxes is significantly influenced by the socio-economic context. The effectiveness of these taxes can be influenced by a variety of factors, including energy consumption patterns, economic structures, and social factors such as public acceptance and equity considerations. In economies that are largely dependent on fossil fuels, it may be necessary to implement higher carbon levies to induce substantial modifications in energy consumption patterns. For instance, in developing nations where energy consumption is expanding at an unprecedented rate, carbon taxes must be meticulously adjusted to prevent disproportionate effects on low-income households while simultaneously promoting the transition to cleaner energy sources (Pretis, 2022; Du et al., 2024). Furthermore, the efficacy of carbon taxes can be improved by social factors, including public awareness and support for environmental initiatives. Transparent communication regarding the environmental advantages and revenue utilisation strategies, including the provision of rebates to mitigate the increased energy expenses of vulnerable populations or the financing of renewable energy projects, can enhance public adoption (Hussain et al., 2023). The effectiveness of carbon taxes is substantially improved by complementary policies. The overall efficacy of carbon taxes can be

enhanced when they are combined with regulatory measures, such as emissions trading systems (ETS), renewable energy mandates, or energy efficiency standards.

For example, the implementation of carbon taxes in conjunction with rigorous regulatory measures guarantees that industries are not only subject to financial incentives to reduce emissions but also adhere to direct regulations that require specific emissions reductions (Akkaya & Hepsag, 2021). Additionally, according to Adam et al. (2022) and He et al. (2019), the integration of carbon taxes with subsidies for renewable energy technologies or energy efficiency improvements can expedite the transition to a low-carbon economy. These studies underscore the synergistic effects of such policy combinations. The efficacy of carbon taxes is significantly challenged by carbon leakage, a phenomenon in which emissions reductions in one country result in increases in another as a result of production transfers (Bashir et al., 2020). Evidence indicates that the environmental advantages of carbon taxes may be compromised in the absence of measures to prevent carbon leakage. For instance, industries that are subject to high carbon levies may relocate to countries with less stringent environmental regulations, which would not lead to a net reduction in global emissions (Hieu, 2022; Yang & Chen, 2018). To prevent emissions reductions attained through domestic carbon taxes from being negated by increases elsewhere, international cooperation and the implementation of border tax adjustments or international carbon pricing agreements are necessary to address carbon leakage.

Case Studies and Best Practices

The implementation of environmental taxes has resulted in a variety of outcomes in various countries and regions, providing valuable insights into both successful practices and significant challenges. Policymakers can more effectively design and implement environmental levies that achieve significant emission reductions while minimising opposition by analysing case studies of successful implementations and identifying the pitfalls encountered in less effective cases. Sweden is one of the most frequently referenced examples of successful environmental levy implementation. Sweden has maintained economic growth while achieving substantial reductions in greenhouse gas emissions since the implementation of a carbon tax in 1991. Industries and households have been encouraged to transition to healthier energy sources by the tax, which was initially implemented at a low rate and progressively increased. Consequently, Sweden's CEs have decreased by more than 25% since the tax was implemented, illustrating the effectiveness of well-designed environmental taxes in reducing emissions (Haites, 2018; He et al., 2019).

British Columbia in Canada is another successful example, as it implemented a revenue-neutral carbon tax in 2008. The tax has been designed to be revenue-neutral and encompasses nearly all fossil fuel emissions. The proceeds are used to reduce personal and corporate income taxes. This methodology has served to alleviate apprehensions regarding the tax's economic implications. Research indicates that British Columbia's carbon tax has resulted in a substantial decrease in per capita emissions in comparison to the rest of Canada, without adversely affecting economic performance (Sarpong et al., 2023; Yang & Chen, 2018). Nevertheless, not all environmental taxes have been implemented successfully. The implementation of a carbon pricing mechanism in Australia in 2012 was met with substantial political opposition and was subsequently repealed two years later. The tax's unpopularity was exacerbated by the perception that it disproportionately affected certain industries and households, as well as the

absence of a distinct communication strategy. This case underscores the necessity of comprehensive stakeholder engagement and public communication, as well as the significance of devising environmental taxes that are perceived as fair and equitable (Shahzad, 2020). In 2009, France's attempt to implement a carbon tax was met with significant opposition, resulting in the policy's suspension. The opposition was primarily motivated by apprehensions regarding the tax's economic implications for rural areas and low-income households, which were perceived to be more significantly impacted. The challenges of instituting environmental taxes in diverse socio-economic contexts are exemplified by the failure to adequately resolve these equity concerns and to develop broad-based support for the policy (Ahmad et al., 2024).

Equity and Distributional Impacts

In the design and implementation of environmental taxes, it is essential to consider the equity and distributional impacts, as these taxes can have regressive effects that disproportionately affect lower-income households. The cost of energy and other products is increased by environmental taxes, such as carbon taxes, which can result in a greater portion of income being consumed by lower-income households than by affluent households. The widespread acceptance and long-term sustainability of taxes are significantly impeded by their regressive nature. Research has demonstrated that the burden of environmental taxes is disproportionately borne by individuals with lower incomes in the absence of compensatory measures, which exacerbates preexisting inequalities (Shahzad, 2020; Yang & Chen, 2018). Various compensatory measures have been proposed and implemented in various contexts to resolve these equity concerns. Targeted subsidies or direct cash distributions to lower-income households are a common strategy for mitigating the increased expenses they incur as a result of environmental taxes. For example, the carbon tax in British Columbia is intended to be revenue-neutral. The government will recoup all of the tax revenue by reducing other taxes and providing direct rebates to low-income households. This method has been effective in preserving public support for the tax while simultaneously reducing its regressive effects (Sarpong et al., 2023).

Revenue recycling is another effective measure, in which the proceeds from environmental taxes are reinvested in programs that benefit lower-income households or the broader public. This may encompass investments in renewable energy projects, public transportation, and energy efficiency programs, which not only contribute to the further reduction of emissions but also offer economic and social advantages. For instance, Sweden allocates a portion of its carbon tax revenue to renewable energy initiatives and public transport, which alleviates the financial burden on lower-income households and facilitates the transition to a low-carbon economy (He et al., 2019). In certain instances, environmental tax revenues are allocated to the reduction of other taxes that disproportionately affect lower-income individuals, such as payroll or income taxes. This method, identified as a tax exchange, has the potential to alleviate the overall tax burden on lower-income households while simultaneously delivering the environmental advantages of the carbon tax. Additionally, targeted energy efficiency programs can assist lower-income households in reducing their energy consumption and expenses, thereby further mitigating the regressive effects of environmental taxes (Ahmad et al., 2024; Hieu, 2022). Achieving a balance between environmental efficacy and equity remains a complex challenge, despite the implementation of these measures. Policymakers must carefully design environmental taxes to ensure that they do not unduly burden lower-income households and that compensatory measures are effectively targeted and implemented. By doing so, they

can enhance the social acceptability and long-term viability of environmental taxes, ensuring that the transition to a low-carbon economy is both fair and effective (Shahzad, 2020; Du et al., 2024).

DISCUSSION OF KEY FINDINGS

Although the magnitude and efficacy of these reductions differ across different contexts, the synthesis of key findings from various studies on the impact of environmental taxes demonstrates a generally positive effect on reducing CEs. In general, environmental taxes, particularly carbon taxes, are demonstrated to encourage the adoption of more sustainable practices and healthier technologies by businesses and individuals, thereby increasing the cost of emitting carbon and reducing greenhouse gas emissions. Several well-documented cases demonstrate the principal effects of environmental levies on CEs. For example, Sweden's carbon tax, which was implemented in 1991, is frequently referenced as a successful example. While Sweden's economy has continued to expand, it has made a substantial contribution to the nation's reduction in CEs. This highlights the feasibility of separating economic growth from CEs through the implementation of well-designed environmental levies (He et al., 2019). Similarly, the carbon tax in British Columbia, which was implemented in 2008, has led to a substantial reduction in per capita greenhouse gas emissions. This reduction has been accompanied by ongoing economic growth and a reduction in the overall tax burden for residents through revenue-neutral mechanisms (Sarpong et al., 2023).

The significance of tax design and implementation is a consistent pattern that is evident in numerous studies. The efficacy of environmental taxes is significantly influenced by the tax rate, the tax structure's flexibility, and the coverage of emissions sources. In general, higher tax rates result in more substantial emissions reductions, as they offer a more robust financial incentive to reduce emissions. Nevertheless, the necessity of a balanced approach is underscored by the potential for political resistance and economic backlash in the event of exceedingly high rates (Du et al., 2024). Furthermore, the tax's overall impact is bolstered by the comprehensive coverage of emissions sources, which encompasses all major sectors, including energy, transport, and industry. This ensures that all major polluters are incentivised to reduce their carbon footprint and prevents emissions leakage (Ahmad et al., 2024). The utilisation of tax revenues is another critical factor. Research indicates that the efficacy of environmental taxes is enhanced when the revenue is reinvested in renewable energy projects, green technologies, and public infrastructure enhancements. Revenue recycling, which involves the use of tax proceeds to reduce other taxes or offer rebates to vulnerable populations, is also essential for the preservation of public support and the mitigation of the regressive effects of environmental taxes (Hieu, 2022). For instance, Denmark contributes to substantial emissions reductions and a transition to a sustainable economy by utilising its carbon tax revenue to finance renewable energy projects and enhance energy efficiency.

In certain instances, challenges and conflicting results have been observed, despite these positive outcomes. The impact on CEs has been less pronounced in countries where environmental levies were inadequately conceived or confronted significant political opposition. For example, the effective implementation of carbon taxes has been impeded in certain developing countries by the presence of large informal sectors and a lack of administrative capacity (Shahzad, 2020). Furthermore, the potential for carbon leakage, which

occurs when emissions reductions in one country result in increased emissions in another as a result of the relocation of carbon-intensive industries, continues to be a major concern. This emphasises the necessity of international collaboration and the implementation of complementary policies to prevent the displacement of emissions (Hussain et al., 2023). A few consistent findings are indicated by the patterns and trends observed across the studies. Initially, the efficacy of environmental taxes is generally more pronounced in high-income countries that possess robust institutional frameworks and the ability to enforce tax compliance. Secondly, countries that have implemented complementary policies, such as public awareness campaigns, stringent regulatory measures, and subsidies for sustainable technologies, have experienced more substantial reductions in emissions (He et al., 2019). Thirdly, tax policies that are transparent and effectively communicated, and that explicitly delineate the economic and environmental advantages, are more likely to be supported and accepted by the public, which is essential for their long-term success (Du et al., 2024).

Gaps and Future Research Directions

While substantial progress has been achieved in comprehending the influence of environmental tariffs on CEs, there are still numerous voids in the literature that require resolution, and these gaps offer potential for future research. The absence of comprehensive longitudinal studies that assess the long-term consequences of environmental tariffs in various economic contexts and sectors is a significant lacuna. Although short-term studies offer valuable insights, they may not fully encompass the complete range of economic and behavioural changes that occur over a longer period. The identification of persistent trends and the sustainability of emissions reductions over time, as well as any potential unintended consequences that may arise, could be facilitated by longitudinal studies. The limited comprehension of the differential impacts of environmental taxes on various socio-economic groups is another critical divide. The economic impacts and aggregate emissions reductions are the primary focus of the majority of studies. However, the impact of these taxes on low-income households, small businesses, and other vulnerable groups has received less attention. The distributional effects of environmental taxes should be further examined in future research, with a focus on how various segments of the population endure the cost of these taxes and how compensatory measures, such as targeted subsidies or tax credits, can mitigate adverse effects. This line of inquiry is essential for the development of tax policies that are socially acceptable and equitable, and that do not disproportionately affect disadvantaged groups.

The issue of carbon leakage continues to be a substantial challenge and a promising area for future research. The overall effectiveness of a tax is undermined when carbon-intensive industries are relocated to countries with less stringent regulations as a result of stringent environmental taxes in one country. This phenomenon is known as carbon leakage. Although some studies have investigated this phenomenon, additional empirical research is required to determine the most effective policy mechanisms for its prevention and to quantify its magnitude. This could encompass the examination of cooperative strategies, international agreements, and border tax adjustments that guarantee a level playing field and global emissions reductions. Furthermore, there is a need for additional investigation into the relationship between environmental taxes and other regulatory measures. The efficacy of carbon taxes can be either augmented or diminished by the presence of other policies, including renewable energy mandates, emissions trading schemes, and energy efficiency standards. Future research should concentrate on the integration of these policies to establish a

comprehensive and cohesive framework for emissions reduction. The design of more effective and efficient climate strategies can be informed by an understanding of the synergies and trade-offs between different policy instruments. The role of technological innovation in response to environmental taxes is another emerging area of interest.

Although there is evidence that carbon taxes encourage investment in green technologies, additional research is required to comprehend the precise mechanisms by which innovation occurs and the conditions that optimise this effect. This encompasses the examination of the role of public and private sector collaboration, the diffusion of new technologies, and the impact of tax incentives on research and development. Finally, there is a need for additional cross-country comparative studies that investigate the impact of various political, economic, and cultural contexts on the efficacy of environmental levies. These studies can offer valuable insights into the best practices and emphasise the contextual factors that either facilitate or impede the successful implementation of these taxes. The formulation of policy recommendations that are sensitive to the unique circumstances of each country or region can also be facilitated by comparative analyses.

CONCLUSION AND IMPLICATION

Environmental taxes have become an essential instrument in the struggle against climate change, providing a market-based mechanism for the effective reduction of CEs. By designating a cost to CEs, these taxes encourage businesses and individuals to implement cleaner technologies and practices. Numerous studies have demonstrated substantial reductions in emissions as a result of the implementation of environmental taxes, which has had a positive overall impact on CEs. Nevertheless, the efficacy of environmental taxes is predicated on a variety of factors, such as the tax's design and implementation, socio-economic contexts, and complementary policies. The conclusion that has been reached from a variety of studies is that CEs can be significantly reduced through the implementation of well-designed environmental taxes. For example, Sweden and Denmark have experienced substantial reductions in their carbon footprints as a result of their implementation of comprehensive environmental tax policies. These accomplishments underscore the significance of establishing tax rates that accurately reflect the actual cost of CEs and guarantee comprehensive coverage across various sectors. Additionally, the use of revenue generated from environmental taxes is essential for improving their efficacy. By reinvesting these revenues in green technologies and infrastructure, they can bolster the transition to a low-carbon economy and further reduce emissions.

The impact of environmental taxes, however, varies depending on the situation. The efficacy of these taxes can be substantially influenced by socioeconomic factors, including the level of economic development, energy consumption patterns, and public acceptance. Environmental taxes are more likely to be effective in industrialised countries with sophisticated economies, as a result of increased public awareness of environmental issues and improved institutional frameworks. In contrast, developing countries may encounter obstacles such as decreased public awareness, inadequate administrative capacity, and opposition from industries that are significantly dependent on fossil fuels. Tailoring strategies that consider the distinctive circumstances of each nation is necessary to confront these obstacles. The impact of environmental taxes is also significantly enhanced by complementary policies. A more

comprehensive and effective policy framework can be established by combining carbon taxes with other regulatory measures, such as emissions trading schemes, renewable energy mandates, and energy efficiency standards. These complementary measures can assist in addressing potential deficiencies of environmental taxes, including the regressive nature of taxes and carbon leakage. For instance, border tax adjustments can prevent industries from relocating to countries with less stringent regulations, thereby preserving the environmental benefits of the tax.

This review has substantial implications for policymakers. First, it is imperative to meticulously evaluate the design and implementation of environmental taxes to optimise their efficacy. This encompasses the establishment of suitable tax rates, the guarantee of comprehensive coverage, and the utilisation of revenue in a manner that facilitates additional emissions reductions. Secondly, policymakers must consider the socio-economic context and customise their strategies to resolve the unique challenges and opportunities that exist within their respective countries. This may entail the provision of targeted assistance to vulnerable groups, the investment in public awareness campaigns, and the reinforcement of institutional frameworks. Additionally, the integration of environmental taxes with complementary policies can improve their efficacy and guarantee a more comprehensive approach to climate change mitigation. Policymakers should endeavour to establish synergies among various policy instruments and mitigate potential trade-offs. This comprehensive strategy can assist in surmounting obstacles to implementation and guarantee that environmental taxes contribute to sustainable, long-term reductions in CEs.

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