The Impact of Financial Competition on Carbon Emissions

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Abstract. Based on the panel data of 30 provinces (municipalities, autonomous regions) in China from 2003 to 2019, this paper constructs a two-way fixed effect model to analyze the influence of financial competition on carbon emissions. It is found that fiscal expenditure competition and tax competition will push up local carbon emission intensity. The analysis of regional heterogeneity shows that the financial competition in the eastern region has no significant impact on carbon emission intensity, while the financial competition in the central and western regions has a more obvious impact on carbon emission intensity. The analysis of time heterogeneity shows that after China's economy entered a new normal in 2012, the impact of financial competition on carbon emission intensity was significantly enhanced. Meanwhile, considering the influence of financial autonomy on carbon emissions, this paper constructs related intersection terms, which further reflect the role of financial autonomy.

Keywords: Fiscal Expenditure Competition; Tax Competition; Carbon Emission Intensity; Financial Autonomy.

1. Introduction

Since the First Assessment Report issued by IPCC in 1990, people have gradually paid more attention to greenhouse gas emissions and climate change. With the increasingly severe global climate change, countries have begun to pay attention to the issues of reducing carbon emissions, promoting low-carbon development, and protecting the global climate, which has become the focus of the international community (Lin & Mao, 2014). In order to achieve low-carbon development, China has made great contributions. In 2020, General Secretary Xi Jinping announced China's double-carbon strategy at the 75th UN General Assembly by claiming that China will adopt more powerful policies and measures to make carbon dioxide emissions peak before 2030 and strive to achieve carbon neutrality before 2060. The proposal of the Double Carbon Strategy shows China's determination to support the world's energy conservation and emission reduction.

Since the Reform and Opening-up, China's economy has created a total growth miracle, and the government has played an important role in promoting the process of economic development. After China's tax-sharing reform in 1994, although the problems of financial distribution between the central and local governments were solved, the pattern of division of powers between the central and local governments did not change (Zhou, 2006), which made the powers of local governments unchanged while the financial power was transferred to the central government, and they still needed to bear the corresponding expenditure responsibilities, resulting in the mismatch between financial power and powers of local governments. The competitiveness of local governments at the expenditure level is gradually strengthened. From the financial perspective, we can see that local governments have the power to allocate corresponding local financial resources. However, the central government's assessment of local officials is based on the performance of local economic growth (Shen and Fu, 2005; Qiao et al., 2014), which aggravates the situation that local governments compete for local economic growth. But it is this kind of competition that has stimulated the rapid development of our economy.

Although financial competition has brought economic dividends, it has also led to obvious differences in the quality and speed of economic growth (Mao et al., 2021). The local government

has allowed some enterprises to relax the standards of pollution discharge by means of tax power and financial transfer payment. It has aggravated the carbon emissions of enterprises. In recent years, China's environmental problems have become increasingly serious, threatening people's health and having a great impact on the sustainable development of energy. It is urgent to deal with related problems. In 2017, China put forward a high-quality development strategy, so it is of significance to probe into the degree of seriousness of the environmental problems induced by fiscal expenditure competition and tax competition among local governments, and the relationship between them. In this paper, by measuring the carbon emission intensity of the relationship between economic development and carbon emission and local government financial competition, the relationship between them is sorted out, aiming to use the influence of financial competition on carbon emission intensity to reduce environmental pollution and promote high-quality development.

The contribution of this paper mainly includes the following aspects: Firstly, the topic selection angle. This study analyzes the influence of financial competition on carbon emission intensity. This research topic enriches the research in related fields. At present, the existing research mainly focuses on the impact of fiscal competition on carbon emission intensity or total carbon emission in the environment from the perspective of fiscal decentralization. However, the impact of fiscal competition on carbon emission intensity from the perspective of fiscal decentralization is still under-researched, so this paper enriches the research in this field from the perspective of fiscal competition. Secondly, the research perspective. From the perspective of financial autonomy, this paper further discusses the impact of financial competition on carbon emissions and enhances the credibility of the empirical results by constructing interactive terms. Thirdly, realistic needs. The influence of financial competition on carbon emission intensity is explored, hoping to further optimize the impact of relevant policies on the environment from the financial point of view, provide inspiration for formulating relevant policies for high-quality development, and help achieve the goal of double carbon.

2. Literature Review and Theoretical Basis

With the continuous development of the market economy, China has gradually played a leading role in the development of the world economy. However, in this process, China's initial development at the expense of environmental resources has promoted the rapid development of China's economy. At present, the situation of environmental governance in China is grim, especially under the direction of the double carbon strategic goal, carbon emission and environmental protection are inevitable topics in the process of our sustainable development. Based on this, our government has paid more attention to it and introduced the theory of fiscal decentralization into the field of environmental economics on the basis of tax-sharing reform, and started with the correlation mechanism between fiscal decentralization, carbon emissions, and economic development, and carried out a series of studies (Gao et al., 2023). Tiebout et al. proposed that the first generation of fiscal decentralization theory was based on the assumption of "benevolent government", and that decentralization can improve the supply efficiency of public goods, while environmental protection has the nature of public goods. Qian et al. believed that the second-generation decentralization theory was based on the assumption of the "self-interest" of local governments and discussed the relationship between fiscal decentralization and economic development. Local governments may damage the regional environmental quality in order to unilaterally pursue the maximization of economic interests. China's current fiscal decentralization system has led to greater competition pressure among local governments, which has a strong impact on carbon emissions, green economic development, and environmental pollution. Based on the proposal of the double carbon strategy, this topic has become a hot research direction.

Financial competition refers to the decentralization of central and local governments, which has strengthened local power after the tax-sharing reform. At the same time, the central government implements a single evaluation standard for promotion and evaluates officials with economic growth

performance, which makes local governments sacrifice the ecological environment in exchange for economic growth in order to enhance their attractiveness to capital, talents, and other liquidity resources. Financial competition has led to an increase in local carbon emissions and the deterioration of the ecological environment (Wu et al., 2018). Meanwhile, under the background of fiscal decentralization, local governments often have fierce competition. There are two mainstream views in academia, that is, "competition for the better" and "competition for the worse". In terms of "competition for the worse", firstly, it is the government's strategy of reducing environmental regulation in order to attract investment as much as possible, forming a "competition for the worse" in the prisoner's dilemma. Secondly, if the local government improves the environmental level of the region, it will have a spillover effect, so that neighboring regions will adopt the method of hitchhiking, which will eventually lead to the investment in environmental governance is lower than the optimal level (Tian et al., 2018). With respect to "competition for the better", Tiebout believed that under the condition of free flow of factors, the emergence of this mechanism of "voting with feet" will prompt local governments to take measures to improve the supply capacity of public goods, so as to attract the inflow of production factors such as capital, talents and technology, and prompt local governments to rationally allocate and compete for resources between the tax burden level and public services (Mao et al., 2021). It is not difficult to draw a conclusion that the forms of financial competition include fiscal expenditure competition and tax competition. In this paper, the influence of the two variables on carbon emissions is discussed.

Concerning economic development and environmental protection, with the intensification of financial competition, local governments compete for fiscal revenue, attract as much investment as possible, and even lower the standards of environmental regulations, showing a situation of "bottom-by-bottom competition" (Wang and Hu, 2015). The spillover of environmental governance leads to hitchhiking behavior, the economic catch-up between governments, and economic performance appraisal implemented by the central government, which makes the short-term effect of pursuing economic growth normal. Besides, it also makes it understandable for local governments to sacrifice the environment in order to improve economic indicators as much as possible (Guang et al., 2019) However, after fiscal decentralization, the competition space of low tax burden was compressed by the policy of financial power moving up and administrative power moving down, and most governments turned to the competition mode of high expenditure. At the same time, due to the upward shift of financial power, the government's financial pressure has surged, and local governments will measure the costs and benefits of different types of financial expenditures (Mao et al., 2021). Given the fixed expenditure capacity, because of the poor mobility of residents compared with capital, the government will be more inclined to improve the business environment, reduce environmental regulations to attract enterprises' investment and decrease the expenditure on people's livelihood services, resulting in the structural distortion of emphasizing infrastructure and neglecting people's livelihood (Keen and Marchand, 1997; Qian and Roland, 1998).

The rapid development of China's economy has also enabled local governments to have greater financial autonomy. Under the performance evaluation of the central economy, local governments will choose expenditures that are beneficial to them. According to the research results of Li's (2019) application of the spatial Dobbin model, compared with public service expenditure, productive expenditure is more attractive to mobile production factors and more conducive to the development of the regional economy. Simultaneously, the research of Wang and Liu (2016) shows that from the perspective of official promotion, the competition of economic expenditure can effectively stimulate economic growth in the short term, but the effect is not obvious in the long run, while the competition of public service expenditure is more conducive to achieving sustainable economic development. Based on this, most local governments choose production expenditure, which leads to an increase in carbon emissions and a decrease in the quality of life of residents.

3. Research Design and Variables

3.1 Model Setting

According to the basic function of fiscal competition on carbon emission intensity, the benchmark regression model is set as follows:

$$y_{it} = \beta_0 + \beta_1 \exp c_{it} + \Sigma\beta_2 X_{it} + \eta_i + \sigma_t + \varepsilon_{it} \quad (1)$$

$$y_{it} = \beta_0 + \beta_1 taxc_{it} + \Sigma\beta_2 X_{it} + \eta_i + \sigma_t + \varepsilon_{it} \quad (2)$$

Among them, i and t represent provinces and years, respectively, and the explained variable y_{it} represents carbon emission intensity, that is, carbon dioxide emissions per unit GDP. $\exp c_{it}$ means the competition of fiscal expenditure, which is calculated by using the ratio of fiscal expenditure to GDP in each province. The greater the index, the higher the actual relative expenditure level and the higher the competition intensity of fiscal expenditure. $taxc_{it}$ means tax competition, which is calculated by using the ratio of tax revenue to GDP in each province. The greater this indicator, the higher the intensity of tax competition. X_{it} is a series of control variables that change with time at the provincial level. η_i represents the provincial fixed effect and σ_t is the year fixed effect. ε_{it} is a random disturbance term.

Further, taking into account the regulatory role of fiscal autonomy and carbon emission intensity, which may also have an impact on carbon emission intensity, the intersection of fiscal expenditure competition and fiscal autonomy, tax competition and fiscal autonomy is constructed, and the specific model is set as follows:

$$y_{it} = \beta_0 + \beta_1 \exp c_{it} + \beta_2 \exp c_{it} \times fd_{it} + \Sigma\beta_3 X_{it} + \eta_i + \sigma_t + \varepsilon_{it} \quad (3)$$

$$y_{it} = \beta_0 + \beta_1 taxc_{it} + \beta_2 taxc_{it} \times fd_{it} + \Sigma\beta_3 X_{it} + \eta_i + \sigma_t + \varepsilon_{it} \quad (4)$$

Among them, the term $\exp c_{it} \times fd_{it}$ represents the intersection of fiscal expenditure competition and fiscal autonomy, the term $taxc_{it} \times fd_{it}$ is the intersection of tax competition and fiscal autonomy, fd_{it} represents fiscal autonomy, and other variables are explained in the same way as in models (1) and (2)

3.2 Definition of Variables

3.2.1 Explained Variables

Carbon emission intensity (CEI). This paper uses the measurement method of Cheng et al. (2013) for reference to calculate the carbon emission intensity of various provinces in China. The specific calculation method is as follows:

$$CEI_{it} = \frac{TEC_{it}}{GDP_{it}}$$

Among them, TEC_{it} represents the total carbon emissions of the i th province in the t th year and the regional GDP of the i th province in the t th year. In fact, it reflects the carbon dioxide emissions per unit GDP, which can reflect the contribution of regional economic development to carbon emissions (Wang et al., 2023), and can also show the development level of a low-carbon economy in the process of economic development.

3.2.2 Core Explanatory Variables

Fiscal expenditure competition (EXPC). Using the ratio of provincial fiscal expenditure to GDP to measure regional fiscal expenditure competition reflects the government's participation in social and economic activities and helps to understand the government's allocation of resources. It is conducive to knowing the relative scale of local government financial expenditure, which is convenient for horizontal and vertical comparison.

Tax competition (TAXC). Based on the calculation method of Qian and Cai (2018), this paper uses the proportion of regional tax revenue to GDP to measure regional tax competition and understand the regional tax burden level.

3.2.3 Control Variables

In order to alleviate the error caused by missing variables, other variables in this paper are all control variables. Based on the research of Wang Feng, Luo Shan, Mao Hui, and Liu Simin, the control variables selected in this paper include (1) investment level, which is measured by the ratio of total investment in fixed assets to GDP in different provinces. China's economic growth is driven by investment, which has a profound impact on economic development. Meanwhile, the scale of investment and different types of enterprises may have an influence on carbon emissions. (2) Environmental regulation is measured by the proportion of industrial pollution control investment in each province to industrial added value. This index shows the degree of industrial pollution control in each province, which directly affects carbon emissions. (3) Infrastructure construction, which is measured by the proportion of the total kilometers of highway mileage and railway mileage in the whole province and the calculated traffic density. This indicator shows the perfection of the local government's infrastructure construction, which is convenient for the government to provide public services, improve the supply level, attract different types of enterprises to invest, and will also have an impact on carbon emission intensity. (4) The population factor is measured by the population density of each province, that is, the ratio of the total population to the area of the whole province. This index represents the spatial distribution pattern of the population, which will influence the emission of pollutants in the region and the environmental governance level of local governments. (5) Technical factors, which are measured by the proportion of internal expenditure of provincial RD funds to GDP. (6) The industrial structure is measured by the proportion of the added value of the secondary industry and the added value of the tertiary industry in each province. This indicator shows the ratio of secondary and tertiary industries in each province, and different leading enterprises will have a greater impact on carbon emissions.

3.2.4 Data Sources and Descriptive Statistics

The panel data of 30 provinces, municipalities, and autonomous regions in China from 2003 to 2019 are selected for analysis (Tibet Autonomous Region, Hong Kong, Macao, and Taiwan regions are excluded due to the availability of data), and the total carbon emission of each province comes from CEADs China carbon accounting database. Other data are from China Statistical Yearbook, China Financial Yearbook, China Environmental Yearbook, and EPS database. STATA software is used for data processing and testing.

Table 1. Descriptive statistics of variables

Variable	Meaning	Sample number	Average/mean value	Standard deviation	Minimum value	Maximum
Strength	Carbon emission intensity	510	0.0237	0.0159	0.0025	0.1242
Finance	Fiscal expenditure compete	510	0.0978	0.0319	0.0481	0.2273
Tax	Tax competition	510	0.0813	0.0433	0.0020	0.2273
Inv	Investment	510	0.6651	0.2495	0.1112	1.4795
Environment	Environmental regulation	510	0.0039	0.0034	0.0002	0.0285
Infra	Infrastructure	510	0.8267	0.5038	0.0353	2.1884
RD	Technical factor	510	0.0142	0.0107	0.0017	0.0631
Industry	Industrial structure	510	1.1313	0.3534	0.1935	2.0228
FD	Financial autonomy	510	0.5098	0.1911	0.1483	0.9509

4. Research Results

4.1 Analysis of Benchmark Results

Table 2 reports the estimation results of models (1) and (2) with and without control variables. The first and second columns test the effects of fiscal expenditure competition and tax competition on carbon emission intensity without control variables. The coefficient of fiscal expenditure competition and tax competition is significantly positive at the level of 1%, which shows that the increase of fiscal expenditure competition and tax competition will lead to the increase of carbon emission intensity of local governments.

The third and fourth columns add control variables. According to Table 2, the coefficients of fiscal expenditure competition and tax competition of local governments in China are significantly positive at the level of 1%, which significantly increases the carbon emission intensity of local governments. Under the condition that other conditions remain unchanged, the intensity of carbon emissions will increase by 0.417 units for every unit of fiscal expenditure competition. Similarly, the coefficient of tax competition is significantly positive at the level of 1%, which means that tax competition also promotes the increase of carbon emission intensity. Specifically, for every additional unit, the local carbon emission intensity will increase by 0.230 units.

The reason why the competition of fiscal expenditure has significantly increased carbon emissions is because of the characteristics of different types of fiscal expenditure competition. Because the central government has implemented a single promotion assessment standard, it examines local officials through economic growth. In order to achieve rapid economic growth and achieve the goal of GDP, local officials will choose production expenditure competition (Yang et al., 2010). Under this category of competition, officials will tend to invest in projects that can promote rapid economic development in the short term, pay attention to the realization of short-term economic goals, and thus choose some high-emission enterprises. It can increase the economic income of this province in a short time, but it is not friendly to environmental development and will increase the intensity of local carbon emissions.

Table 2. Benchmark estimation result

	CO (1)	CO (2)	CO (3)	CO (4)
EXPC	0.466*** (6.10)	——	0.417*** (5.66)	——
TAXC	——	0.238*** (4.13)	——	0.230*** (4.05)
Inv	——	——	-0.035 (-1.29)	-0.02 (-0.72)
Environment	——	——	0.058*** (4.70)	0.065*** (5.21)
Infra	——	——	-0.105** (-2.01)	-0.072 (-1.37)
Population	——	——	-0.795*** (-5.79)	-0.769*** (-5.52)
RD	——	——	0.138*** (3.49)	0.163*** (4.07)
Industry	——	——	-0.126*** (-2.81)	-0.113** (-2.48)
Time effect	YES	YES	YES	YES
Regional effect	YES	YES	YES	YES
Constant term	-2.151*** (-10.43)	-2.738*** (-16.90)	-4.462*** (-8.09)	-4.66*** (-8.35)
R2	0.869	0.864	0.889	0.886
Obs	510	510	510	510

Note: * * *, * *, and * indicate the significance levels of 1%, 5%, and 10%, respectively, and the t value is in brackets.

The reason why tax competition significantly increases carbon emissions is that some enterprises with serious pollution can provide more tax revenue to the local area. Meanwhile, because of the assessment system implemented by the central government, local governments will lower the entry threshold of high-pollution enterprises in order to obtain more fiscal revenue, which makes taxation not play a positive role in environmental protection and resource conservation, which in turn promotes the improvement of local carbon emission intensity.

As can be seen from Table 2, among the control variables, the influence of investment on carbon emissions is not significant, which means that investment in China has not significantly increased carbon emissions. The coefficient of environmental regulation is significantly positive at the level of 1%, which shows that the current level of environmental regulation in China is low, and local governments prefer to choose productive investment in order to promote economic development, which leads to more industrial added value and increased carbon emission intensity. The coefficient of the population factor is also significantly positive at the level of 1%, indicating that the increase in population density in China will also increase the intensity of carbon emissions. In terms of the industrial structure, the industrial structure coefficient of provinces and cities in China is significantly negative at the level of 1%, which means that the increase of industrial structure in provinces, cities, and autonomous regions in China will lead to the decline of carbon emission intensity.

4.2 Regional and Temporal Heterogeneity

China has a vast territory and a large span between the eastern and western regions. At the same time, it is influenced by many factors such as geography and resource distribution, which leads to great differences in economic development among regions. In order to investigate the influence of financial competition in different regions on carbon emissions, this paper divides the variables into the eastern region and the central and western regions. From Table 3 and Table 4, we can see that the fiscal expenditure competition and tax competition in eastern region is not significant, while the central and western regions are significantly positive, so the influence of financial competition in China on carbon emissions is mainly reflected in the central and western regions. Through the results of the regional heterogeneity test, we can see that the fiscal expenditure competition and tax competition in the central and western provinces of China are “competition for the worse”, while in the eastern region with a higher economic development level, the fiscal expenditure competition and tax competition are mainly “competition for the better”, that is, the tax competition in the eastern region can effectively reduce carbon emissions (Wang, Luo et al., 2023). In addition, compared with the central and western regions, the eastern region has more extensive tax sources and less fiscal competition. In the central and western regions, the level of economic development is weak, the tax revenue is less, and the competition between fiscal expenditure and tax revenue is more intense, but the natural resources are richer than those in the eastern region, which makes it easier to attract a large number of heavy industrial enterprises. The level of economic development magnifies the role of this competition in carbon emissions, which makes the economically underdeveloped areas lower the environmental regulations and further lower the entry threshold for high-polluting enterprises for economic development. In addition, high-polluting enterprises are not sensitive to the tax burden, which leads to high-polluting enterprises in the central and western regions with large carbon emissions. In the economically developed eastern region, where the tax source is sufficient, more consideration will be given to improving the supply capacity of public goods, so as to attract liquidity factors such as capital and talent, rather than choosing highly polluting enterprises that have great damage to the environment to enhance economic development.

After 2012, China’s economic development entered a new normal. Considering the different economic development levels and policy priorities of countries at different time nodes, this paper divides the variables from 2012 into before the new normal of economic development and after the new normal of economic development. As can be seen from Table 3 and Table 4, the coefficient of fiscal expenditure competition and tax competition on carbon emissions before the new economic normal is not significant, but after the economic development enters the new normal, the coefficient

of fiscal competition is significant at the level of 1%. China's economic development began to transition from "extensive and quantitative" to "intensive and quality". The economic growth slowed down and turned to focus on high-quality development, and the fiscal revenue became tenser because of the reduction of tax sources. In order to ensure their fiscal revenue as much as possible, various regions increased their fiscal expenditure, reduced environmental regulations, and enhanced financial competition among regions, which led to an increase in carbon emissions.

Table 3. Regression results of competition heterogeneity of fiscal expenditure

	Eastern regions	Central and western regions	Before 2012	After 2012
EXPC	0.127 (1.54)	0.546*** (4.95)	-0.088 (-0.98)	0.531*** (6.15)
Inv	-0.041 (-1.27)	-0.043 (-1.09)	0.119** (2.37)	-0.062** (-2.34)
Environment	-0.001 (-0.11)	0.084*** (4.45)	0.025* (1.88)	0.011 (0.71)
Infra	-0.039 (-0.67)	-0.224*** (-2.86)	-0.064 (-1.53)	0.228 (1.27)
Population	-1.543*** (-12.48)	1.001*** (3.27)	-0.175 (-0.84)	-1.001** (-2.58)
RD	0.378*** (8.47)	0.038 (0.68)	0.187*** (4.64)	0.035 (0.43)
Industry	-0.197*** (-4.33)	-0.055 (-0.77)	0.078 (1.57)	-0.249*** (-2.92)
Time effect	YES	YES	YES	YES
Regional effect	YES	YES	YES	YES
constant term	-6.504*** (-17.53)	2.989** (2.19)	-3.241*** (-3.77)	-6.286*** (-4.27)
R2	0.956	0.884	0.862	0.738
Obs	221	289	270	240

Note: * * *, * *, and * indicate the significance levels of 1%, 5%, and 10%, respectively, and the t value is in brackets.

Table 4. Regression results of tax competition heterogeneity

	Eastern regions	Central and western regions	Before 2012	After 2012
TAXC	0.062 (0.85)	0.254*** (3.48)	0.066 (1.08)	0.405*** (4.94)
Inv	-0.024 (-0.82)	-0.059 (-1.49)	0.111** (2.23)	-0.057** (-2.10)
Environment	-0.001 (-0.08)	0.096*** (4.99)	0.024* (1.84)	0.011 (0.68)
Infra	-0.029 (-0.49)	-0.178** (-2.24)	-0.061 (-1.46)	0.138 (0.76)
Population	-1.511*** (-12.42)	1.175*** (3.79)	-0.243 (-1.17)	-0.748* (-1.86)
RD	0.376*** (8.06)	0.099* (1.73)	0.184*** (4.54)	0.133 (1.65)
Industry	-0.196*** (-4.25)	-0.080 (-1.09)	0.083* (1.66)	-0.290*** (-3.32)
Time effect	YES	YES	YES	YES
Regional effect	YES	YES	YES	YES
Constant term	-6.552*** (-17.55)	3.422 ** (2.42)	-3.106*** (-3.63)	-5.057*** (-3.25)
R2	0.955	0.879	0.862	0.722
Obs	221	289	270	240

Note: * * *, * *, and * indicate the significance levels of 1%, 5%, and 10%, respectively, and the t value is in brackets.

4.3 The Construction of Intersection Terms

In order to investigate the regulatory effect of fiscal autonomy on carbon emissions, this paper further constructs the intersection terms of fiscal expenditure competition and fiscal autonomy; tax competition and fiscal autonomy.

Concerning the intersection items constructed by fiscal autonomy, the results in the third row and the fourth row are all significantly positive, indicating that the improvement of fiscal autonomy will also increase carbon emissions. In areas with high financial autonomy, the impact of financial competition on carbon emissions is more obvious. This may be because financial autonomy will reduce the local government's control over the environment and investment in environmental governance. Although financial autonomy can stimulate the enthusiasm of local governments to a certain extent, this model of official promotion with a single GDP assessment index usually lowers the local environmental level (Liu, Yang et al., 2021). Because local governments have greater autonomy, they will invest more resources in production enterprises with quick results, high energy consumption, and high pollution, which will lead to an increase in financial autonomy and aggravate carbon emissions. Regarding the influence of financial autonomy on carbon emissions through financial competition, it can be shown that financial autonomy is not suitable for excessive decentralization to local governments, which will lead to a significant increase in carbon emissions.

Table 5. Results of intersection items

	CO(1)	CO (2)	CO (3)	CO (4)
EXPC	0.779*** (7.60)	——	0.630*** (6.15)	——
TAXC	——	0.392*** (5.43)	——	0.311*** (4.43)
EXPC*FD	0.177*** (4.47)	——	0.118*** (2.97)	——
TAXC*FD	——	0.115*** (3.46)	——	0.067** (2.03)
Inv	——	——	-0.043 (-1.56)	-0.024 (-0.86)
Environment	——	——	0.058*** (4.73)	0.065*** (5.19)
Infra	——	——	-0.084 (-1.62)	-0.053 (-0.99)
Population	——	——	-0.759*** (-5.56)	-0.729*** (-5.20)
RD	——	——	0.117*** (2.93)	0.156*** (3.93)
Industry	——	——	-0.085* (-1.81)	-0.089* (-1.91)
Time effect	YES	YES	YES	YES
Regional effect	YES	YES	YES	YES
Constant term	-1.665*** (-7.26)	-2.547*** (-15.04)	-4.082*** (-7.26)	-4.408*** (-7.72)
R2	0.875	0.867	0.891	0.887
Obs	510	510	510	510

Note: * * *, * *, and * indicate the significance levels of 1%, 5%, and 10%, respectively, and the t value is in brackets.

4.4 Robustness Test

Potential endogenous problems

The sources of endogenous problems are generally: first, the omission of variables leading to endogenous problems; second, selective deviation; and third, two-way causality. In this paper, the two-way fixed effect model is used for regression, and the endogeneity caused by missing variables can be alleviated to some extent. This paper uses the data from 30 provinces and autonomous regions

from 2003 to 2019, accounting for 88.23% of the 34 provincial-level administrative regions in China. It can be considered that there is less selective bias. Therefore, the possible endogenous problem in this paper lies in two-way causality, that is, while financial competition enhances carbon emissions, the growth of carbon emissions may also affect regional financial competition.

1. Lag effect

As shown in Table 6, In order to reduce this impact as much as possible, this paper adopts the lag effect and instrumental variable method. The lag effect takes into account that the impact of fiscal competition on carbon emissions is affected by many miscellaneous factors, and the results are still significant by using fiscal competition and control variables with a lag period, indicating that the estimated results are stable.

2. Instrumental variable method

In this paper, the instrumental variable method is adopted, and the financial competition data of the lagging period is selected as the instrumental variable based on Xiao (2019). The reason is that on the one hand, the endogenous explanatory variables are significantly related to their lagging variables, and the F statistics are 326.172 and 732.027, respectively, which are significantly greater than 10. The corresponding *p*-value is less than 0.01, indicating that there is no weak instrumental variable, which satisfies the relevant conditions, that is, the previous financial competition will produce current or future financial competition. On the other hand, because the lagging variable has been issued, the value has been fixed from the current point of view, so as to ensure the accuracy of the estimation results. The specific regression results are shown in Table 6. To sum up, there is no significant difference between the regression results of instrumental variables and the benchmark results, which shows that the potential endogeneity has not brought substantial influence on the estimation results, and once again shows that the estimation results are robust.

3. Replacement of the sample

Table 6. Robustness test result

	Lag one period		Instrumental variable		Replacement variable	
EXPC	0.206** (2.38)	——	0.325*** (2.75)	——	0.278*** (4.21)	——
TAXC	——	0.116* (1.92)	——	0.156** (2.49)	——	0.224*** (4.69)
Inv	-0.026 (-0.68)	-0.013 (-0.34)	-0.034 (-1.16)	-0.022 (-0.73)	-0.057** (-2.32)	-0.050** (-2.08)
Environment	0.069*** (5.12)	0.072*** (5.37)	0.061*** (5.14)	0.066*** (5.45)	0.044*** (3.96)	0.046*** (4.18)
Infra	-0.103* (-1.86)	-0.085 (-1.53)	-0.076 (-1.08)	-0.051 (-0.71)	-0.146*** (-3.19)	-0.129*** (-2.83)
Population	-0.738*** (-4.72)	-0.714*** (-4.58)	-0.752*** (-4.55)	-0.731*** (-4.13)	-1.091*** (-8.74)	-1.125*** (-9.02)
RD	0.057 (1.36)	0.067 (1.61)	0.112** (2.55)	0.135*** (3.05)	0.125*** (3.44)	0.147*** (4.08)
Industry	-0.124*** (-2.59)	-0.113** (-2.37)	-0.160*** (-4.04)	-0.154*** (-3.82)	-0.154*** (-3.85)	-0.141*** (-3.55)
Time effect	YES	YES	YES	YES	YES	YES
Regional effect	YES	YES	YES	YES	YES	YES
Constant term	-5.205*** (-8.48)	-5.245*** (-8.53)	-6.167*** (-14.10)	-6.284*** (-15.27)	-5.970*** (-12.59)	-6.094*** (-13.15)
Cragg-Donald Wald F Statistic	——	——	326.172	732.027	——	——
R2	0.872	0.871	0.963	0.961	0.929	0.929
Obs	480	480	480	480	442	442

Note: * * *, * *, and * indicate the significance levels of 1%, 5%, and 10%, respectively, and the t value is in brackets.

In order to eliminate the bias of the estimation results caused by the differences in local economic development levels and enhance the universality of the financial competition, firstly, there are differences between regions due to geographical location and resource differences, which will also affect economic development. Meanwhile, a few ethnic autonomous regions have strong financial autonomy, and the corresponding fiscal policies are different from those of ordinary provinces, which may lead to errors in the results. Second, municipalities directly under the central government such as Beijing, Tianjin, Shanghai, and Chongqing have special financial systems, which makes them more special than other provinces in terms of finance, which leads to the special influence on their financial competition on carbon emissions. In view of this, in order to ensure the accuracy of the estimation results, this paper excluded four municipalities directly under the central government and four ethnic minority areas with particularity from the sample, accounting for 26.7% of the total sample, and the regression results of the remaining samples are as follows. It can be seen that the positive impact of fiscal expenditure competition and tax competition on carbon emissions is still significant at the level of 1%. The estimation results in this paper show good robustness.

5. Conclusion and Suggestions

5.1 Research Conclusion

Based on the panel data of 30 provinces, municipalities, and autonomous regions in China (except Hong Kong, Macao and Taiwan, Tibet) from 2003 to 2019, this paper constructs a two-way fixed effect model, systematically investigates the influence of fiscal expenditure competition and tax competition on carbon emission intensity, and considers the regulatory effect of fiscal autonomy on carbon emission, adding interactive terms. The robustness of the model is tested by using the lag effect, instrumental variable method, and replacement variable. The main conclusions are as follows:

1. In terms of the arrangement, fiscal expenditure competition and tax competition have positive effects on carbon emission intensity, and the promotion of fiscal competition has significantly increased carbon emissions. Infrastructure construction, population density, and the ratio of secondary industry to the tertiary industry are conducive to alleviating the carbon emission intensity in this region, while environmental regulation, technology research, and development expenditure will push up the local carbon emission intensity. However, the investment structure has no great influence on the carbon emission intensity.

2. The regional and temporal heterogeneity shows that there are significant differences in the influence of fiscal expenditure competition and tax competition on carbon emission intensity between the eastern and central and western regions. The eastern region presents “competition for the better”, with a wide range of tax sources. Compared with the central and western regions, the financial competition is milder, and it has no significant impact on the carbon emission intensity. However, the central and western regions present “competition for the better”, the economic development level of the eastern and western regions is weak, the tax sources are tight, the tax revenue is less, and the financial competition is more intense, which has a significant impact on the carbon emission intensity. The temporal heterogeneity is reflected in China’s economic development entering a new normal. After 2012, China’s economic growth rate gradually slowed down and fiscal revenue was tight. Local governments increased fiscal competition among governments, thus increasing carbon emissions.

3. The intersection terms between fiscal expenditure competition, tax competition, and the construction of fiscal autonomy, the coefficient of intersection term is significantly positive at the level of 1%, which has promoted the intensity of carbon emissions. It shows that local officials consider the assessment, and with the continuous improvement of financial autonomy, they make local governments invest more resources in enterprises with high energy consumption and high pollution, which cannot effectively restrict the increase of carbon emissions.

5.2 Policy Suggestions

1. Different tax policies have different impacts on carbon emissions. When formulating, the central government should do a good job in top-level design, clarify the ownership of various fiscal revenues at the central and local levels, reasonably improve fiscal decentralization, adjust the matching of administrative power and financial power, and accelerate its unification. Besides, it is also necessary to reasonably broaden local sources of fiscal and taxation, reduce local government's dependence on the land, and reduce competition among governments. Therefore, we can gradually establish a fiscal and taxation system to support green and low-carbon development.

2. We also should optimize the fiscal decentralization structure and strengthen institutional supervision. Because of the information asymmetry between the central government and local governments, it is necessary to optimize the fiscal decentralization structure in order to provide good public goods. As the high carbon emission intensity is an important aspect of local environmental problems, it is difficult for fiscal expenditure to tilt to the field of environmental protection due to the lack of incentives and constraints from the central government to local governments. In order to change this situation, we must first change the assessment mechanism of "GDP only" of local governments, strengthen the supervision of government fiscal expenditure and carbon emission control measures, and strive to promote local governments to upgrade environmental protection to the same important position as economic construction. At the same time, we can also strengthen the assessment and audit system of local government officials after leaving office, which can effectively avoid blindly pursuing short-term economic benefits and economic indicators and ignoring local long-term sustainable development. Only when local governments establish a correct concept of fiscal expenditure and truly tilt the fiscal expenditure structure to the field of environmental protection can they effectively solve local development problems and reduce the intensity of carbon emissions.

3. We should promote coordinated regional development and narrow regional development differences. At present, there is an imbalance in the development of the regional economy and technology in China, which makes the impact of fiscal decentralization on carbon emission intensity vary from region to region. The increase of carbon emissions caused by polluting enterprises in underdeveloped areas such as the central and western regions is difficult to offset by the savings of carbon emissions in economically developed areas, which makes it difficult to control the total carbon emissions. Therefore, when formulating the system design, it is necessary to consider the existing stage differences in different regions, design a more reasonable and effective fiscal decentralization system, better guide and standardize the public expenditure of local governments, improve the activity of regional innovation and development according to local conditions, promote coordinated development among regions, avoid "bottom-to-bottom competition" between regions, and narrow regional differences.

In terms of different time nodes, China's background is different. It is necessary to formulate fiscal and tax policies that are in line with the province and city in combination with the central government's package of economic policies and invest more financial resources in energy conservation and environmental protection to lay the foundation for carbon neutrality.

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