Enabling Mechanism of Carbon Emission Allowance and Total Factor Productivity Improvement

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Abstract. Taking the listed companies in the carbon trading pilot zone from 2011 to 2020 as the research sample, this paper explore the impact of CET system on corporate total factor productivity. The results show that the ETS effectively increases the total factor productivity of firms. Government efficiency has a positive moderating effect on the impact of CET system on corporate TFP; The interaction between the two is stronger when the government is more efficient.

Keywords: CET system, TFP, Carbon trading market activityFirst.

1 Introduction

The development of the EU emissions trading system has gone through changes in the international situation. After the outbreak of the "Russia-Ukraine conflict" in 2022, European and American sanctions on Russia and the rupture of the "Nord Stream pipeline" triggered a global energy crisis. At this point, the external international situation has fallen into a situation of "frequent local regional conflicts and crises in the energy field". In such an international context, China is also facing external pressure and challenges. Will the emission reduction policies introduced by the chaotic international environment and the domestic environment of economic transformation have a negative impact on Chinese emission control enterprises? As an emission reduction tool to reconcile economic growth and environmental pressure, the implementation effect of carbon trading policy is related to the realization of China's emission reduction target and the choice of economic model. How to design the relevant policies of carbon trading, not only can help enterprises ease the pressure of emission reduction, smoothly through the policy adaptation period, but also promote enterprises to achieve green transformation and upgrading, improve production efficiency, and ensure the smooth implementation of the "dual carbon" strategy? At present, there is still insufficient research on how carbon emission reduction policies affect the real economy[1]. Although some researchers have analyzed the linkage relationship between emission reduction policies and stock prices of related enterprises, and the guiding role of price fluctuations of carbon spot and carbon derivative products on stock prices of controlled emission enterprises, corporate stock prices are only one aspect of corporate performance. It can not fully reflect the overall operating conditions of enterprises.

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2 Research Hypothesis

2.1 Direct Impact

From a human capital perspective, the primary function of the CET system is to optimize the human capital structure within enterprises and enhance labor productivity. The core objective of this system is to promote carbon reduction, an effectiveness that has been corroborated by prior research. Environmental improvements tend to attract migrants with higher educational qualifications and professional skills, improves return on investment for enterprises. Companies listed under the emissions trading scheme often exhibit high emissions, indicating suboptimal utilization of internal production resources[2]. Consequently, at the production stage, carbon trading compels companies to reassess inefficient products, redesign them, or alter their product mix to reduce costs and increase productivity while optimizing daily operating capital. From an asset capital standpoint, the carbon emission trading system encourages enterprises to upgrade their assets and strengthen asset management. Under carbon emission constraints, enterprises may scale back production or adopt low-emission methods. Based on these insights, this paper proposes the following hypotheses:

H1: Carbon emission trading system can improve the total factor productivity of enterprises.

2.2 Regulatory Mechanism Analysis

The regulatory impact of government efficiency on carbon markets. Government efficiency serves. In practice, the government stabilizes carbon prices and ensures quota compliance among emission control entities through measures such as setting initial quotas, repurchasing carbon allowances, and enhancing market supervision. These actions facilitate smooth carbon market operations and promote emissions reductions[3]. The effectiveness of these regulatory measures is contingent upon government efficiency. A more efficient government enhances its capacity to regulate the carbon market, significantly reducing transaction costs for emission control enterprises and increasing their willingness to participate in market trading. At the same time, the government can improve relevant laws and regulations to enhance the supervision and control of emission control enterprises[4], and form a synergistic mechanism with carbon trading by formulating relevant laws and regulations to enhance the implementation effect of carbon trading. In this regard, governments with higher administrative efficiency will make more targeted regulations on carbon emission trading and make enterprises enhance the disclosure of carbon emissions-related information, which is conducive to alleviating the information asymmetry between the market and enterprises, improving the efficiency of capital use of enterprises and significantly improving the efficiency of capital allocation of enterprises[5]. Therefore, this paper recommends:

H2: The higher the government efficiency is, the stronger the effect of CET system on corporate TFP is.

3 Research Design

3.1 Sample Selection and Data Source

This paper selects the data of A-share listed companies in Shanghai and Shenzhen stock exchanges in 8 provinces and cities in China from 2011 to 2020 as the research samples.

3.2 Model Setup and Variable Description

In this paper, we employ the SFA model to estimate TFP, which is comprised of human capital, financial capital, and asset capital. Input and output indicators need to be determined using the above model, and relevant indicators are constructed in this paper. The output indicator is measured by total operating income, denoted as Y. The input index is divided into three parts: human capital input, working capital input and asset capital input, among which human capital input is equal to the number of employees of the company and is denoted as L; Financial capital input equals total operating cost + selling expenses + general and administrative expenses - employee compensation payable - cash paid to and for employees - depreciation of fixed assets, depletion of oil and gas properties, depreciation of productive biological assets + cash paid for investments + other cash paid in connection with investing activities, denoted as M; Asset capital input is equal to the cash paid for the purchase and construction of fixed assets, intangible assets and other long-term assets, which is recorded as A. After determining the above indicators, this paper uses the following model to determine the capital allocation efficiency[6]. The baseline model is formulated as follows:

$$\ln Y_{it} = \beta_0 + \sum_n \beta_n \ln X_{nit} + \beta_t t + \frac{1}{2}\sum_n \sum_k \beta_{nk} \ln X_{nit} \ln X_{kit} + \frac{1}{2}\beta_u t^2 + \sum_n \beta_n \ln X_{nit} t + v_{it} - u_i \tag{1}$$

To verify H1, the following differential model is used in this paper:

$$ECA_{i,t} = \beta_0 + \beta_1 Interact_{i,t} + \beta_2 Controls_{i,t} + Year + Firm + \varepsilon_{i,t} \tag{2}$$

Where, i and t represent the i and t sample years respectively, ECA represents the total factor productivity of the enterprise.

In order to verify H2, the adjustment effect model proposed was firstly referred to for the following Settings:

$$ECA_{i,t} = \beta_3 + \beta_4 Interact_{i,t} + \beta_5 Interact_{i,t} \times Moderator_{i,t} + \beta_6 Moderator_{i,t} + \beta_7 Controls_{i,t} + Year + Firm + \varepsilon_{i,t} \tag{3}$$

Where $Moderator_{i,t}$ is the regulating variable. Among them, the government efficiency（GE） is measured by DEA model. The input indicator utilized in this study is the general budget fiscal expenditure. These indicators collectively reflect a multi-dimensional assessment of government performance across various sectors including education, transportation, healthcare.

4 Empirical Results and Analysis

4.1 Benchmark Regression Analysis

Table 1 reports the results of the main regression in this paper. According to the corresponding regression results(1) - (2), the coefficients of $Interact_{i,t}$, which represent the virtual variables are significant. Therefore, H1 is validated.

Table 1. Benchmark Regression Analysis

Variable	（1） ECAi,t	（2） ECAi,t	（3） ECAi,t	（3） ECAi,t
Interacti,t	0.0097*	0.0121**	-0.0093	-0.0209
	(1.88)	(2.19)	(-1.11)	(-1.10)
GEi,t				0.0022
				(0.10)
GEi,t×Interacti,t				0.0607*
				(1.78)
Control variablei,t	YES	YES	YES	YES
Firm	NO	YES	YES	YES
Year	NO	NO	YES	YES
Observations	5,601	5,601	5,601	5,601
R2	0.231	0.231	0.262	0.267

4.2 Mechanism Analysis

Columns (3) and (4) report the regulatory, respectively. From column (1), the coefficient of interaction terms is 0.0023 and statistically significant at 1%. From column (2), the coefficient of the interaction terms $GE_{i,t}$×$Interact_{i,t}$ is 0.0607 and statistically significant at 10%. H2a and H2b are verified. It shows that the government plays an important role in promoting the smooth operation of carbon trading, and its own work efficiency is closely related to the economic effect of carbon market. By strengthening law enforcement, speeding up administrative examination and approval, and implementing environmental responsibility assessment, the government can ensure the compliance rate of emission control enterprises and reduce the transaction cost of enterprises[7]. The above empirical results show that carbon trading market activity and government efficiency play a positive role in regulating the relationship between carbon emission trading system and corporate capital allocation efficiency, that is, H2a and H2b are verified.

5 Research Conclusions and Policy Suggestion

By applying DID model, this study explores the effect of the carbon emission trading scheme on enterprises' overall productivity. The findings indicate that the introduction of this scheme notably boosts overall productivity. Furthermore, it is found that government efficiency serves as a positive moderator in this relationship.

Based on these conclusions, we proposed: As a pilot initiative aimed at establishing a national carbon emission trading market, the pilot should fully capitalize on its exemplary role by developing comprehensive mechanisms for quota allocation, market trading, supervision, and management. Attention should be given to balancing efficiency and fairness, providing valuable practical insights. Government departments ensure accurate monitoring of emission data from key sectors to prevent underreporting of carbon emissions, thereby ensuring efficient initial allocation. In terms of market trading, the principle of government guidance with market leadership should be upheld, respecting the free trading of emission rights while closely monitoring and strictly penalizing intentional price gouging. As the pilot policy to open the national carbon emission trading market, the pilot carbon emission trading should give full play to its demonstration role, form a complete mechanism design in quota allocation, market trading and supervision and management, pay attention to the principle of giving priority to efficiency and giving consideration to fairness, and provide good practical enlightenment for the full implementation of carbon emission trading.

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