

Article

Analyzing the Effect of Carbon Emission Regulations and Policy Tools in China on Reducing Emissions

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Abstract: In China, whilst various policies have been implemented to mitigate carbon emissions in different periods, a lack of appropriate research and a narrow research perspective have manifested as the principal problems in past studies. In this study, China's carbon emission policies were analyzed using dual-dimensional content analysis, the key characteristics are identified, and solutions are proposed to address the existing challenges. Content analysis was used for estimating the policy objectives; as a result, the findings of this study indicate that China's carbon emission regulations can be divided into three distinct phases: the budding stage (2007–2013), the initial development period (2014–2018), and the rapid development period (2019–present). During this regulatory evolution, a significant concentration of authority was observed within specific sectors, particularly in the National Energy Administration and the National Development and Reform Commission; meanwhile, the level of cross-sectoral collaboration has remained insufficient. The primary regulatory instruments consist of notifications and advisory opinions, with a noticeable lack of enforceable, high-level legislation, highlighting the need for greater regulatory attention. Furthermore, China's approach to the reduction in carbon emissions predominantly relies on mandatory command-and-control policy tools, with the key objectives focusing on quantitative control and management, sectoral emission regulations, and adjustments to the energy structure.

Keywords: carbon emission reduction rules; policy tools; policy goals; content analysis method



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1. Introduction

Since the beginning of the 21st century, climate change has continued to intensify, posing a significant challenge to both society and sustainable development [1,2]. Several countries have implemented regulations to mitigate greenhouse gas emissions and foster low-carbon transitions to reduce the effect of climate change. China is the largest developing nation and significantly contributes to world trade and production; therefore, its policies on carbon emissions could have a significant impact on development and CO₂ mitigation, improving the domestic ecological environment and influencing global climate change policy [3]. Several different types of policies have been used to promote low-carbon transitions, including direct regulation, carbon taxes, trading carbon emissions, financial subsidies, public procurement, and government initiatives. The Organization for Economic and Cooperative Development (OECD) has classified carbon emission reduction policy tools into the following four categories, according to their intrinsic characteristics: regulations and standards; economic incentives; requirements for information disclosure and reporting; and support for technological innovation, research, and development. There are also challenges in selecting the appropriate policy; consequently, in exploring the problem of policy tool selection, politics, efficiency, and fairness have become the focus of a country's stakeholders.

China has implemented various measures to mitigate carbon emissions, including proposing a dual-carbon objective and establishing a carbon trading market; however, improving the effectiveness of specific rules remains imperative [4]. Policies provide the means for a rational selection of the appropriate tools and a legitimate establishment of goals that are mutually reinforcing. In China, a systematic review is required of its tool selection and target setting in carbon emission reduction regulations to improve the rules' effectiveness and standardization of governance [5]. In this study, we employed quantitative methods for the empirical analysis, based on the "policy tools–policy goals" framework and content analysis, to systematically categorize the carbon emission reduction regulations. Frequency analysis was also used, based on the temporal trends in the Chinese government's carbon emission policies and inter-sectoral disparities. Our analysis covers the Chinese government's policy objectives from the 11th to the 14th Five-Year Plans. The Five-Year Plan, which refers to the Outline of the Five-Year Plan for National Economic and Social Development of the People's Republic of China, is a pivotal element in China's national economic strategy, defining its long-term goals, major infrastructure initiatives, resource allocation, and crucial economic ratios. Initiated in 1953, China has enacted multiple Five-Year Plans, each steering the nation's economic path and developmental focus. At present, China is executing its 14th Five-Year Plan, highlighting the sustained importance of this strategic economic blueprint and indicating a shift from a single focus on carbon emission reductions to multifaceted requirements that include total emissions and intensity. Additionally, correlation tests provide a quantitative framework for aligning the policy instruments with the policy's objectives.

Although China has made significant progress in the construction of its carbon emission strategies, the existing literature still shows significant gaps in the analysis and organization of these rules. Firstly, the current research is insufficiently systematic [6], focusing only on the signing and enactment of domestic and extra-territorial regulations but ignoring the historical background, political, and economic factors behind the regulations, as well as the challenges and dilemmas in the implementation process. This approach fails to fully capture the historical evolution of the carbon emission reduction regulations and only partially captures the carbon emission situation [7], so that only relatively homogeneous research perspectives are provided. Policy tools undoubtedly play a key role in the process of reducing carbon emissions; however, the academic research on carbon reduction targets is relatively undeveloped and lacks a comprehensive, in-depth understanding. The decision-making-level commitment to the value of carbon market targets needs to be enhanced, and the related policy measures are insufficiently robust. Currently, research tends to perform quantitative analyses of the carbon emission reduction rules from a singular policy tool perspective and thus ignores the interaction and correlation characteristics between policy tools and policy targets [8]. In view of this, in this study, the significant gaps in the current literature are filled through the provision of a comprehensive, historically grounded analysis of China's carbon emission reduction regulations. This analysis enhances our understanding of the policy tools employed and their interactions, contributing valuable insights to the formulation and implementation of effective carbon emission reduction strategies by compensating for the shortcomings, and collecting and analyzing the carbon emission reduction rules issued by the Chinese authorities at all levels using content analysis. In this study, a contribution is made to the existing literature from the following perspectives. First, unlike prior studies that have primarily focused on the signing and enactment of domestic and extra-territorial regulations without considering their historical context, political factors, economic implications, challenges, and implementation dilemmas, in this research, a more systematic and holistic view is provided. Through the incorporation of these elements, in this study, a fuller understanding is provided of the evolution and effectiveness of carbon emission reduction regulations over time. Secondly, recognizing the crucial role of policy tools in reducing carbon emissions, in this study, the limited focus of the existing literature is extended, and the need for a more developed and nuanced understanding of carbon reduction targets is emphasized. In this research,

the importance of enhancing the commitment of the decision-making layer to the value of carbon market targets and strengthening the related policy measures is highlighted. Thirdly, academic research has often relied on quantitative analyses of carbon emission reduction rules from a singular policy tool perspective, neglecting the interaction and correlation between different policy tools and their respective targets. In this study, this gap is addressed by exploring how various policy tools interplay and influence one another, providing a more integrated and dynamic understanding of carbon reduction strategies.

2. Literature Review

Various studies have been conducted by analyzing the implications of environmental policies based on an analytical framework of policy tools; however, the two-dimensional analytical framework based on “policy tools–policy objectives” has rarely been involved. In exploring the problem of policy tool selection, politics, efficiency, and fairness have become the focus of international scholars. For example, DellaValle and Sareen (2020) [9] pointed out that the selection of carbon emission reduction policies should consider the efficiency characteristics of the incentive tool and its fairness to ensure that the emission reduction effect is maximized and achieves social justice [6,9]. Beck (2020) [10] reported that modern social risk has become institutionalized and uncertainty exists, and that when selecting coping tools, taking the actual impacts into account, and weighing the social justice implications of the risks, caution should be used [7,10]. Due to the significant degree of politicization of the climate policy instruments and the obvious differences in the level of public support for the different tools [8,11], Bidwell and Schweizer [9,12] argued that public participation is at the core of environmental decision-making and that including public opinion in tool selection can help enhance the regulation’s credibility, improve the quality of decision-making, and improve the performance and implementation. However, the studies relating to China generally focus on applying two policy tools, namely carbon taxes and carbon trading.

Therefore, Chinese scholars have generally focused on the application of these two legal instruments relating to carbon taxes and carbon trading. Liu et al. (2023) [13] suggested that carbon trading tools could reduce China’s carbon emissions more effectively than command-and-control environmental policies [10,13]. Huang et al. (2022) [14] pointed out that the carbon taxes are considered to be a more effective carbon emission reduction policy tool in China, which can achieve positive results in reducing greenhouse gas emissions and in promoting energy conservation and emission reductions [11,14].

In contemporary research, the studies that focus on environmental policy frequently evaluate the cost-efficiency of carbon emission reductions, such as cost–benefit analyses, economic incentives, technological innovations, and market dynamics. Holechek, Geli et al. (2022) [15] evaluated the effectiveness of using eight pathways in combination for a complete transition from fossil fuels to renewable energy by 2050, which included the development of renewable energy, improving energy efficiency, increasing energy conservation, carbon taxes, a more equitable balancing of human welfare and per capita energy use, cap and trade systems, carbon capture, utilization, storage, and development of nuclear power. The studies originating in China generally believe that the use of carbon taxes and carbon trading is more cost-effective than command-and-control policies. Huang, Fan et al. (2021) [16] asserted that market-oriented policy tools such as carbon taxes and carbon trading can effectively reduce carbon emissions, while the effect of traditional tools such as command-and-control policies is relatively limited. Therefore, the academic community remains divided on the cost-effectiveness of carbon taxes and carbon trading.

The analysis of the intrinsic role and economic value of carbon reduction efforts is a focal point of the contradictory research. Haque and Ntim (2022) [17] emphasized that to achieve the dual objectives of reducing carbon emissions and fostering economic growth, it is essential to balance the economic effects of carbon emission transfers within industries. Diesendorf [13,18] argued that the impact of carbon reductions on energy costs and the overall economy carries uncertainties and negative implications for the

environment. Metcalf and Stock [14,19] noted that the burden of carbon taxes primarily falls on capital rather than on labor, suggesting that offsetting carbon tax revenues by lowering personal income taxes could facilitate a “double dividend”. Additionally, they suggested that a carbon tax could impede economic growth. Zhang et al. [15,20] suggested that carbon taxes adversely affect business pricing, profits, and social welfare during the implementation of carbon reduction policies.

Through an analysis of the legal texts of carbon emission reduction in the region, it is evident that most scholars believe that the current carbon emission reduction laws in China generally lack targeted fiscal and tax policies and legal guarantees and fail to effectively stimulate the enthusiasm for R&D of innovative entities [21]. Tan et al. (2022) [22] performed a comprehensive review of 168 low-carbon regulations since the “Eleventh Five-Year Plan” and concluded that a significant gap in the current carbon emission reduction framework was the insufficient development of emission regulations [16,22]. Luo et al. (2023) [23] argued that the existing regulations do not recognize carbon dioxide as a statutory “air pollutant”. They advocated that carbon reduction measures should extend beyond the regulatory frameworks to legal statutes [17,24]. Guo et al. (2023) [25] analyzed carbon emission regulations in agriculture and found that the absence of a comprehensive regulatory framework in the agricultural carbon reduction sector impedes agricultural productivity [18,25]. Keith et al. (2019) [26] analyzed the implementation effect of carbon emission reduction policies and the implications for enterprises under different carbon quota allocation rules. They suggested that the substantive actions of enterprises in carbon emission reductions are closely related to carbon emission accounting and emission reduction policies [19,26]. Through an analysis of the legal texts relating to the achievements of extra-territorial carbon emission reductions, some scholars have summarized China’s position and role in the global emissions reduction task and then proposed governance plans that will help promote the control of China’s carbon emissions [27]. Zhang Yangyang [28] concluded that in the European Union, the United States, Australia, and other countries, carbon capture and storage laws have gradually been established and improved, while there remains a legislative gap in China. He suggested how to build a total CO₂ emissions control system in China that fully considers the market and administrative means by summarizing the experience of the EU in using administrative means for controlling greenhouse gas emissions from sectors not covered by the ETS.

3. Materials and Methods

In this study, we developed a dual-dimensional framework for analyzing China’s carbon emission reduction rules, focusing on “policy tools” and “policy goals”, as shown in Figure 1. In this framework, China’s carbon emission reduction regulations were quantitatively analyzed. A panoramic view of the framework of China’s carbon emission reduction rule is provided in this study, and the challenges and problems in the implementation of the rules are identified. A two-dimensional framework like this allows for the monitoring and evaluation of the effectiveness of the current regulations and the establishment of an integrated and coordinated plan for reducing carbon emissions.

The first dimension is that of the policy tools (Dimension X) which provide a means of achieving policy goals, with the fundamental characteristics determining the method and efficiency of policy implementation. Each tool has its optimal context for application, along with potential strengths and limitations. The selection and design of these tools are critical in determining the effectiveness of a policy. The details of the policy tools used for carbon emission reduction, as discussed in this paper, can be found in Table 1.

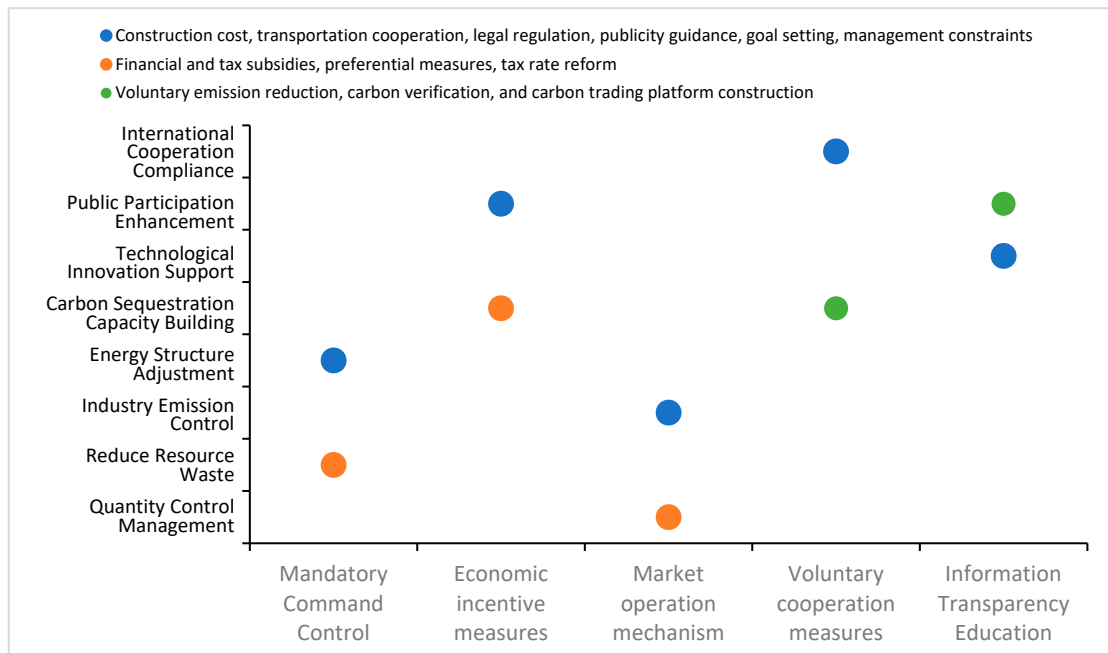


Figure 1. The legal analysis framework for carbon emission reductions.

Table 1. Dimension X: the policy tools dimension.

Policy Tools	Meaning and Examples
Command-and-control measures	Including emission standards, technical requirements, etc.
Economic incentives	Tax reductions, financial subsidies, etc.
Market-based mechanisms	This mainly involves carbon trading, carbon taxes, etc.
Voluntary cooperation initiatives	Encouraging enterprises and individuals to voluntarily reduce carbon emissions
Information transparency and education	Enhancing environmental awareness, promoting environmentally friendly behaviors

The second dimension in this study is that of policy goals (Dimension Y), which represents the fundamental direction and anticipated outcomes that indicate the formulation and implementation of regulations. In our case, this represents the carbon emission reduction regulations; the setting of objectives reflects the importance and urgency of the national emissions reduction task and also has a direct impact on the effectiveness of the regulations and the effectiveness of their implementation. Detailed descriptions of the policy Sgoals related to carbon emission reductions are provided in Table 2.

Table 2. Dimension Y: the policy goals dimension.

Policy Goals	Target Meaning and Examples
Quantity control management	Imposing restrictions on total carbon emissions to ensure the achievement of the set emission reduction targets within a specific period
Waste reduction	Lowering the overall carbon footprint of society through multiple measures such as optimization of the industrial structure, promotion of energy-saving technology, and green consumption advocacy

Table 2. Cont.

Policy Goals	Target Meaning and Examples
Industry emission control	Carbon emission control in high energy-consuming industries is crucial, and providing low-carbon development guidance for emerging sectors
Energy structure adjustment	Adjusting the composition of energy consumption, reducing the proportion of fossil fuels, and increasing the use of clean and renewable energy
Carbon sink capacity building	Increasing the carbon sequestration capacity of forests and ecosystem vegetation, converting carbon dioxide and other gases into organic carbon stored in organisms and the soil
Technological innovation support	Encouraging enterprises and research institutions to carry out low-carbon technology research, promoting industrialization and market development
Public participation enhancement	Raising public awareness of the importance of carbon reduction and guiding people to participate in low-carbon lifestyle practices
International cooperation and compliance	Actively participating in multiple international agreements on climate change, promoting global carbon reduction, and jointly addressing climate change challenges

4. Research Methodology and Data Sources

4.1. Data

In order to ensure the accuracy of this study and the carbon emission regulations, the following steps were taken to collect and select data for this study. In this study, data were collected for variables such as “carbon emissions”, “carbon reduction”, “low carbon”, “tax”, “market”, and “transaction”. These data contain 98 central regulations, 1064 local regulations, 12 legislative documents, and 1 item of legal news. In terms of regulations, the documents issued by the central government are limited, including the National People’s Congress and its Standing Committee, the State Council and its agencies, the Supreme People’s Procuratorate, the Supreme People’s Court, and the central government departments. Only documents containing normative content, such as laws, administrative regulations, and departmental regulations, were selected. Non-normative contents, such as administrative license approvals and leaders’ speeches, were excluded. The relevance of the content to carbon reduction measures was a key criterion in this selection.

On the basis of the second round of screening, a third round was conducted (as shown in Table 3). This phase involved further narrowing the scope by retaining only departmental regulations and normative documents, while excluding working documents and administrative licensing approvals. As of 18 April 2024, 28 emission regulations were selected as samples after three rounds of screening. These samples included three laws, eight administrative regulations, and seventeen departmental regulations.

Table 3. The screening process.

Screening Rounds	Tactics	Number of Documents Collected	Remark
Round 1	Keyword search	1175 articles	Preliminary collection of the relevant legal literature

Table 3. Cont.

Screening Rounds	Tactics	Number of Documents Collected	Remark
Round 2	Screening criteria	82 articles	Select legal documents that are directly related to carbon reduction targets and measures
Round 3	Culling hierarchies	28 articles	Eliminate non-related bills such as working papers and permit approvals

4.2. Research Methodology

NVIVO 14 software was used to perform detailed coding (as shown in Table 4), and the reliability tests of the 28 regulations, as shown in Appendix A, were collected, which were analyzed according to the two dimensions of policy tools and policy goals.

Table 4. Examples of emission regulations.

Code	Name of the Rule	Rule-Based Text Content Analysis Module	Policy Tools	Policy Goals	Year
1–14	Interim Regulations on the Administration of Carbon Emission Trading	Article 14: Key emission units may purchase or sell carbon emission allowances	Market operation mechanism	Sectoral emissions control	2024

To ensure the reliability and internal consistency of coding, the regulations of the 28 carbon reduction rules were allocated to four coders, divided into sub-groups of two each. Prior to formal coding, the coding specifications were explained to each coder to ensure that each coder's thinking was consistent. Each pair of coders initially received three identical sets of emission regulations for preliminary coding. We then compared and analyzed the differences between the two pairs' results, repeating this preliminary coding until their results aligned. In the formal coding phase, the first coder in each pair performed the initial coding independently, while the second coder audited their work. At the end of the coding, a reliability test was carried out, based on Equations (1) and (2), as follows:

$$A = \frac{N1/2+M}{N2} \quad (1)$$

$$R = \frac{[1 + (n - 1)A]}{n} \quad (2)$$

In this context, A represents the degree of agreement, R represents the degree of reliability, $N1$ represents the number of agreements by the first coder, M represents the total number of agreements between the two coders, $N2$ represents the number of agreements by the second coder, and n represents the number of coders, set at 4. After many repeated tests and adjustments, the coding's degree of agreement A in the present study was 0.823, and the coding reliability R was 0.906, which represents a certain degree of reliability. Then the coded policy regulations were classified and aggregated according to the policy objectives they implied and the policy tools they used, and frequency statistics were examined for the classified data to analyze the frequency of use of each type of policy tool and objective. From these analyses, we derived the characteristics of China's carbon reduction policies in terms of the tools and objectives, the identified challenges, and the formulated recommendations. In order to gain a deeper understanding of the actual application of policy tools and targets, these research methods were used to systematically and quantitatively analyze the existing carbon emission reduction rules so that effective suggestions could be made to optimize China's carbon emission reduction regulations.

5. Results and Discussion

Through the analysis of the carbon emission reductions in the selected rules, a trend was identified of multiple subjects, single department issuance, and coordinated issuance by various departments. Specifically, the National Energy Administration (NEA) and the National Development and Reform Commission (NDRC) are at the forefront of carbon reduction initiatives and play pivotal roles in driving carbon reduction efforts. The State Council has issued seven documents, which also play a role in promoting the process of carbon emission reduction; meanwhile, the Ministry of Finance (MOF) and the Ministry of Ecology and Environment (MOE) have issued fewer than two documents.

The effectiveness levels of China's carbon emission reduction rules were classified. Among these, the departmental normative documents, which have the lowest legal effectiveness, comprise 16 entries, representing 57.14% of the total. There is a single departmental regulation, making up 3.57% of the rules. The administrative regulations total eight, accounting for 28.57%, while laws, which carry the highest level of effectiveness, number three, making up 10.71%. The Chinese carbon emission reduction rules were classified on the basis of their types, as shown in Figure 2. The "notice" category contains 15 regulations, which accounts for 53.57%. The "opinion" category contains six regulations, accounting for 21.43%. The "opinion" category contains six regulations, accounting for 21.43%. The "report" category contains four regulations, accounting for 14.29%. The "report" category contains four regulations, accounting for 14.29%. The "resolution" category contains two rule texts, accounting for 7.14%. The "resolution" category contains two rule texts, accounting for 7.14%. The "catalogue" category only contains one emissions regulation, accounting for 3.57%.

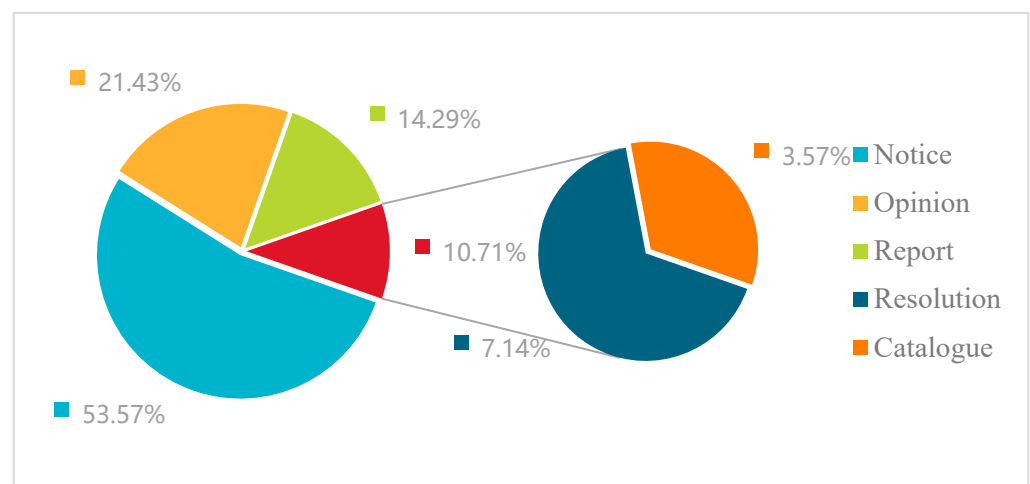


Figure 2. The types of carbon emission reduction rules in China.

In summary, China's carbon emission reduction rules are primarily based on notices and opinions, with few authoritative regulations such as laws and administrative regulations. Therefore, it is necessary for China to strengthen the criteria for the development of carbon emission reduction laws in order to create more effective and authoritative regulations.

The frequency statistics were analyzed for the policy tools, and the results are shown in Table 5. The two-dimensional statistical results are shown in Table 6 and Figure 3. In this study, it is revealed that in China, command-and-control measures are widely used, followed by carbon trading, while carbon taxes are less frequently used. The command-and-control measures dominate due to their direct enforceability, practicality, and convenience. One of the best examples is that of Jiangsu Province, which actively responds to the national laws and regulations on carbon emission trading and strictly implements the Interim Regulation on the Management of Carbon Emission Trading. This regulation provides a legal basis for the operation and management of the national carbon market, clarifying the management principles, coverage, the conditions for determining key emission units, and the total annual carbon emission quota and allocation plan for carbon emission trading and related activities. On the other hand, the carbon trading mechanism, which allows for

control over the total emissions, offers lower costs and greater sustainability, making it a vital strategy for managing China's carbon emission goals. Although China's Ministry of Finance proposed a carbon tax 15 years ago, it has not yet been effectively implemented, so there is relatively limited carbon tax legislation in the current legal framework. With the continuous improvement of China's carbon trading market mechanisms, the number of carbon tax-related laws will gradually increase in the future.

Table 5. The distribution of policy tools.

Types of Policy Tools	Quantities	Percentage	Tool Name
Mandatory command and control	15	53.57%	Engineering, communication and cooperation, publicity and guidance, goal-oriented control
Economic incentive initiatives	5	17.86%	Financial subsidies, tax incentives, tax credits
Market operation mechanism	10	35.71%	Conventional carbon, market-based trading
Voluntary cooperation measures	2	7.14%	Reduce carbon emissions
Education for information transparency	3	10.71%	Announcements, press releases, carbon-inclusive education

Table 6. The two-dimensional statistical table.

Policy Goals	Command-and-Control Measures	Economic Incentives	Market-Based Mechanisms	Voluntary Cooperation Initiatives	Information Transparency and Education	Total	Percentage
Quantity control management	20	0	4	0	0	24	23.53%
Waste reduction	9	0	0	0	1	10	9.80%
Industry emission control	18	0	0	1	0	19	18.63%
Energy structure adjustment	10	0	6	1	1	18	17.65%
Carbon sink capacity building	5	1	0	0	2	8	7.84%
Technological innovation support	9	1	0	1	0	11	10.78%
Enhanced public participation	3	0	1	1	2	7	6.86%
International cooperation and compliance	1	0	2	0	2	5	4.90%

In this study, the carbon emission reduction rules were analyzed using a two-dimensional framework comprising policy goals and policy tools. The X dimension represents the policy tools, while the Y dimension represents the policy goals. The policy goals of China's carbon emission reduction rules focus on the following three aspects: quantitative control and management, sectoral emissions control, and energy structure adjustment. China's carbon market started online trading in 2021, marking the beginning of a challenging journey. In the long term, perfecting carbon market trading remains the key goal of China's carbon emission reduction laws. The analysis in this study reveals that China's approach to carbon management integrates governmental measures—such as quantitative controls, sector-specific emission regulations, and energy structure reforms—with market-driven initiatives aimed at reducing resource wastage and fostering technological innovation.

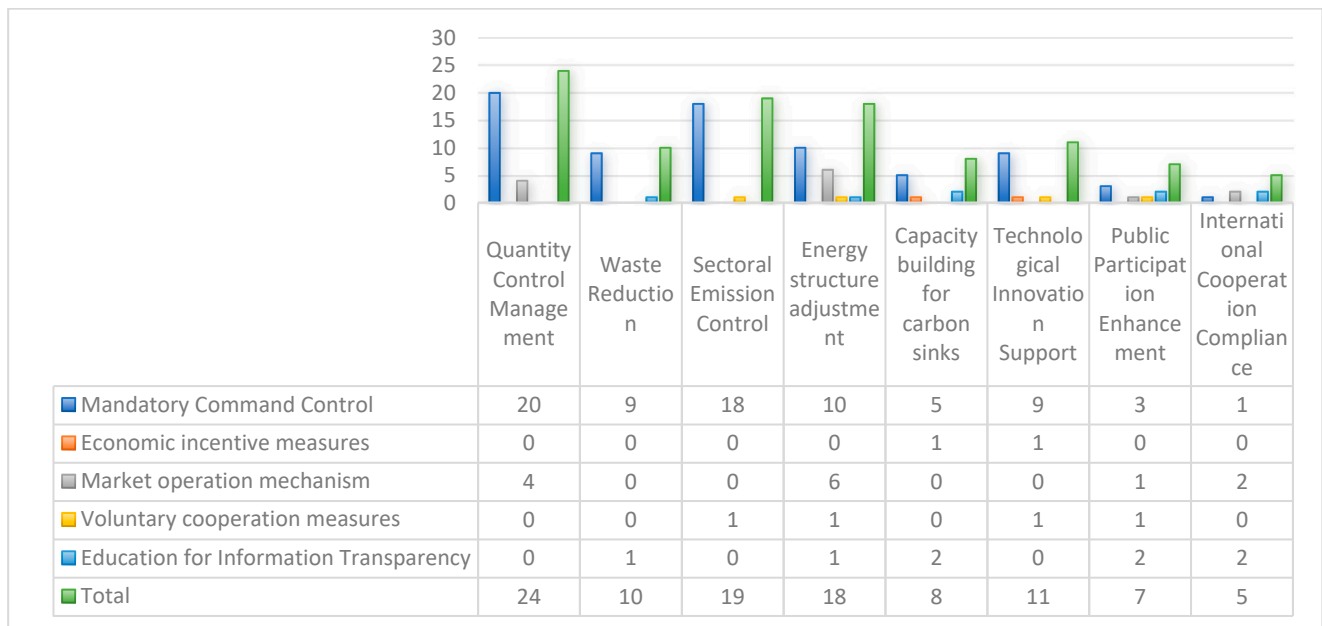


Figure 3. The two-dimensional statistical table.

The evolution of China's carbon emission reduction rules can be divided into the following three stages, as shown in Table 7: the budding stage (2007–2013), the initial development period (2014–2018), and the rapid development period (2019–present). During the budding stage, China's rules were relatively stable, with a focus on controlling greenhouse gas emissions and experimenting with carbon emission trading. Then the initial development stage saw a gradual transition towards market-oriented regulatory mechanisms. Finally, in the rapid development period, there was an incremental increase in the number of rules related to carbon emission reductions, with a focus on establishing and managing the carbon trading market.

Table 7. Legal stages of carbon emission reductions in China.

Stages	Legal Instrument Orientation	Legal Goal Orientation
The budding stage	Command-and-control means are dominant	Adjusting the energy structure and controlling the total amount
The initial development period	Market-based adjustment mechanism started	Optimizing the energy structure and establishing a market mechanism
The rapid development period	Improvement of the market mechanism	Carbon trading market establishment and management

The period from 2007 to 2013 marked the beginning of China's efforts to reduce carbon emissions. In 2007, the China's National Climate Change Program pointed out that the relevant rules and regulations for climate change mitigation and adaptation should be improved. The relevant departments should promote efforts to address climate change in accordance with the law. In 2011, the State Council issued China's Policies and Actions for Addressing Climate Change, identifying the need for legal research in the areas of climate change development. During the budding stage, the focus of the legislation was to encourage the modernization of the energy structure and to achieve overall control of carbon emissions through command-and-control measures. Additionally, the proposal for a pilot carbon emission trading scheme marked a pivotal development in China's carbon

market, setting the groundwork for its future national rollout. The period between 2014 and 2018 marked the initial development of China's carbon emission reduction rules. In 2014, the National Development and Reform Commission issued the Interim Measures for the Management of Carbon Emissions Trading, proposing to strengthen the control and management of greenhouse gas emissions and the standardization of the construction of the carbon emission trading market. In 2016, the State Council issued the Notice on the Work Plan for Controlling Greenhouse Gas Emissions during the 13th Five-Year Plan, which identified the need to accelerate green and low-carbon development and promoted the concept of a peak in China's carbon dioxide emissions in around 2030. The Environmental Protection Tax Law was promulgated in 2018, linking environmental protection taxes to carbon emissions and carbon emission methods and proposing to control the amount of carbon emissions from multiple aspects. Compared with the budding stage, the application of the carbon market mechanisms increased in this period, and attention to improving the carbon market also gradually increased. However, the regulatory framework still attached great importance to the control of carbon emissions through command-and-control measures. Since 2019, China experienced a rapid evolution in its carbon emission reduction policies. Although China formally proposed the "dual-carbon" target in 2020, various regions in China had enacted a series of carbon emission-related trade management laws in the previous year, effectively bridging the gap in the legal formulation in the "dual-carbon" area. This illustrates China's resolute determination and forward-looking thinking in reducing carbon emissions.

These laws are valuable for regulating carbon emission reduction efforts across the country. In 2020, the Ministry of Ecology and Environment issued the National Carbon Emission Rights Registration, Transaction and Settlement Management Measures (Trial), which require the full use of market mechanisms to standardize carbon emission rights trading and related activities. In 2023, the Administrative Measures for the Greenhouse Gas Voluntary Emission Reduction Trading (Trial) were issued to encourage voluntary greenhouse gas emission reduction behaviors. The much-anticipated Regulations on the Management of Carbon Emission Trading were implemented on 1 May 2024. The regulations clarify the carbon market trading system in the form of administrative regulations, representing a milestone in the construction and development of the carbon market.

China's carbon emission reduction laws have evolved through three stages of development. The first was the budding stage (2007–2013), which saw a fluctuation in the number of laws and mainly adopted command-and-control measures. The focus was on promoting the upgrading of the energy structure and controlling the total amount of carbon emissions. At this stage, China implemented a pilot carbon emission trading program, which provided a solid foundation for the future establishment of a nationwide carbon trading market [20,21,29,30]. During the initial development period (2014–2018), the number of carbon emission reduction laws remained stable, showing an embryonic form of market-based trading. Although policy tools diversified, the command-and-control approaches still predominated. In the rapid development period (2019–present), the number and types of carbon emission reduction laws in China increased significantly, and the market mechanism became more efficient [3,22].

While our analysis provides a comprehensive overview of China's evolving carbon emission reduction rules, it is essential to acknowledge the potential limitations in both the content analysis and reliability testing. One limitation is the reliance on publicly available documents and legislative texts, which may not capture all the nuanced aspects of local implementation or enforcement challenges. Another potential flaw lies in the subjective nature of categorizing rules into distinct phases, as the transition between the stages might not always be clear-cut. Furthermore, while we strove for accuracy, human error in data collection and interpretation may have impacted the reliability of our findings. Future studies could benefit from incorporating empirical data on enforcement outcomes and stakeholder perceptions to provide a more robust assessment of China's carbon policies' effectiveness.

6. Robustness Testing

To substantiate the reliability and robustness of this study's conclusions, a series of tests were conducted. These included endogeneity testing, the substitution of explanatory variables, and sensitivity analysis through the exclusion of specific sample subsets. The outcomes of these robustness tests are presented in Table 8.

Table 8. The results of the robustness tests.

Test Type	Core Variable Coefficient	Lagged Variable Coefficient	DID Coefficient	Carbon Tax Coefficient	Market Incentive Coefficient	Before Exclusion	After Exclusion
Original model	0.145 ***	-	-	-	-	0.145 ***	-
Lagged independent variable	0.138 ***	0.112 ***	-	-	-	-	-
Difference-in-differences (DIDs)	0.127 ***	-	0.105 **	-	-	-	-
Replaced with carbon tax variable	-	-	-	0.132 ***	-	-	-
Replaced with market incentives' strength	-	-	-	-	0.141 ***	-	-
Excluding high emission areas	0.145 ***	-	-	-	-	0.145 ***	0.144 **
Excluding year 2020	0.146 ***	-	-	-	-	0.146 ***	0.144 ***
Excluding low policy coverage areas	0.143 ***	-	-	-	-	0.143 ***	0.142 ***

** : This indicates that the coefficient is statistically significant at the 5% level ($p < 0.05$). *** : This indicates that the coefficient is statistically significant at the 1% level ($p < 0.01$).

1. Endogeneity Testing

(1) Lagged Independent Variable

To mitigate the potential endogeneity concerns, we incorporated the one-period lag of the primary explanatory variable to examine its delayed impact on the dependent variable. Specifically, we conducted a regression analysis using the lagged term of "Carbon Emission Policy Intensity" and employed the Hausman test to assess any coefficient shifts arising from the inclusion of the lagged variable. The results indicated that after incorporation of the lag, the coefficient of the primary variable retained both its directional consistency and statistical significance, suggesting that the model exhibits considerable robustness with respect to endogeneity concerns.

(2) Difference-in-Differences (DIDs)

To further confirm the causal effects attributable to policy implementation, we employed the Difference-in-Differences (DIDs) methodology. The regions lacking specific carbon emission policy implementations were designated as the control group, while regions that implemented the policy constituted the treatment group. A time variable distinguishing the pre- and post-policy periods was constructed and interacted with the treatment indicator. The positive and significant DID interaction coefficient reinforces the inference that the policy exerted a favorable impact on carbon emission reductions.

2. Substitution of Explanatory Variables

To ensure that the model's conclusions were not artificially dependent on the specific variables employed, we substituted the primary explanatory variable with alternative metrics pertinent to the carbon emission policy. Initially, we replaced the original core variable with carbon tax rates and the carbon trading mechanism's intensity, and the regression's results demonstrated that the directional alignment and statistical significance of these alternative metrics were consistent with those of the original model. Additionally,

we introduced market incentives' intensity (e.g., tax exemptions and subsidy levels) as an alternative explanatory variable, which yielded similarly significant results, reinforcing the robustness of the primary conclusions. These substitutions verify that the findings of this study do not hinge on a single variable specification, thereby affirming their generalizability.

3. Sensitivity Analysis by Exclusion of Specific Samples

To control for the influence of extreme observations, sensitivity analyses were conducted by excluding specific sample subsets, including high-emission regions, data from outlier years, and the regions with minimal policy coverage.

Exclusion of high-emission regions: High-emission provinces with carbon outputs significantly exceeding the national average (e.g., highly industrialized regions) were excluded, with minimal shifts observed in the core variable's coefficient and significance, suggesting that the findings are not unduly influenced by these regions.

Exclusion of outlier years: To attenuate the impact of anomalous events (such as the COVID-19 pandemic) on carbon emission data, we excluded the year 2020 and re-estimated the model. The findings indicate that the core results remained consistent, thus underscoring the stability of the model's conclusions even when excluding this exceptional year.

Exclusion of regions with low policy coverage: The regions with insufficient policy coverage or weaker policy implementation were excluded, yielding model results that aligned closely with those of the full sample, thereby offering additional support for the robustness of the findings.

7. Conclusions

Over the past few decades, due to the uncertainties of global climate change, various countries have implemented carbon emission regulations to achieve low-carbon and economic development goals. However, the synergistic difference between the application of legal tools and the setting of goals has led to a requirement for the effectiveness of the law's implementation to be improved. Thus, we studied China, the world's second largest economy, and mainly examined the role of tool selection and target setting in China's carbon reduction laws. In this study, China's carbon reduction laws are shown to have developed over the following three stages: the embryonic stage (2007–2013), the early stage of development (2014–2018), and the rapid development stage (2019–present). In terms of policy characteristics, policies are multi-sectoral, emphasizing quantity control and energy structure adjustment, but there are deficiencies in the diversity of policy tools and cross-sectoral cooperation. There are still shortcomings in these policies, such as the overlapping functions and insufficient coordination of law enforcement, the lack of unity and coordination in local government management mechanisms, and an insufficient level of market incentives and constraints in agricultural production.

The conclusion of this study is that China's carbon reduction laws and policies face challenges in terms of multi-sectoral cooperation, the diversity of policy instruments, legal authority, the uniformity of local governments' management mechanisms, and agricultural market incentives, and so need to be further improved to effectively achieve the "dual-carbon" goal. Based on our findings, the following policy recommendations are suggested: First, to achieve the "dual-carbon" goals, it is essential to enact specialized carbon reduction laws that define the legal responsibilities and establish robust trading and management frameworks for carbon rights. Additionally, the existing environmental protection and energy laws and regulations should be revised to make them more responsive and effective in reducing carbon emissions. In order to ensure the effective implementation of the law, supporting regulations and details of their implementation need to be improved, including specific implementation standards, supervision and management measures, and corrective mechanisms to ensure the intensity and effect of the law's execution. Law enforcement requires strengthening in order to improve the implementation of the carbon emission laws in the country. This implementation can be achieved through the establishment of law enforcement teams comprising representatives from the departments of environmental protection, development and reform, energy, and other related departments. These teams

should clarify their respective responsibilities and workflows and strengthen collaboration and information sharing. Local governments may collaborate with the central government's environmental regulation departments and work together to achieve the implementation of the law.

In addition, the implementation of the environmental protection laws should be transparent and open, encouraging public participation in the hearings and oversight processes. The individuals and organizations that provide information on carbon emission violations should be rewarded and recognized. To enhance its carbon emission reduction efforts, China should leverage the advanced experiences of other countries. This can be achieved by drawing on relatively mature legal carbon emission reduction systems, such as the European Union's carbon trading system (EUETS), and increasing the use of hybrid policy tools. Concurrently, China must engage more deeply in international cooperation, actively participate in the global carbon emission trading market, and work towards the development and refinement of international legal standards for carbon reduction, embracing a spirit of unity and mutual growth. Finally, strengthening the construction of the legal remedial system is the key to ensuring its effectiveness and authority. China must be committed to improving this remedial legal mechanism and protecting the legitimate rights and interests of individuals and organizations in the enforcement of carbon emission reduction laws. Prompt judicial reviews and remedies for infractions are vital to ensure societal equity, justice, and regulatory compliance.

Policy Recommendations

In order to achieve the "dual-carbon" goals, it is essential to enact specialized carbon reduction laws that define the legal responsibilities and establish robust trading and management frameworks for carbon rights. Additionally, the existing environmental protection and energy laws and regulations should be revised to make them more responsive and effective in reducing carbon emissions. In order to ensure the effective implementation of the law, the supporting regulations and the details of their implementation need to be improved, including specific implementation standards, supervision and management measures, and corrective mechanisms to ensure the intensity and effect of the law's execution. To improve the implementation of carbon emission reduction laws, it is necessary to strengthen the enforcement of laws. This can be achieved by forming law enforcement teams comprising environmental protection, development and reform, energy, and other departments. These teams should clarify their respective responsibilities and workflows and strengthen collaboration and information sharing. Furthermore, the process of formulating, promulgating, and implementing laws to reduce carbon emissions should be transparent and open, encouraging public participation in hearings and oversight processes, including the necessity of improving the witness protection mechanism. The individuals and organizations that provide information on carbon emission violations should be rewarded and recognized. To enhance its carbon emission reduction efforts, China should leverage the advanced experiences of other countries. This can be achieved by drawing on relatively mature legal carbon emission reduction systems, such as the European Union's carbon trading system (EUETS), and increasing the use of hybrid policy tools. Concurrently, China must engage more deeply in international cooperation, actively participating in the global carbon emission trading market, and working towards the development and refinement of international legal standards for carbon reduction, embracing a spirit of unity and mutual growth. Finally, strengthening the construction of the legal remedy system provides the key to ensuring the effectiveness and authority of the legal system. China must be committed to improving the legal remedial mechanism and protecting the legitimate rights and interests of individuals and organizations in the enforcement of carbon emission reduction laws. Prompt judicial reviews and remedies for infractions are vital for ensuring societal equity, justice, and regulatory compliance.

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Appendix A

Serial Number	Name	Issuing Department	Date of Publication
1	Report of the Environment and Resources Protection Committee of the National People's Congress on the Results of the Deliberation of Bills Submitted by Deputies Submitted by the Presidium of the First Session of the 14th National People's Congress	Environment and Resources Protection Committee of the National People's Congress	2023
2	Resolution of the First Session of the 14th National People's Congress on the Implementation of the 2022 National Economic and Social Development Plan and the 2023 National Economic and Social Development Plan	National People's Congress	2023
3	Resolution of the Fifth Session of the 13th National People's Congress on the Implementation of the 2021 National Economic and Social Development Plan and the 2022 National Economic and Social Development Plan	National People's Congress	2022
4	Mid-term Assessment Report of the State Council on the Implementation of the Outline of the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Long-Range Objectives Through the Year 2035	State Council	2023
5	Notice of the State Council on Printing and Distributing the Overall Plan for the China (Xinjiang) Pilot Free Trade Zone	State Council	2023
6	Report of the State Council on the State of the Environment and the Achievement of Environmental Protection Targets in 2021	State Council	2022
7	Notice of the State Council on Printing and Distributing the Comprehensive Work Plan for Energy Conservation and Emission Reduction in the 14th Five-Year Plan	State Council	2021
8	Notice of the State Council on Printing and Distributing the Action Plan for Peaking Carbon Emissions Before 2030	State Council	2021
9	Opinions of the State Council on the Division of Work for the Implementation of the Government Work Report	State Council	2021
10	Notice of the State Council on Printing and Distributing the Work Plan for Controlling Greenhouse Gas Emissions during the 13th Five-Year Plan	State Council	2016
11	Notice (2015) of the General Office of the State Council on Printing and Distributing the National Standardization System Construction and Development Plan (2016–2020)	General Office of the State Council	2015
12	National Development and Reform Commission's Industrial Structure Adjustment Guidance Catalogue	National Development and Reform Commission	2023
13	Implementation Opinions of the State Post Bureau on Promoting the Green and Low-Carbon Development of the Postal Express Industry	State Post Bureau	2023

Serial Number	Name	Issuing Department	Date of Publication
14	Opinions of the National Development and Reform Commission and the National Energy Administration on Improving the Institutional Mechanisms and Policy Measures for Green and Low-Carbon Energy Transformation	National Development and Reform Commission, National Energy Administration	2022
15	Guiding Opinions of the Ministry of Ecology and Environment, the Ministry of Commerce, and the National Development and Reform Commission on Strengthening Ecological and Environmental Protection in Pilot-Free Trade Zones and Promoting High-Quality Development	National Development and Reform Commission, Ministry of Ecology and Environment, Ministry of Commerce	2021
16	Guiding Opinions of the National Development and Reform Commission, the National Energy Administration, and the Ministry of Finance on Promoting the Industrialization of Bio-natural Gas	National Development and Reform Commission, National Energy Administration, Ministry of Finance	2019
17	Guiding Opinions of the National Development and Reform Commission, the National Energy Administration, and the Ministry of Finance on Promoting the Industrialization of Bio-natural Gas	National Energy Administration	2023
18	Notice (2016) of the National Development and Reform Commission and the National Energy Administration on Printing and Distributing the Energy Production and Consumption Revolution Strategy (2016–2030)	National Development and Reform Commission, National Energy Administration	2016
19	Notice of the National Development and Reform Commission, the National Energy Administration, and the Ministry of Finance on Printing and Distributing the 14th Five-Year Plan for Renewable Energy Development	National Energy Administration, National Development and Reform Commission, Ministry of Finance	2021
20	Circular of the General Department of the National Energy Administration on the issuance of the 2023 Formulation and Revision Plan for Industry Standards in the Energy Field and the Translation Plan for Foreign Languages	National Energy Administration	2023
21	Notice of the General Department of the National Energy Administration on the issuance of the 2022 Formulation and Revision Plan for Industry Standards in the Energy Field and the Translation Plan for Foreign Languages	National Energy Administration	2022
22	Notice of the Ministry of Ecology and Environment, the National Development and Reform Commission, and the Ministry of Science and Technology on Issuing the National Strategy for Adaptation to Climate Change 2035	National Development and Reform Commission, Ministry of Ecology and Environment, Ministry of Science and Technology	2022
23	Notice of the National Development and Reform Commission and the National Energy Administration on Printing and Distributing the 14th Five-Year Plan for [a] Modern Energy System	National Energy Administration, National Development and Reform Commission	2022
24	Notice of the Civil Aviation Administration of China on Printing and Distributing the Roadmap for the Construction of Smart Civil Aviation	Civil Aviation Administration of China	2022
25	Natural Gas Development Report of the National Energy Administration, Development Research Center of the State Council, and Ministry of Natural Resources	National Energy Administration, Development Research Center of the State Council, Ministry of Natural Resources	2022
26	Notice of the General Office of the Ministry of Industry and Information Technology and the General Department of the Bureau of Science, Technology and Industry for National Defense on Printing and Distributing the “Catalogue for the Promotion of the Transfer of Military Technology to Civilian Use (2018)”	Ministry of Industry and Information Technology, Bureau of Science, Technology and Industry for National Defense	2018
27	Notice of the National Energy Administration on Printing and Distributing the “13th Five-Year Plan for the Demonstration of Coal Deep Processing Industry”	National Energy Administration	2017
28	Notice of the National Development and Reform Commission and the National Energy Administration on Printing and Distributing the 13th Five-Year Plan for the Development of the Coal Industry	National Energy Administration, National Development and Reform Commission	2016

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