Financial Agglomeration, Resource Tax Collection and Carbon Emissions—An Empirical Study Based on 31 Provinces

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Abstract. Since the reform and opening up, China's economy has grown rapidly, becoming the world's second-largest economy. However, this achievement has come at the cost of high resource consumption and severe environmental pollution. China is urgently in need of transitioning to a sustainable development model. To this end, China began to levy a resource tax in 1984. The proposal of the 2020 "dual carbon" goals further highlights the importance of carbon emission reduction. At the same time, with the continuous development of the financial sector, while supporting the development of the real economy, a significant environmental effect has also been generated. To study the impact mechanism between financial agglomeration, resource tax, and carbon emissions, this paper selects panel data from 31 provinces in mainland China from 2007 to 2021 and empirically analyzes the impact of resource tax revenue on carbon dioxide emissions using the system GMM model. The research shows that the resource tax can effectively suppress carbon emissions and promote the improvement of the financial agglomeration level. Furthermore, the enhancement of financial agglomeration further promotes the reduction of carbon emissions.

Keywords: Resource Tax; Carbon Emissions; Financial Agglomeration; Mediating Effect

1 INTRODUCTION

With China's carbon emissions ranking first in the world, resource conservation and environmental governance have become urgent tasks. Resource tax is an important fiscal tool for regulating resource development and utilization. Since the reform and opening up, China has been continuously exploring the resource tax. In 1984, China began to impose a resource tax for the first time, and the Resource Tax Law was promulgated in 2019 and officially implemented in 2020. Subsequently, at the 75th United Nations General Assembly, China made a commitment to achieve the "dual carbon" goals. As the financial industry continuously develops, the significant improvement of the financial agglomeration effect has promoted the efficient allocation of financial resources and the development of green finance, driving the development of the real economy

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and the tertiary industry, while optimizing the industrial structure. Through the inclination of funds towards green and low-carbon projects, financial product innovation, financial agglomeration effectively supports the green transformation of the economy and promotes carbon emission reduction, having a positive impact on environmentally sustainable development. So, can the imposition of resource tax and financial agglomeration significantly reduce carbon emissions? What effect do they have on the role of resource tax and carbon emissions? To clarify these questions, this paper constructs a dynamic relationship between resource tax, financial agglomeration, and carbon emissions, and uses the system GMM model to empirically examine the relationship between resource tax, financial agglomeration, and carbon emissions.

2 LITERATURE REVIEW

2.1 Studies on the Impact of Resource Tax on Carbon Emissions

Siriwardena (2007) et al. [1] found that resource taxes significantly curb carbon emissions in Sri Lanka. Glomm (2008) et al. [2] based their research on a standard dynamic general equilibrium model. Valadkhani et al. (2014) [3] argue that energy prices have significantly reduced carbon emissions in both China and Australia in the long and short term, due to high energy prices encouraging economic structural optimization and modernization. Zakeri et al. (2015) [4] used actual data from an Australian company to confirm the effectiveness of tax policies in energy conservation and emission reduction. Xu Xiaoliang et al. [5] constructed a CGE model to study the carbon emission reduction effects of resource taxes and found that increasing the resource tax rate could promote regional industrial restructuring, improve energy efficiency, and advance energy conservation and emission reduction. Zhang Xiaofang et al. [6] used a difference-in-differences model to estimate the effects of coal resource tax reform policies on per-unit output energy consumption, industrial pollution emissions, and resource tax revenue. The results show that the reform of coal resource taxation has a positive effect on energy conservation and emission reduction.

2.2 Studies on the Impact of Financial Agglomeration on Carbon Emissions

Tamazian et al. [7], using data from the BRICS countries, found that the rapid development of the financial sector contributes to the decline in per capita carbon emission intensity. Shahbaz et al. [8] discovered that the development of the financial sector reduces carbon emissions by attracting foreign investment, encouraging corporate technological innovation, and promoting carbon trading. Acheampong et al. [9] found that the intensity of carbon emissions varies at different stages of financial development, with the carbon reduction effect being optimal in developed financial economies. Ozturk et al. [10] showed that although economic expansion and industrialization process increase carbon emissions, the development of the financial sector could, to some extent, promote carbon reduction.Lei Ran et al. [11] demonstrated that financial agglomeration in the six central provinces of China has a significant inhibitory effect on carbon emissions. Song Zhixiu and Ge Xiangyu [12] found that understanding the pattern of financial agglomeration and its impact on regional economic development is important for fully utilizing the agglomeration and spillover effects of financial agglomeration and promoting high-quality development of the modern economy. Wang Xing et al. [13] discovered that financial agglomeration has a significant smooth transition effect on carbon emission efficiency, and economic growth pressure significantly adjusts the relationship between financial agglomeration and carbon emission efficiency.

In summary, current scholars both domestically and internationally employ a variety of angles and methods in their research on the impacts of resource tax and financial agglomeration on carbon emissions, and the conclusions reached vary. Most scholars study the direct effects of resource taxes on carbon emissions and financial agglomeration on carbon emissions. Therefore, this paper uses the system GMM method and considers financial agglomeration as an intermediate variable to study whether resource taxes affect carbon emissions through the influence of financial agglomeration.

3 THEORETICAL ANALYSIS AND RESEARCH HYPOTHESIS

First, the inhibitory effect of resource tax on carbon emissions can be explained through the supply and demand theory in economics. Below is a simple derivation process to illustrate how resource tax affects carbon emissions. (Other influencing factors are not considered apart from the resource tax).

Ignoring tax implications, the supply and demand for a certain resource in the market can be represented by the following equations:

Demand equation: Q_d=D(p) Supply equation: Q_s=S(p)

Here, $Q_d$and D(p)represent the quantity demanded and supplied, respectively, while D(p) and S(p) are the functions of demand and supply quantities with respect to price p. Generally, the quantity demanded decreases as the price rises, while the quantity supplied increases with the price. When the government imposes a resource tax t (tax per unit of resource), the cost for businesses increases, and the supply equation changes. Assuming that the market equilibrium price before the tax is p_0, for suppliers to maintain the same net price after tax, the market price needs to rise to p_1. The new supply equation becomes: Q's=S(p−t).Without considering taxes, the market is in equilibrium when supply equals demand: Q_d=Qs.After considering taxes, the new market equilibrium also has equal supply and demand, but the quantity supplied is reduced: Q'_d=Q' s.Since the demand curve is typically downward sloping, a resource tax leads to a price increase, resulting in a decrease in the quantity demanded, i.e., Q'd<Q_d.As the quantity demanded—and thus resource consumption—decreases, it demonstrates that the resource tax has reduced resource consumption, thereby decreasing carbon emissions. Based on this, Hypothesis 1 is proposed:

H_1: An increase in resource tax revenue can reduce carbon emissions.

Furthermore, the role of resource taxes in promoting financial agglomeration can be demonstrated through the following theoretical analysis. Firstly, the theory of resource-oriented financial development. This theory suggests that countries or regions rich in resources often develop financial institutions and markets that serve resource extraction and trade. By increasing the cost of resource extraction and export, resource taxes may encourage related businesses and financial institutions to seek more efficient capital management and investment opportunities, including developing new financial instruments and attracting external investment. These activities can promote financial agglomeration. Secondly, the Pigouvian tax theory in environmental economics. A Pigouvian tax aims to correct market failure by taxing environmentally harmful activities to reduce external diseconomies. In the context of resource taxes, this tax not only can reduce the over-extraction of resources and environmental damage but also can stimulate financial market innovation, such as green finance and sustainable investment. The increase in these financial activities helps to form and develop financial agglomeration. Therefore, Hypothesis 2 is proposed:

H_2: Financial agglomeration can promote carbon emission reduction.

An improvement in the level of financial agglomeration encourages the development of green finance, such as green bonds and green funds. These financial instruments provide funding for low-carbon technologies and projects, and through the effect of financial agglomeration, more capital is effectively invested in green technologies and low-carbon projects. These investments accelerate the development and application of clean energy technologies, thereby indirectly supporting the reduction of carbon emissions. Thus, Hypothesis 3 is proposed:

H_3: Financial agglomeration plays a mediating role in the impact of resource taxes on carbon emissions.

4 MEASUREMENT OF FINANCIAL AGGLOMERATION LEVELS AND CARBON EMISSIONS

4.1 Measurement of Financial Agglomeration Levels

In measuring financial agglomeration, academia primarily uses single-indicator and multi-indicator methods. However, multi-indicator methods have not shown great advantages in improving accuracy and are prone to errors during processing. In contrast, the single-indicator method of locational entropy is academically recognized for its relative accuracy and ease of operation. Therefore, this paper adopts the locational entropy method to calculate the level of financial agglomeration, with the formula as follows: $FI_{it}=\frac{F_{it}/G_{it}}{F_t/G_t}$.Where F_{it} is the financial industry added value of province i in year t, G_{it} is the gross regional product of province i in year t, $F_t$is the national financial industry added value in year t, and $G_t$is the national gross domestic product in year t.

4.2 Calculation of Emissions

This paper calculates the total carbon emissions (in million tonnes) for each province based on the carbon emission coefficients provided by the Intergovernmental Panel on Climate Change (IPCC). The formula is as follows: $CO_2=\sum_{i=1}^{8} E_i \times CEF_i$.Where

$CEF_i = H_i \times CH_i \times COR_i \times \frac{11}{3} \times 10^{-6}$, E_i is the total consumption of fossil energy, CEF_i is the carbon emission coefficient, H_i is the average low heating value, CH_i is the carbon content per unit of heating value, and COR_i is the carbon oxidation rate. The composition of the main fossil energies and their corresponding carbon emission coefficients are shown in Table 1. (The average low heating value is taken from the "China Energy Statistical Yearbook", and the carbon content per unit of heating value and carbon oxidation rate are taken from the "Provincial Greenhouse Gas Inventory Compilation Guide" (NDRC Climate [2011] No. 1041); (For natural gas, the average low heating value unit is KJ/m_3, and the carbon emission coefficient unit is kgCO_2/m_3)

Table 1. Carbon Emission Coefficients of Major Energy Types

Energy	H_i (kJ/kg)	CH_i (tC/TJ)	COR_i	CEF_i (kgCO_2/kg)
Coal	20,908	26.37	0.94	1.900 3
Coke	28,435	29.5	0.93	2.860 4
Crude Oil	41,816	20.1	0.98	3.020 2
Fuel Oil	41,816	21.1	0.98	3.170 5
Gasoline	43,070	18.9	0.98	2.925 1
Kerosene	43,070	19.5	0.98	3.017 9
Diesel	42,652	20.2	0.98	3.095 9
Natural Gas	38,931	15.3	0.99	2.1622

Data Source: "China Energy Statistical Yearbook," "Guidelines for Compiling Provincial Greenhouse Gas Inventories" (NDRC Climate Office [2011] No. 1041)

5 EMPIRICAL PROCESS AND RESULTS ANALYSIS

5.1 Model Setting and Variable Selection

Based on the theoretical analysis and research hypotheses previously discussed, to study the mediating effect of financial agglomeration in the impact of resource taxes on carbon emissions and considering autocorrelation issues, as well as to capture the influence of the previous period's financial agglomeration level and carbon emissions on the current period's $\boldsymbol{FI_{i,t}}$ and $\boldsymbol{CO2_{i,t}}$, the following models are established:

$$\boldsymbol{lnFI_{i,t} = \beta_0 + \beta_1 lnRT_{i,t} + \beta_2 lnRT_{i,t-1} + \beta_3 lnCO2_{i,t-1} + \beta_4 \sum control_{i,t} + \varepsilon_{i,t}} \quad (1)$$

$$\boldsymbol{lnCO2_{i,t} = \beta_0 + \beta_1 lnRT_{i,t} + \beta_2 lnRT_{i,t-1} + \beta_3 lnCO2_{i,t-1} + \beta_4 lnFI_{i,t} + \beta_5 \sum control_{i,t} + \varepsilon_{i,t}} \quad (2)$$

Where i (i=1,2,3...31) and t represent different provinces (municipalities, autonomous regions) and years (2012-2021), $\boldsymbol{\beta}$ represents the coefficient of the independent variable, $\boldsymbol{FI_{i,t}}$ is the financial agglomeration level of province i in year t, $\boldsymbol{lnRT_{i,t}}$ is the resource tax revenue of province i in year t, $\boldsymbol{lnRT_{i,t-1}}$ is the lagged variable, $\boldsymbol{CO2_{i,t-1}}$ is the carbon dioxide emissions of province i in the previous year t-1,

$\boldsymbol{control}_{i,t}$ are control variables, and $\boldsymbol{\varepsilon}_{i,t}$ is the random disturbance term.Specific variable selection is as follows:

Dependent variable: Carbon emissions ($\boldsymbol{CO_2}$). The total carbon emissions for each province are calculated using the above method and converted into the natural logarithm form, i.e., ln $\boldsymbol{CO_2}$.

Independent variable: Resource tax revenue (**RT**). Represented by the resource tax revenue of each province (in billions of yuan), taken in natural logarithm form, i.e., lnRT.

Mediating variable: Financial agglomeration (**FI**). Calculated using the above locational entropy method.

Control variables:

Economic development level (PGDP). Represented by per capita GDP (in ten thousand yuan).

Technical level (TL). Represented by the investment in research and experimental development (in ten thousand yuan).

Industrial structure (IS). Represented by the proportion of the secondary industry's output value in GDP.

Urbanization level (UR). Represented by the proportion of urban population to total population.

The specific variable settings are shown in Table 2.

Table 2. Variable Classification

Variable Type	Primary Indicator	Secondary Indicator
Explanatory Variable	Resource Tax **(RT)**	Resource Tax Revenue
Explained Variable	Carbon Emissions **($\boldsymbol{CO_2}$)**	Carbon Emission Volume
Mediating Variable	Financial Agglomeration **(FI)**	Regional Entropy
Control Variables	Economic Development Level **(PGDP)**	Per Capita GDP
	Technological Level **(TL)**	Research and Development Investment
	Industrial Structure **(IS)**	Proportion of Secondary Industry Output to GDP
	Urbanization Level (**UR**)	Proportion of Urban Population to Total Population

5.2 Data Sources and Descriptive Statistics

5.2.1. Data Sources

Considering the availability of data, this paper selects panel data from 31 provinces in China, excluding Hong Kong, Macao, and Taiwan, for the 15 years from 2007 to 2021. The impact of resource tax revenue on carbon emissions can be empirically studied through the changes in financial agglomeration. The relevant data were sourced from the "China Statistical Yearbook," the "National Bureau of Statistics," the "China

Science and Technology Statistical Yearbook," and the statistical yearbooks of each province.

5.2.2. Descriptive Statistical Analysis

The descriptive statistical results of the main variables are shown in Table 3. According to the statistics in the table, the maximum value of the resource tax (lnRT) is 6.204, the minimum value is 0, the mean is 2.758, and the standard deviation is 1.256. These results are generally consistent with the statistical outcomes of existing domestic literature and indicate significant differences in resource tax revenue across regions. The maximum and minimum values of carbon emissions (CO2) are 11.061 and 8.707, respectively, with a standard deviation of 0.573. This indicates significant individual differences in carbon emissions across different regions. As control variables, this paper selects the level of economic development (RGDP), technological level (TL), industrial structure (IS), and urbanization level (UR), as shown in Table 3

Table 3. Descriptive Statistical analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
lnCO2	403	10.191	0.573	8.707	11.061
lnRT	403	2.758	1.256	0	6.204
lnTL	403	14.377	1.614	8.849	17.505
lnPGDP	403	10.61	0.573	9.331	11.963
lnIS	403	0.418	0.083	0.173	0.587
lnUR	403	0.561	0.142	0.215	0.896

Data sources: "China Statistical Yearbook", "National Bureau of Statistics", "China Science and Technology Statistical Yearbook", and the statistical yearbooks of various provinces.

5.3 Empirical Analysis

5.3.1 Baseline Regression Analysis

Considering the characteristics of the short panel data of this paper and the endogeneity problem that may be caused by the lagged terms in the explanatory variables, the System Generalized Method of Moments (SYS-GMM) is used for model estimation. The specific regression results are shown in Table 4. The results in columns (1), (2), and (3) of the table correspond to regressions without lagging carbon emissions and resource tax, with only carbon emissions lagged but not the resource tax, and with lagged terms for both, respectively. The regression results show that resource tax has a significant negative effect on carbon emissions when lagged effects are not considered. After accounting for the lagged effects of resource tax collection on carbon emissions, the coefficient is -0.0852, which is significant at the 1% level, indicating that the resource tax has a significant impact on curbing carbon emissions at this time. Looking at the third column of regression results, the regression coefficient of the resource tax is -0.0864, which passes the significance test at the 5% level, suggesting that the resource tax can significantly reduce carbon emissions, with an average increase of 1% in resource tax revenue leading to a decrease of about 0.1% in carbon emissions.

Table 4. Baseline Regression Result

	(1) CO2	(2) CO2	(3) CO2
lnRT	0.0766**	-0.0852***	-0.0864**
	(-2.26)	(-2.63)	(-2.24)
lnIS	-0.4714	-0.3828	-0.3857
	(-0.96)	(-0.81)	(-0.81)
lnUR	-0.3792	0.1834	0.1827
	(-0.53)	(0.27)	(0.27)
lnTL	-0.0377	-0.0242	-0.0244
	(-0.54)	(-0.34)	(-0.34)
lnPGDP	0.2510	0.1213	0.1218
	(1.29)	(0.62)	(0.62)
L. lnCO2		-0.1484	-0.1486
		(-1.63)	(-1.63)
L.lnRT			0.0014
			(0.06)
N	403	403	403
AR (1)	0.000	0.000	0.000
AR (2)	0.470	0.275	0.275

5.3.2 Robustness Check

The following methods were chosen for robustness checks: (1) Shortening the sample interval. The sample interval was changed to 2008-2011, and the data processed were regressed. (2) Changing the regression model. The paper re-analyzed the sample using a fixed effects model. The specific test results are shown in Table 5. The regression results of the above tests are consistent with the main regression results.

Table 5. Robustness Test Results

	(1) Shortening sample interval	(2) Repalcement Regression Model
lnRT	-0.0864**	-0.1408***
	(-2.24)	(-6.77)
L. lnCO2	-0.1486	
	(-1.63)	
L.lnRT	0.0014	
	(0.06)	
lnIS	-0.3857	-1.0998***
	(-0.81)	(-3.64)
lnUR	0.1827	0.9934***

	(0.27)	(3.27)
lnTL	-0.0244	0.3553***
	(-0.34)	(18.69)
lnPGDP	0.1218	-0.7756***
	(0.62)	(-7.24)
_cons		13.1851***
		(15.15)
N	403	403
adj. R^2		0.549
AR (1)	0.000	
AR (2)	0.275	

5.3.3 Mediation Mechanism Test

The mediation effect test results of financial agglomeration (FI) between resource tax (lnRT) and carbon dioxide emissions (CO2) are shown in Table 6. Column (1) of Table 6 confirms that the resource tax has a significant negative impact on carbon dioxide emissions. The regression coefficient of resource tax on financial agglomeration is significantly positive in column (2), indicating that the resource tax can enhance the level of financial agglomeration. In column (3), with the mediating variable financial agglomeration added, the regression coefficient of resource tax on carbon dioxide emissions is significant, indicating that resource tax can indirectly curb carbon dioxide emissions by improving the level of financial agglomeration. With other factors held constant, for each additional unit of resource tax, carbon dioxide emissions will directly decrease by 0.19 units and will also increase financial agglomeration by 0.06 units, thereby indirectly reducing carbon dioxide emissions by 0.01 units ($0.19 \times 0.06 \approx 0.01$), leading to a total effect improvement of 0.09 units. The indirect effect brought by financial agglomeration accounts for about 11.11% of the total effect.

Table 6. Mediation Mechanism Test Results

	(1) CO2	(2) FI	(3) CO2
lnFI			-0.1980**
			(2.37)
lnRT	-0.0864**	0.0580**	-0.0527**
	(-2.24)	(-2.08)	(-1.64)
L. lnCO2	-0.1486	0.0604	-0.1104
	(-1.63)	(0.92)	(-1.27)
L.lnRT	0.0014	0.0053	-0.0108
	(0.06)	(0.29)	(-0.48)
lnIS	-0.3857	0.3601	-0.5000*
	(-0.81)	(1.05)	(-1.75)
lnUR	0.1827	-1.3625***	0.7402
	(0.27)	(-2.82)	(1.25)
lnTL	-0.0244	-0.2407***	0.0988

	(-0.34)	(-4.70)	(1.60)
lnPGDP	0.1218	0.0566	0.1059
	(0.62)	(0.40)	(0.85)
lnFI			0.1980**
			(2.37)
N	403	403	403
AR (1)	0.000	0.000	0.000
AR (2)	0.275	0.695	0.398

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This paper has studied the relationship between financial agglomeration, resource tax collection, and carbon emissions using the system GMM model. The empirical results lead to the following conclusions:

Firstly, in general, an increase in resource tax revenue significantly suppresses carbon dioxide emissions. The effect of carbon emission reduction becomes more evident as resource tax revenue increases.

Secondly, an increase in resource tax revenue promotes the level of financial agglomeration. The increase in resource tax revenue enhances the government's macroeconomic regulatory ability and investment attractiveness, fosters economic development and financial innovation, and product diversification, thus having a positive effect on improving the level of financial agglomeration.

Thirdly, an enhanced level of financial agglomeration can suppress carbon dioxide emissions. The improvement of financial agglomeration can promote green finance development, technological innovation, optimize resource allocation, and strengthen the enforcement of environmental policies. These mechanisms help drive the economy towards a low-carbon, environmentally friendly transformation, thereby effectively suppressing carbon dioxide emissions.

Fourthly, financial agglomeration plays a significant partial mediating effect in the relationship between resource tax and carbon emissions. As resource tax revenue increases and financial agglomeration levels rise, this indirectly leads to a reduction in carbon dioxide emissions. Financial agglomeration is an important mediating factor in the effect of resource tax on reducing carbon dioxide emissions.

6.2 Recommendations

First, optimize the resource tax policy to enhance the environmental benefits of resource tax revenue. The government should further refine the resource tax collection system to ensure that resource tax policies reflect both the market value of resources and their environmental costs. By increasing the resource tax rate and expanding the tax base, resource tax revenue can both promote resource conservation and rational use, and provide fiscal support for environmental protection and carbon emission reduction.

It is also recommended to establish a special fund for resource tax revenue dedicated to supporting environmental protection projects, green technology innovation, and its application, to maximize the inhibitory effect of resource tax revenue on carbon emissions.

Second, leverage the effect of financial agglomeration to promote the development of green finance. Increase support for financial agglomeration areas and use resource tax revenue to promote financial innovation and product diversification, especially in the field of green finance. Encourage financial institutions to develop financial products and services related to environmental protection and energy saving, such as green credit, green bonds, green investment funds, etc., to provide funding support for low-carbon technologies and projects. In addition, improve the policy framework and incentive mechanisms of the green financial market to attract more private capital to the green economy and foster the concentration of financial resources in environmentally friendly projects.

Third, strengthen the linkage mechanism between financial agglomeration and technological innovation. Promote the deep integration of financial agglomeration and technological innovation by accelerating green technology research and application through financial support. Governments should guide financial institutions to increase credit support for high-tech enterprises, especially environmental and clean energy companies, and reduce their financing costs. At the same time, strengthen the coordination between financial policies and science and technology policies, establish a long-term mechanism for financial support for technological innovation, and promote the rapid development and widespread application of green technologies, thereby improving the overall economy's energy efficiency and emission reduction capabilities.

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