

The Environmental Protection Tax Plays a Key Inhibitory Role in Carbon Emissions-Take the Analysis of Carbon-Related Taxes in Heilongjiang Province as an Example

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Abstract: Heilongjiang Province, as an important old industrial base and resource-based province in northern China, faces an urgent need for green and low-carbon under the "double carbon" goal. This paper takes the six taxes that have an impact on green and low-carbon transformation as the research object, based on the carbon emission of whole province's 13 cities, and uses the fuzzy set qualitative comparative analysis method (fsQCA) to empirically analyze the impact of each tax on carbon emission, and that the environmental protection tax plays a key inhibitory role in carbon emission.

Keywords: Heilongjiang Province; Carbon Emission; Tax Incentive

1. Introduction

Heilongjiang Province, located in the northernmost part of China, experiences severe winters and a long heating period. At the same time, as a with heavy industries such as heavy machinery and equipment manufacturing, petrochemicals, and mineral processing as its economic pillars, it also faces the challenge of declining efficiency in the use of clean energy sources. This makes it even more necessary to have targeted tax policy arrangements to help Heilongjiang accelerate its green and low-carbon transformation and to expedite the adjustment industrial structure, energy structure, transportation structure, and land use structure. As an important tool in macroeconomic management, taxation plays a crucial supporting role in helping to achieve the "carbon" goals.

2.The Industrial Energy Consumption Structure of Heilongjiang Province

2.1 Analysis of Relevant Indicators

From the perspective of total energy consumption, it reached 12,067.3 million tons of standard coal in 2023, the industrial energy consumption has accounted for 53%-55% of the total for four consecutive years, which is the absolute main body of energy consumption. Among them, the of industrial terminal consumption in 2023 was 48.2%; the energy consumption of agriculture, forestry, animal husbandry and fishery decreased significantly, with consumption of 425.9 million tons in 2023; the energy consumption of construction industry reached 110.7 million tons, an increase of 140% over the previous year, far exceeding the historical level; the performance of living consumption is rigid demand, which continues to grow, and it was 2,115.2 million tons in 2023, with an average annual growth rate of 2.1%, reflecting the deepening of urbanization and the improvement of standards of residents.

Heilongjiang's unit GDP energy consumption decreased from 4.5% in 2014 to 2.2% in 2023 with fluctuation, indicating that the green transformation had initially achieved results. See Table 1.

2.2The Current Situation of Carbon Emissions in Heilongjiang Province

Heilongjiang Province is an important heavy industry and agricultural base in China. The production activities of the energy industry and equipment manufacturing industry, which are the pillar of Heilongjiang, always come with a large amount of carbon emissions. At the same time, Heilongjiang Province is also a major grain-producing province in, and the agricultural share is also large, and agricultural production activities will also affect the amount of carbon

emissions to a certain extent.

In recent years, the carbon emission of Heilongjiang Province has shown a trend of rising first and then falling, with a slow rise in carbon emission from 2018 to 2022, but a decrease in 2022, with the carbon emission being about 37,377.0 ten thousand tons,

accounting for about 2.6% of the national total, indicating that the carbon emission of Heilongjiang Province in recent years has been relatively stable, that the progress of green and low-carbon transformation is slow and the effect is not significant, and it is only in 2022 that it has shown some performance.

Table 1. Decrease in Energy Consumption per Unit of GDP in Heilongjiang Province from 2014 to 2023 (%)

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Energy consumption reduction (%)	-4.50	-4.01	-4.50	-4.02	-2.76	-2.49	-1.17	-0.30	-3.90	-2.20

Source of data; Statistical Yearbook of Heilongjiang (2021-2024)

3 Empirical Research on the Impact of Green Taxation on Carbon Emissions in Heilongjiang Province

3.1 Research Method

This studies the impact of green taxation on the green and low-carbon transformation of Heilongjiang Province. Based on the green taxation of various prefecture-level cities in Heilongjiang Province and the Daxinganling area, six types of taxes are sorted out as explanatory variables. The QCA method can help researchers to comprehensively analyze the effects of multiple explanatory variables on the result variables, so that the best configuration that affects the effect can be found among various results, and provide multiple path choices for solving the research. In this paper, the QCA method is used to analyze carbon emissions, which can find various effective paths for the impact of

green taxation on it under the actual background of Heilongjiang Province, and provide various path choices for promoting the reduction of carbon emissions and green and low-carbon development in Heilongjiang Province.

3.2 Variable Selection

(1)Dependent Variable.The dependent variable in this article is the carbon emission of the 12 prefecture-level cities and regions in Heilongjiang Province in 2023. This part of the data comes from EDGAR.

(2)Variable.In this article, the environmental protection tax, resource tax, vehicle and vessel tax, urban maintenance and construction tax, urban land use tax, and cultivated land occupation tax are as green taxes due to the availability of data. This part of the data comes from the final accounts of finance of prefecture-level cities and regions in Heilongjiang in 2023. See to Table 2:

Table 2. Variable Measurement Indicators and Sources

Type	Name	Data Source	Abbreviation
dependent variable	Carbon emissions in various regions	EDGAR	Tt
independent variable	Environmental protection tax	Financial final accounts report of each region	hj
	Resource tax		Zy
	Vehicle and vessel tax		Ch
	Urban maintenance and construction tax		Cs
	Urban land use tax		Cz
	Farmland occupation		gd

3.3 Variable Calibration

Firstly, the explained variable and the explanatory variables are subject to variable calibration, and they are all converted into variables between "0-1". This article uses the direct calibration method to calibrate the structure based on three qualitative anchor points, which are 95% quantile, 50% quantile

and 5% quantile respectively, which are "full membership, cross membership, and full non-membership". See Table 3.

Table 3 analyzes the correlation between the explained variable and the explanatory variable, the complete attribution anchor of the explained variable "carbon emission of each region is 3,584.3 thousand yuan, the cross point is 1,325.2 thousand yuan, and the

complete non-attribution is 51.4 thousand yuan.

This indicates that when the influence of the explanatory variable reaches 35.843 million yuan, the explained variable is completely subordinate to this variable; while when the influence reaches 13.252 million yuan, it indicates that the explanatory variable has a rather vague effect on the explained variable; when it is 591.4 million yuan, the explained variable is not completely subordinate to the influence of the explanatory variable.

The fully-owned calibration anchor point of urban land use tax in the explanatory variables in Table 3 is the highest, at 216,369.6 yuan, while the fully-owned calibration anchor point of environmental protection tax is the lowest, at only 4,346.6. This shows urban land use tax exhibits the highest degree of membership for carbon emissions in various regions, while the impact of environmental protection tax is relatively small.

Table 3. Calibration Anchor Points of Explained Variable and Explanatory Variables (Ten Thousand Yuan)

Type	variable	complete membership	intersection	complete non-membership
dependent variable	Carbon emissions in various regions	3 584.3	1 325.2	591.4
independent variable	Environmental protection tax	4 346.6	1 267.0	688.0
	Resource tax	44 823.4	5 490	577.8
	Vehicle and vessel tax	63 548.8	10 745.0	3 351.0
	Urban maintenance and construction tax	192 138	15 622	6 507
	Urban land use tax	216 369.6	16 897.0	2 276.6
	Farmland occupation	16 131.8	6 445.0	2 513.8

3.4 Analysis of the Necessity of a Single Green Tax on Carbon Emissions

Conduct a necessity analysis of the explanatory variables , According to

heterogeneity and coverage, it can be determined whether a tax necessary to advance the green and low-carbonization of Heilongjiang Province, and whether it can achieve the path of carbon emission reduction. See Table 4:

Table 4 Necessity of a single green tax

independent variable	Low carbon emissions in each region		Non-low carbon emissions in each region	
	Consistency level	coverage rate	Consistency level	coverage rate
Environmental protection tax	0.636	0.67	0.495	0.58
Non-environmental protection tax	0.602	0.517	0.718	0.687
Resource tax	0.805	0.7	0.502	0.486
Non-resource tax	0.41	0.425	0.69	0.798
Vehicle and vessel tax	0.511	0.556	0.626	0.759
Non-vehicle and vessel tax	0.779	0.652	0.634	0.59
Urban maintenance and construction tax	0.551	0.587	0.627	0.744
Non-urban maintenance and construction tax	0.759	0.646	0.652	0.618
Urban land use tax	0.548	0.614	0.568	0.709
Non-urban land use tax	0.74	0.606	0.69	0.63
Cultivated land occupation tax	0.579	0.554	0.621	0.661
Non-cultivated land occupation tax	0.646	0.605	0.581	0.606

It can be seen from Table 4 that the consistency level of the low-carbon emission and non-low-carbon emission of each green tax in various is all lower than 0.9, indicating

that none of the green taxes is a necessary condition for affecting low-carbon emission or non-low-carbon emission, indicating that is difficult for a single tax to exert a

significant effect on the carbon emission of the region. In order to find the combination of conditions for the impact of various green taxes on the emission of various regions in Heilongjiang Province, it is necessary to construct a truth table for the six explanatory variables, find the explanatory variables that have sufficient explanatory for the explained variables, and reveal the complex relationship and dynamic mechanism between green tax types and carbon emission.

3.5 Configuration Analysis of Carbon Reduction Conditions

In order to obtain the conditional configurations of various green taxes, this paper makes a sufficient analysis of the configurational of calibrated variables, with the original consistency threshold set at 0.8 and the case frequency threshold set at 1. By running the influencing carbon emissions in each region as a result variable, the corresponding complex solutions, parsimonious solutions and intermediate solutions are obtained, and the path of carbon emissions realization is analyzed

accordingly.

Table 5 shows the results of the influence of 6 explanatory variables on carbon emissions in Heilongjiang Province. Solid circles indicate the presence of conditions, circles with ticks indicate the absence of core conditions, and blanks indicate that the impact of the condition on the results is negligible. The consistency of the two configurations shown in 5, whether it is configuration 1, configuration 2, or the overall solution, is greater than 0.8, and the consistency level of the overall solution is 0.967, and the coverage of the solution is 0.423. This means that the two configurations have a strong explanatory power for the carbon emission in each region.

From Table 5, environmental protection tax, resource tax, vehicle and vessel tax, urban maintenance and construction tax, and urban land use tax have a certain explanatory power for carbon reduction in various regions of Heilongjiang Province, but environmental protection tax plays a more important role in it.

Table 5. Analysis Results of Conditional Configurations

Explanatory variable	Carbon emission reduction in various regions	
	Configuration 1	Configuration 2
Environmental protection tax	●	●
Resource tax	●	●
Vehicle and vessel tax	⊗	●
Urban maintenance and construction tax	⊗	●
Urban use tax	⊗	●
Cultivated land occupation tax		⊗
Consistency of solutions	0.969	0.993
Original coverage	0.408	0.238
Unique coverage	0.185	0.015
Consistency of solutions	0.967	
Coverage solutions	0.423	

Note: ●=Core condition present, ⊗=Core condition absent, ●=Auxiliary condition present, ⊗=Auxiliary condition absent, “space” that this condition can be either present or absent

4. Conclusion

This paper refers to the method of robustness test in qca analysis in KONG Tingting(2025),and the determined “full, cross-membership, and full non-membership” anchor points are changed and determined as the 90% quantile (full membership), 50%ile (cross-membership) and 10% quantile (full non-membership) for calibration. At the

same time, the threshold of full membership in the data is adjusted from the 0.8 quantile to the 0.85 quantile, and the analysis is rerun. The output consistency of the solutions shown in test results, the original coverage, and the configural composition are almost the same as the original solution, and the configural composition is basically the same as the previous configural composition changes enough to affect the previous results,

which shows that the research results of this paper are robust.

Acknowledgments

This paper is supported by Special Research on the Spirit of the Important Speech and Instructions of General Secretary Xi Jinping (Project number: 23XZT033)

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