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Analysis of the Impact of Carbon Emissions Trading on the Total Factor Froductivity of Enterprises

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Abstract: This paper firstly analyzes the impact of carbon emissions trading intensity on the total factor productivity of enterprises, and investigates the impact of government subsidies on both. The results show that: Firstly, there is an inverted U-shaped relationship between the intensity of carbon emissions trading and the total factor productivity of enterprises.Secondly, government subsidies can significantly contribute to the total factor productivity of enterprises. Thirdly, government subsidies have a moderating effect on the relationship between the intensity of carbon emissions trading and the total factor productivity of enterprises, and there is a threshold value. When the value of government subsidies is in the range of Sub≤15.19, carbon emissions trading intensity has a significant positive contribution to the total factor productivity of enterprises≥19.844, carbon emissions trading intensity has a significant inhibitory effect on the total factor productivity of enterprises.

Keywords: Carbon emissions trading; Government subsidies; Total factor productivity of firms; Instrumental variables approach

Introduction

In 2021, China's economic growth has rebounded dramatically from 2020, but the huge recovery has been accompanied by rapid growth in carbon emissions. Since the inclusion of 'peak carbon' and 'carbon neutrality' in the government's work report in 2021, China is facing the challenge of achieving carbon neutrality in the shortest time in its history, and the two sessions of the National People's Congress in 2022 have reiterated the need for an orderly push to achieve peak carbon. How to achieve the lowest carbon emissions with the least impact on economic development is now an urgent issue. To this end, on the premise of learning from the successful emission reduction in the EU carbon trading market, the carbon trading policy brings new ideas to solve the carbon emission problem in China.

1. Theoretical model and assumptions

1.1 Theories and assumptions related to the impact of carbon trading on the total factor productivity of firms

1.1.1 Carbon emissions trading and total factor productivity of firms

According to Pigou's externality theory[1] , the negative externality of pollution emissions by firms requires the government to take a series of measures to regulate the dysfunctional environmental market, such as pollution taxes and fines. The[2] relationship between flexible environmental regulations and firm competitiveness is not irreconcilable. Building on Porter's hypothesis, Hicks' (1963) induced innovation hypothesis argues[3] that when the cost of a factor of production rises, firms will seek alternative ways to reduce this cost of production in order to save on what has now become an expensive factor of production. He argues that the development of a carbon tax or carbon trading policy will inevitably lead to an increase in the cost of production factors for firms. The relationship between environmental regulation and firms' total factor productivity has been studied by a large number of scholars.[4-6] The relationship between environmental regulation and firms' total factor productivity can be classified as facilitative, inhibitory, non-linear and insignificant. When focusing environmental regulation of carbon emissions trading, most domestic scholars have explored the effectiveness of carbon emissions trading policies on firms' total factor productivity from a policy perspective (Song Deyong et al. 2021; Xiong Guangqin et al. 2020; Zhang Haiqin et al. 2019)[7-9] . However, as the intensity of carbon trading increases, i.e., the intensity of environmental regulation increases, whether carbon trading policies can also promote the improvement of firms'

total factor productivity, relevant scholars conduct further research on the non-linear relationship between the two (He Yumei and Luo Qiao, 2020)[10] . Whether firms are proactive in reducing emissions depends on the costs and benefits of a carbon trading system. [11] The carbon trading mechanism controls carbon dioxide emissions by giving carbon quotas to emission reduction enterprises in terms of the total amount of quotas , thus achieving the effect of emission reduction. In the early stages, the "resource compensation" effect of the emissions trading mechanism should be greater than the "cost effect" of emission reduction, so that the emissions trading mechanism can stimulate enterprises to improve their total factor productivity. In the later period, the "resource compensation" effect of the emissions trading mechanism is too small, resulting in a lack of incentive for enterprises to reduce emissions and inhibiting their total factor productivity.

H1: There is an inverted "U" shaped relationship between the intensity of carbon trading and the total factor productivity of firms.

1.1.2 Government subsidies and total factor productivity of firms

From the input side and output side of enterprise innovation, government subsidies can help enterprises reduce the risks associated with innovation activities on the input side, lower their R&D costs, encourage them to invest in technological innovation and bring about an increase in total factor productivity. At the same time, it takes a lot of time to transform an enterprise's innovation results, for example, patents often take months or even years to be granted, which brings huge time costs to enterprises. Government subsidies can help enterprises to apply for patents for relevant research results and facilitate the application process for the relevant enterprise's innovation results, which will greatly reduce the innovation results time, prompting enterprises to carry out more technological innovation in the same amount of time originally. This not only increases the number of innovations, but also increases the incentive for firms to innovate.[12-14] Government subsidies can therefore eliminate the effects of externalities and boost the productivity of firms. The following hypothesis is therefore put forward in this paper.

H2: Government subsidies have a catalytic effect on firms' total factor productivity.

1.2 Model setting

To test hypothesis H1, regression model 1 (Equation 1.1) and model 2 (Equation 1.2) are developed.

$$TFP_{it} = \delta_0 + \delta_1 Tra_{it} + \delta_2 Clr_{it} + \delta_3 Cash_{it} + \delta_4 Roa_{it} + \delta_5 Age_{it} + \delta_6 State_{it} + \varepsilon_{it} \quad \text{Equation 1.1}$$

$$TFP_{it} = \alpha_0 + \alpha_1 Tra_{it} + \alpha_2 Tra_{it}^{\ 2} + \alpha_3 Clr_{it} + \alpha_4 Cash_{it} + \alpha_5 Roa_{it} + \alpha_6 Age_{it} + \alpha_7 State_{it} + \varepsilon_{it} \quad \text{Equation 1.2}$$

Where i represents the firm, t represents the year, TFP represents total factor productivity of the firm, δ_1 is the coefficient for carbon trading, and δ_2 - δ_6 is the coefficients for the control variables fixed asset size, cash ratio, profitability, firm maturity and firm nature, in that order. δ_0 denotes the intercept term and ε_{it} is the random error term. In Model 2, Tra² is the squared term for carbon trading and the remaining variables are consistent with Model 1.

2. Empirical analysis

2.1 Sample selection and data sources

In 2013, China started to implement the carbon trading mechanism in six carbon trading pilot regions, namely Beijing, Tianjin, Shanghai, Shenzhen, Guangdong and Hubei, and achieved positive emission reduction results. In order to more accurately reflect the impact of China's current carbon emissions trading market on the productivity of micro enterprises, this paper selects all A-share listed companies in the six carbon trading pilot regions from 2014 to 2020 as the research sample, mainly involving a number of high-emission industries such as power generation, building materials and domestic civil aviation, and excludes ST,* ST, incomplete financial data and enterprises with abnormal financial conditions. We also excluded companies with incomplete financial data and unusual financial conditions. A total of 1,645 observations were obtained through the above screening. The data were obtained from the China Statistical Yearbook, the Guotaian database, annual reports of enterprises and the China Carbon Trading website, and then further Winsorize the main continuous variables at the 1% and 99% quartiles using Stata 16.0. In addition the literature on the interaction between environmental regulation and total factor productivity of firms is usually treated with a one-period lag, the year-end amount of carbon trading taken in this paper is a response to the current period of market-based environmental regulation and is not considered lagged.

2.2 Descriptive statistics and correlation analysis

The descriptive statistics of the variables selected in this paper are shown in Table 2.1. Considering that enterprises may have a government subsidy amount of size 0 in a particular year, the paper adds 1 to the government subsidy amount and then takes the logarithm. From Table 2.1, some basic information of the data can be seen. The mean and standard deviation of total factor productivity (TFP) of enterprises are the largest, with the figures being 8.712 and 1.175 respectively, which indicates that the overall distribution of the sample of total factor productivity of enterprises is relatively scattered, and there is a large gap between the total factor productivity of different enterprises. The median size of the carbon trading intensity of each region is 0.282, which shows that the carbon trading intensity of most regions is smaller than the average, indicating that the carbon trading intensity is not yet very large. The difference between the maximum and minimum values of the logarithm of government subsidies (Sub) is large, at 22.13 and 12.14 respectively, and the standard deviation of government subsidies is relatively large, at 1.869, indicating a significant difference in the amount of government subsidies for individual companies. The magnitude of the mean value of 17.01 and the median value of 16.875 indicate that the majority of government subsidies do not reach the mean value. Of the remaining selected control variables: the mean value of the nature of the enterprise (State) is 0.4, indicating that there are fewer state-owned enterprises than non-state-owned enterprises.

Table 2 .1 Descriptive statistics of the variables of interest

Variables	LLC		IPS	
	Statistical quantities	p-value	Statistical quantities	p-value
TFP	-26.2857	0	-7.336	0
Tra	-19.859	0	-4.2683	0
Sub	-31.1352	0	-11.15	0
Roa	-47.9526	0	-20.6975	0
Clr	-61.4122	0	-25.1717	0
Cash	-41.689	0	-14.7409	0
Lev	-42.3228	0	-8.919	0

2.3 Regression analysis

2.3.1 Carbon trading intensity and total factor productivity of firms

The regressions were conducted using the benchmark model and the results are shown in Table 2.3. shows a significant positive correlation between the coefficient δ1 of carbon emissions trading intensity and total factor productivity of firms at the 10% level, indicating that carbon emissions trading intensity exhibits a contributing effect on total factor productivity of firms during the sample period.

2.3.2 The regulatory role of government subsidies

From the regression results, the coefficients of government subsidies and carbon trading are significantly positively related to the total factor productivity of firms at the 1% and 5% levels respectively, but the cross coefficients are significantly negative at the 5% level.This suggests that when government subsidies and carbon trading act together as the total factor of a firm's However, the marginal effect of government subsidies (partial derivative) shows that the larger the amount of government subsidies, the smaller the marginal effect of carbon trading on the total factor productivity of the firm.

Table 2.3 Regression results of carbon trading intensity and total factor productivity of firms

Variables	Model 1 TFP Coefficient	Model 2 TFP Coefficient
Tra	0.144*(0.0733)	0.366*(0.139)
Tra^2		-0.676**(0.205)

State	0.288*** (0.0506)	0.269***(0.051)
Age	-0.0003 (0.004)	-0.0113**(0.00503)
Roa	1.007*** (0.33)	4.605*** (0.477)
Clr	0.349***(0.0163)	0.346*** (0.0159)
Cash	1.196***(0.262)	1.201*** (0.264)
C	0.880**(0.366)	0.872**(0.363)
R2	0.443	0.337
Year	Control	Control

3. Conclusion

According to the empirical results: (1) there is an inverted U-shaped relationship between the intensity of carbon emissions trading and the total factor productivity of enterprises. (2) Government subsidies can significantly contribute to the total factor productivity of enterprises. (3) Government subsidies have a moderating effect on the relationship between carbon emissions trading intensity and total factor productivity of enterprises, and there is a threshold value. (4) There are significant differences between the productivity of different firms in terms of the intensity of carbon trading. Among them, it can significantly contribute to the total factor productivity of non-state enterprises, while the effect on the total factor productivity of state-owned enterprises is insignificant.

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