

A Study of the Impact of Free Trade Zones on The Efficiency of Low-carbon Production

Xinrui Lian^{1, a}

¹University of International Relations, Beijing, 100091 China

^a2810466524@qq.com

Abstract

The Pilot Free Trade Zone is a 'testing ground' for high-level opening up, and in the context of the 'dual-carbon' goal, achieving carbon emission reduction and improving low-carbon productivity are important measures for China to make new breakthroughs in the high-quality development of social economy. Based on the panel data of A-share listed companies in Shanghai and Shenzhen from 2009 to 2020, this paper examines the impact of FTZ construction on low-carbon productivity using the double-difference method. It is found that FTZ construction can positively promote the low-carbon productivity level of enterprises, and this result holds under multiple robustness tests. Compared with state-owned enterprises, the low-carbon productivity of non-state-owned enterprises is more significantly improved by the impact of FTZ policies. The FTZ policy promotes enterprises to utilise resources more efficiently, improve operational efficiency, and achieve technological efficiency improvement, which in turn improves low-carbon productivity. This study helps to enrich the path of enterprise productivity improvement, promote enterprises to realise green production, and provide a new implementation path for the government's FTZ policy.

Keywords

FTA policies, low-carbon productivity, green development, environmental impacts.

1. Introduction

In the twenty-first century, when globalisation is accelerating, the formulation and implementation of rules for international trade, as an important engine of economic growth, is of particular importance. Trade agreements, as the basic framework for historically adjusting trade relations between countries and facilitating the flow of goods and services, have been widely used globally since the late nineteenth century. From the early bilateral trade agreements to the rise of multilateral trade agreements, these agreements have not only lowered tariff barriers, but also promoted the standardisation and legalisation of international trade. However, with the in-depth development of regional economic integration, free trade area (FTA), as a higher-level form of trade cooperation, has gradually become the new favourite of countries to promote trade liberalisation and deepen economic cooperation. Against the background of the new period in which China has determined a new pattern of opening up to the outside world on all fronts, the Pilot Free Trade Zone (FTZ) has taken system innovation as its core, accelerated the facilitation of the free flow of commodities, services, talents, capital, and information, and has risen from the opening of elements to the opening of international trade and investment rules. [1] The impact of FTZ policies on enterprises is not only limited to economic benefits, but also includes the impact on the environment. With the increasingly severe global climate change problem, reducing greenhouse gas emissions has become an important task for governments. Carbon productivity, as a measure of economic output

generated per unit of carbon emissions, reflects the relationship between economic growth and carbon emissions.

Against the backdrop of today's increasingly severe global climate change and energy security issues, green development, low-carbon development and low-carbon productivity have become important issues in promoting sustainable economic and social development. Green development emphasises the harmonious coexistence of the economy, society and the environment, and aims to achieve high-quality economic development through a resource-saving and environmentally friendly approach. It requires that in the process of economic development, not only economic benefits should be pursued, but also ecological benefits, so as to achieve a win-win situation for both the economy and the environment. Low-carbon development, on the other hand, is a sustainable development model characterised by low energy consumption, low pollution and low emissions, which requires that greenhouse gas emissions be minimised while meeting the needs of economic and social development in order to meet the challenges posed by global climate change. Low-carbon development is not only about environmental protection, but also an important way to promote the optimisation of energy structure and the transformation and upgrading of industrial structure. Low-carbon productivity, as an important indicator of the relationship between economic development and carbon emissions, reflects the economic benefits generated per unit of carbon emissions. Improving low-carbon production efficiency means that while maintaining economic growth, resources can be used more efficiently and carbon emissions can be reduced, which is the key to achieving green and low-carbon development. An in-depth study of the intrinsic links between green development, low-carbon development and low-carbon productivity is of great significance in promoting China's comprehensive green and low-carbon economic and social transformation and achieving the goal of sustainable development.

In exploring the relationship between FTZs and low-carbon production, it is not difficult to find that FTZs, as new heights of the open economy, not only carry the important mission of promoting trade liberalisation and facilitation, but also play a key role in promoting green and low-carbon development and upgrading low-carbon production efficiency. There is a close and interactive relationship between FTZs and low-carbon production. FTZs, with their unique policy advantages, institutional innovation capacity and open market environment, provide a broad space and platform for the research and development, application and promotion of low-carbon technologies. Through the introduction of international advanced low-carbon technologies and management experience, the FTZ can promote the optimisation and upgrading of the industrial structure, and facilitate the transformation of traditional industries into low-carbon and green ones. The FTZ can also enhance the low-carbon production efficiency of the whole region by establishing a green and low-carbon trade and investment system and guiding the flow of capital into low-carbon and environmental protection areas. At the same time, low-carbon production also has a positive impact on the FTZ by enhancing its international competitiveness, promoting sustainable development and expanding the space for international co-operation, enhancing the brand image and global influence of the FTZ. This mutually reinforcing relationship forms a virtuous circle, jointly promoting the synergistic development of FTZs and low-carbon production, and contributing to global green and low-carbon development. Therefore, an in-depth study of the impact of FTZs on low-carbon production is of great significance in promoting the high-quality development of FTZs and realising green and low-carbon transformation. Scholars at home and abroad have assessed the economic and social benefits of the establishment of FTZs from different perspectives, and have achieved abundant research results. The existing studies mainly focus on the analysis of the economic effects of FTZs, paying attention to the impact of FTZ policies on economic growth, trade flows or industrial structure, while there are fewer studies on low-carbon production. The research on green development mainly focuses on the macro level of FTZ on the green

development of cities or regions to achieve high-quality development of the economy, and the lack of research on the FTZ on the low-carbon production of micro-enterprises, based on which, this paper takes the panel data of 17277 enterprises listed in A-share companies in Shanghai and Shenzhen from 2009 to 2020 as a sample, and empirically examines the impacts of the FTZ on the low carbon production of enterprises in the context of the construction of the 'dual carbon'. In this paper, we empirically examine the impact of corporate low-carbon productivity (CTFP) on the construction of free trade zones (FTZs) under the background of 'dual-carbon' construction, and the results of the study can provide empirical references for the high-quality channels of enterprises and the government's FTZ policies. It is found that FTZ construction can positively promote the low carbon productivity level of enterprises, and this result holds under multiple robustness tests. Compared with state-owned enterprises, the low-carbon productivity of non-state-owned enterprises is more significantly improved by the impact of FTZ policies. The FTZ policy promotes firms to utilise resources more efficiently, improve operational efficiency, and achieve technological efficiency, which in turn increases low-carbon production efficiency.

Compared with previous literature, the possible marginal contributions of this paper include:

- ① In terms of research perspective, this paper takes the lead in looking at the impact of FTZ policies on green economic development and social benefits from the perspective of microenterprises, systematically evaluates the comprehensive impact of FTZ policies on low-carbon production efficiency, adopts the double-difference-in-differences (DID) method to quantify the impact of FTZ policies on the low-carbon production efficiency of enterprises, and assesses the impacts before and after the implementation of FTZ policies enterprise low-carbon production efficiency changes and provide empirical evidence to fill the gap in the existing literature on the relationship between policy and low-carbon production efficiency research;
- ② for the content of the study, different types of enterprises (e.g., different sizes, different nature of the enterprise) in the face of the FTZ policy, the changes in its low-carbon production efficiency may be different. A sub-sample regression is used to examine the differences in the impact of FTZ policies on the low-carbon productivity of different types of enterprises. These heterogeneous effects are explored in depth to provide more detailed policy recommendations;
- ③ In terms of dynamic changes, this paper analyses the long-term dynamic effects of the FTZ policy on the low-carbon production efficiency of enterprises, reveals the persistence and change trends of the policy effects, and tests the robustness of the policy.

2. Literature Review and Research Hypothesis

2.1. Relevant research on FTZ policies

At present, China's research on the impact of FTZ policies on enterprises mainly focuses on the level of economic effects. In the economic effect, the FTZ plays an effective role at both the macro and micro levels. At the micro level, the establishment of FTZs can promote the new quality productivity level of enterprises in FTZs by promoting capital agglomeration, improving market competitiveness and optimising the business environment[2]. Ding Yaochuan studied that the FTZ has a significant positive effect on the ESG rating performance of enterprises in the zone [3]. Residence in the FTZ can significantly improve the over-investment behaviour of enterprises and enhance the effectiveness and importance of enterprise investment efficiency [4]. Influenced by policy dividends, the establishment of free trade significantly improves the performance of enterprises in the zone by reducing transaction costs such as financing constraints and period costs[5]. In macro, the FTZ, as a national institutional highland, significantly reduces the regional development gap and promotes coordinated regional development [6]. The FTZ promotes the upgrading of regional industrial structure by exerting

the regulatory effects of innovation-driven effect, resource allocation effect and other pathways [7]. Ding Renzhong and Li Ximing [8] pointed out that FTZ policies can promote urban economic growth through 2 paths: expanding openness and innovation overflow, and have strong spatial spillover.

In international trade, the economic benefits of FTAs are significant. Ding Mengshi's study points out that the construction of the China-Japan-Korea FTA contributes to the mutual benefit of industries in the region, and the expansion of the scale of import and export of trade in goods as well as the scale of import of trade in services [9]. The FTA between China and Bangladesh will promote the bilateral economic development by dividing the bilateral industries and producing products with comparative advantages and importing products with comparative disadvantages [10]. After the establishment of the FTA, the trade creation effect of China's import and export trade in digital product manufacturing with FTA partner countries has grown rapidly and is much larger than the trade diversion effect [11].

At the level of environmental effects, foreign scholars on the regional environmental benefits of the FTA has produced large differences, some scholars' research results show that the FTA in promoting regional economic development at the same time brought more serious environmental problems, and thus white by trade may lead to increased environmental pollution in the world [12][13], some scholars have pointed out that the establishment of FTA may increase the environmental burden, the establishment of the North American FTA to promote Mexico's economic growth at the same time exacerbated the local environmental pollution [14]. Another part of the scholars believe that the white trade is conducive to environmental protection, to achieve regional green development. Domestic scholars basically hold a positive attitude towards the environmental benefits of China's FTZ, some scholars found that the FTZ promotes the green innovation of enterprises by alleviating the financing constraints of enterprises and improving the participation of the public in environmental protection [15], and significantly improves the efficiency of green innovation in the city through the scale effect and the structural effect [16]; the construction of the Pilot Free Trade Zone also promotes green innovation from the aspects of research and development level, environmental protection, industrial structure and other aspects have improved the green total factor productivity of Chinese provinces as a whole [17]. Wang Sanxing et al. [18] verified that the 'pollution refuge' hypothesis proposed by traditional free trade theory is not applicable to China's Pilot Free Trade Zones. Jia Caiyan et al. [19] point out that FTZs can curb environmental pollution through three channels: optimising regional industrial structure, improving regional green innovation capacity and promoting regional economic agglomeration, and can even have positive spillover effects on neighbouring cities [20].

2.2. Related research on low carbon productivity

Low carbon productivity is affected by a variety of factors, including the level of technology, energy structure, and industrial policy.

Carbon productivity is a concept proposed by Kaya (1993) to measure the relative relationship between the economy and the environment, which refers to the ratio of regional economic output to carbon emissions over a certain period of time [21]. This concept considers carbon emissions as a production input factor and emphasises the efficiency of considering carbon constraints in economic activities, i.e., while pursuing economic development, the environmental problems caused by carbon emissions must be taken into account [22]. Under the current 'dual-carbon' goal, improving the efficiency of urban low-carbon production has become the key to promoting urban low-carbon development. He [23] and others pointed out that improving low-carbon production efficiency can not only offset the incremental carbon emissions brought about by GDP growth, but also reduce the existing carbon emissions stock, which is the core of low-carbon development; Xia Yan [24] and others argued that, as a kind of

efficiency evaluation index, low-carbon production efficiency introduces the reference of the base year when assessing carbon emission reduction performance, which not only guarantees the fairness of the assessment, but also reflects the efficiency advantage. fairness and reflects the efficiency advantage. Current research on low carbon productivity focuses on the agricultural sector, with a robust and significant 'inverted U-shape' relationship between the scale of agricultural land management and the intensity of agricultural carbon emissions at the national level [25]. In the manufacturing sector, the input of high-quality labour and the green transformation of energy consumption structure can promote the carbon productivity of the manufacturing industry, while the effect of R&D investment is not significant [26]. Lu Juchun [27] and other scholars found that the carbon emission intensity inefficiency level of the construction industry is the first in the three major regions of East, Central and West. In recent years, low-carbon productivity research has increasingly paid attention to the pilot perspective of meso-city, from the perspective of the whole process management, at present, China's cities in the low-carbon construction of the overall level of productivity is low [28], and the use of digital technology through precision agriculture, intelligent equipment, scientific data decision-making, etc., significantly improve the efficiency of food production, but also to reduce resource consumption and environmental pollution, and to improve the utility of low-carbon production [29], and digital economic policies significantly improve the low-carbon production efficiency of cities, reflecting both economic and ecological benefits [30], which also reflects the broad development vision of low-carbon production.

2.3. Trade Liberalisation Policies and Low-Carbon Production

Therefore, in recent years, scholars have been paying more and more attention to the relationship between policies and low-carbon development, such as studying the carbon productivity effects of policies such as carbon emissions trading [31], national-level financial reform experiments [32], and upgrading of provincial development zones [33]. The level of digital economy development and low carbon productivity in China's cities have a positive spatial correlation and agglomeration effect, and the development of the digital economy can promote the improvement of low carbon productivity, and there is a positive spatial spillover effect on the improvement of low carbon productivity in neighbouring places [34]. In contrast, the impact of trade liberalisation on low-carbon production efficiency is dual, which may either improve low-carbon production efficiency through technological progress or lead to an increase in carbon emissions as a result of industrial transfer [35]. The green finance pilot policy promotes agricultural carbon total factor productivity of farmers in the pilot area through technological frontier progress drive [36]. And it has been confirmed by scholars that relatively loose carbon emission policies are more able to promote the development of remanufacturing industry [37], which also provides ideas for the heterogeneity test aspect of this paper.

By combing through the existing literature, this paper argues that there is still room for expansion of related research: ① Existing literature mainly focuses on the economic benefits generated by the FTZ policy, and there is a lack of detailed research and discussion on the impact of environmental benefits. ② At present, there is little literature discussing the correlation between the construction of FTZ and the carbon production level of micro enterprises, but focus on the overall benefits of prefecture-level cities. Existing research focuses more on the short-term effects of the initial implementation of the policy, and has not yet revealed the continuity of the policy effect and the trend of change.

2.4. Theoretical Analysis and Research Hypotheses

The construction of FTZs can form an effective control of carbon emissions, and although the expansion of economic scale may theoretically bring about an increase in carbon emissions, several studies have shown that the construction of FTZs has generally produced a significant

inhibiting effect on carbon emissions in practice. The FTZ policy has improved the carbon production capacity of enterprises and reduced carbon emissions through the optimisation of industrial structure and the optimisation of resource allocation.

FTZ policies have played a crucial role in promoting the optimisation and upgrading of industrial structure. The policies are clearly orientated to encourage and support the transformation of traditional industries with high energy consumption and high emissions to new industries with low carbon and environmental protection, which promotes the greening and upgrading of the industrial structure. For example, the FTZ policy provides many preferences and support for high-tech industries and service industries, which, with their lower carbon emission intensity, have become a new engine of economic development, not only driving economic growth, but also effectively reducing the overall level of carbon emissions.

The FTZ policy has also demonstrated a strong leading role in optimising resource allocation. Enterprises in the FTZ face a more competitive market environment, which forces them to continuously improve production efficiency, optimise production processes and reduce resource wastage, thus enhancing competitiveness while significantly reducing carbon emissions. In addition, the FTZ policy also actively encourages enterprises to carry out green technological innovation and vigorously promotes the application of clean energy and energy-saving technologies. Specifically, enterprises in the FTZ, guided by the policy, are more inclined to adopt renewable energy sources such as solar energy and wind energy, and through continuous technological innovation, improve the efficiency of energy use, reduce energy consumption, and achieve a win-win situation in terms of economic benefits and environmental protection. Based on this, this paper proposes hypothesis 1:

Hypothesis 1: The establishment of FTZs can promote the significant improvement of low-carbon production efficiency of enterprises.

By creating a more open trade and investment environment, the FTZ policy promotes a significant increase in investment, and at the same time, with the help of financial innovation and service trade facilitation measures, as well as the strengthening of the market competition mechanism and the dual role of policy guidance, effectively incentivise enterprises to increase investment in the field of green innovation, and actively adopt advanced environmental protection technology and equipment to reduce energy consumption and emissions in the production process, thus enhancing the level of green innovation of enterprises while significantly improving their low-carbon production efficiency. This has improved the green innovation level of enterprises and significantly increased their low-carbon production efficiency. More critically, these investments have become powerful enablers of green innovation for enterprises while promoting their growth. FTZs incentivise enterprises to carry out green innovation in an all-rounded and deep-rooted manner through the following key approaches. In terms of policy guidance and incentives, the government has formulated and implemented a series of targeted policies. For example, the government has set up special subsidies for green innovation, and provided financial subsidies to enterprises with outstanding performance in green technology research and development and green product production; and implemented a tax relief policy to reduce or waive part of the tax for enterprises that actively practise the concept of green development and carry out green innovation activities, so as to reduce the operating costs of the enterprises and increase their motivation to carry out green innovation.

From the perspective of industrial agglomeration and synergistic effect, the FTZ has attracted many related industries to cluster in the zone by virtue of its favourable geographical location and perfect infrastructure. This industrial agglomeration not only promotes resource sharing among enterprises, such as sharing R&D equipment and technical talents, but also promotes technological exchanges and cooperation among enterprises. In the exchanges and cooperation, different enterprises inspire each other, complement each other's strengths, and

work together to overcome technical problems in the process of green innovation. For example, a new energy enterprise cooperated with a material research and development enterprise to jointly develop a more efficient and environmentally friendly energy storage material, which greatly enhanced the performance and market competitiveness of new energy products.

In the field of international cooperation and exchange, the FTZ actively builds an international exchange platform and encourages enterprises in the zone to cooperate with internationally renowned enterprises. Through the introduction of advanced green technologies and management experience from abroad, enterprises are able to rapidly improve their green innovation capability. For example, an enterprise in the zone cooperated with a European enterprise and introduced advanced green production processes, which not only improved production efficiency, but also significantly reduced energy consumption and pollutant emissions in the production process.

Under the active promotion of the FTZ, enterprises in the zone have responded by actively engaging in green innovation practices. Enterprises have made great efforts to optimise their energy structure, gradually reducing their reliance on traditional fossil energy sources and increasing the proportion of clean energy sources such as solar energy, wind energy and hydroelectric energy. In terms of production processes, enterprises have increased R&D investment, continuously improved production processes, adopted more environmentally friendly and efficient production technologies, and reduced waste and pollutant emissions in the production process. At the same time, the enterprise focuses on enhancing the added value of its products, meeting the market demand for environmentally friendly products through the development of green products, and improving the market competitiveness and economic benefits of its products. These efforts have significantly improved the enterprises' low-carbon productivity and achieved a win-win situation in terms of economic and environmental benefits. This process of green innovation and development is undoubtedly a profound green transformation for enterprises in the FTZ. Through green innovation, enterprises have not only enhanced their core competitiveness and achieved sustainable development, but also set up a benchmark for green development in the industry and driven the green upgrading of the whole industry. From a more macroscopic perspective, the green development practices of FTZ enterprises have contributed valuable experience and positive power to the development of the global green and low-carbon economy, highlighting the irreplaceable and important role of FTZs in attracting investment, promoting green innovation of enterprises, and improving low-carbon productivity. Based on this, this paper puts forward the second hypothesis:

Hypothesis 2: The FTZ policy leads to an increase in investment and promotes the role of the channel of the level of green innovation of enterprises, which in turn promotes the improvement of low-carbon production efficiency of enterprises.

Under the FTZ policy, non-state-owned enterprises have unique advantages in enhancing low-carbon productivity. Xi suggests that the advantages of non-state-owned enterprises in responding to the FTZ policy are: (1) more flexible market mechanisms, which enable them to quickly adjust their strategies, optimise their products and adapt to changes in the international market; (2) stronger motivation to innovate, as they are determined to do so in the face of fierce competition; (3) more efficient management and flexible incentives, with a focus on efficiency and market orientation, and an advantage in staff incentives, resource allocation and decision-making efficiency; (4) foreign-owned enterprises with international experience, which can integrate into the international market more quickly and improve product quality and competitiveness [38]. The foreign-funded enterprises have rich experience in internationalisation and can integrate into the international market more quickly to improve product quality and competitiveness [38]. Non-state-owned enterprises respond quickly to the market and are able to flexibly adjust their strategies and quickly adapt to the flexible policies and market opportunities provided by the FTZ, so that they can more effectively adopt green

technologies and low-carbon production methods. Moreover, NSOEs are more efficient in resource allocation, can quickly integrate resources and optimise production structure, and are more likely to achieve green transformation. In the face of fierce market competition, NSOEs are more motivated and capable of introducing advanced low-carbon technologies and efficient management modes to rapidly improve production efficiency and energy utilisation. These advantages make non-state-owned enterprises more competitive and efficient in low-carbon development. Based on this, the third hypothesis is proposed:

Hypothesis 3: The promotion effect of the FTZ policy on the low-carbon productivity of non-state-owned enterprises is more obvious depending on the ownership of enterprises and their management systems.

3. Research Methodology

3.1. Data Source

This paper uses panel data of Chinese A-share listed companies in Shanghai and Shenzhen, and selects 17,277 firm-year observations from 2009 to 2020 as the research sample. The data sources include Guotai Junan, National Bureau of Statistics and annual reports of enterprises. In this paper, the original samples are treated as follows: samples of enterprises with abnormal operation in the study period (ST and PT categories) are excluded; samples of financial and insurance industries are excluded; samples with missing core variables are excluded. At the same time, in order to avoid the influence of extreme values and make the model results more robust, this paper shrinks the continuous variables at the 1% and 99% quantiles in the robustness test.

3.2. Model Setting

The double difference method (DID) is used to assess the impact of FTA policy on the low carbon productivity of enterprises. The model setting is as follows:

$$Y_{it} = cons + \alpha_1 D_{it} + \alpha_2 X_{it} + \theta_t + \mu_i + \varepsilon_{it} \quad (1)$$

Where (Y_{it}) denotes the low-carbon productivity of enterprise i at time t , D_{it} is the FTZ policy dummy variable, and X_{it} is each control variable, including: enterprise age (Age) is expressed as the difference between the year of observation and the year of enterprise establishment; enterprise size is measured by the natural logarithm of the total assets of the manufacturing enterprises; return on net assets (roe) is expressed as The return on net assets (roe) is expressed as 'manufacturing enterprise tax profit/net assets'; total debt ratio (tl) is measured by 'total liabilities/total assets'; asset structure (tang) is measured by '(net fixed assets + net inventory)/total assets'; current asset ratio is recorded as cr; cash flow (cr) is measured by the natural logarithm of the total assets of the manufacturing enterprise. is recorded as cr; cash flow (cflow) is measured by 'net cash flow from operating activities/total assets'; and investment expense ratio (invt) is measured by 'cash paid for the purchase and construction of fixed assets, intangible assets and other long-term assets/total assets'. θ_t and μ_i and represent time and firm fixed effects, respectively. $cons$ indicates constant term coefficients, ε_{it} is the error term.

3.3. Variable description.

3.3.1. Explanatory variable

Firms' low carbon productivity (CTFP) refers to the economic output produced per unit of carbon emissions over a given period of time. An increase in low carbon production efficiency means an increase in economic output at the same level of carbon emissions, or a decrease in

carbon emissions at the same level of economic output. To calculate the low carbon production efficiency of enterprises, reference is made to the study of [39], which adopts the non-radial directional distance function, NDDF, with the GLM index to calculate the CTFP of the enterprises. the NDDF allows for an inconsistent proportion of increase or decrease in desired and non-desired outputs, which provides greater flexibility. Meanwhile, the year 2009 is considered as the base period, and the calculated GLM index is multiplied to obtain the low-carbon productivity (CTFP) of enterprises in different years. The factor inputs of enterprises include capital inputs and labour inputs, of which capital inputs are calculated by the perpetual inventory method to obtain the capital stock of enterprises; labour inputs are expressed by the average number of workers in enterprises; desired outputs are measured by the gross sales value of enterprises, and non-desired outputs are measured by the carbon dioxide emissions of enterprises.

3.3.2. Core explanatory variable

The establishment of the FTZ. Drawing on the idea of Wang Shuo[40], if the city where the listed firm is registered establishes a FTZ in year t, FTZ takes the value of 1 in year t and thereafter, and 0 otherwise.

Table 1. Descriptive statistics for key variables

Variable	Symbol	(1) Sample size	(2) Mean	(3) Standard deviation	(4) Minimum	(5) Maximum
Total Debt Ratio	tl	17,277	0.435	0.199	0.00708	1.037
Asset Structure	tang	17,258	0.398	0.170	3.19e-05	0.971
Current Asset Ratio	cr	17,277	0.556	0.203	0.0147	0.999
Cash Flow Investment	cflow	17,277	0.0548	0.0709	-0.528	0.664
Expenditure Ratio	invt	17,273	0.0513	0.0481	0	0.642
Tobin's Q	tobin	17,002	2.032	1.666	0.684	78.75
Total Net Asset Profit Margin	roa	17,277	0.0492	0.0431	-0.00761	0.786
Firm Size	size	17,277	22.37	1.351	17.97	28.64
Ln(Year of Listing)	lnage	17,277	2.253	0.645	1.099	3.401
TFPCH	TFPCH	16,901	1.014	0.0195	0.350	1.447
FTZ	FTZ	17,277	0.187	0.390	0	1

Table 1 is a descriptive statistical presentation of the main variables, the results show that the minimum value of the total debt ratio of enterprises (tl) is 0.00708, the maximum value is 1.037, and the average value is 0.435, which indicates that the gap in the total gearing ratio between enterprises is relatively small, and that the level of gearing ratio between enterprises is similar, more concentrated, and has a certain degree of similarity. And the average value of cash flow (cflow) of enterprises is 0.0548, the minimum value is -0.528, and the maximum value is 0.664.

It shows that the difference of cash flow of each enterprise is obvious, and the level is not the same. And in terms of enterprise size, the mean value is 22.37, the standard deviation is 1.351, the minimum value is 17.97, and the maximum value is 28.64. Under the calculation method of this paper, the enterprise size is closely related to the amount of total assets, which can be seen in the study of the enterprise size although there is a certain degree of difference, but basically belong to the small and medium-sized enterprises, and the space for development is vast.

4. Analysis of Empirical Results

4.1. Benchmark regression analysis

Table 2. The impact of FTZ establishment on firms' low-carbon productivity: a benchmark regression

VARIABLES	(1) y	(2) y
FTZ	0.0014** (0.001)	0.0021*** (0.001)
tl		0.0108*** (0.003)
tang		-0.0089*** (0.002)
cr		0.0055** (0.003)
cflow		0.0061 (0.005)
inv		-0.0512*** (0.005)
tobin		0.0002 (0.000)
roa		0.0783*** (0.012)
size		-0.0023*** (0.001)
lnage		0.0069*** (0.001)
Firm/Year Fixed Effects	yes	yes
Control Variables	no	yes
Observations	16,784	16,505
R-squared	0.159	0.185

Robust standard errors in parentheses (Robust standard errors in paren papers)

*** p<0.01, ** p<0.05, * p<0.1

In order to explore the effect of FTZ construction on the carbon production level of enterprises, this paper adopts DID to regress the benchmark model, and this paper examines the impact of the FTZ policy on the low-carbon production efficiency of enterprises as a whole after controlling for enterprise and time fixed effects. Table 2 shows the results of the regression of FTZ policy and low-carbon production efficiency of manufacturing enterprises according to the

benchmark regression model, i.e., model (1). The FTZ policy (FTZ) is the core explanatory variable, and the explanatory variable is the low-carbon production efficiency of enterprises. As shown in column (1), the coefficient of FTZ is significantly positive at the 5% level with the inclusion of enterprise and time fixed effects, which initially proves that there is a significant positive correlation between FTZ and low-carbon productivity, i.e., the establishment of FTZ is conducive to the promotion of low-carbon productivity of enterprises. The results in Column (2) indicate that the coefficients of FTZ are significantly positive at 1% level after further inclusion of control variables, and the coefficient estimates of the core explanatory variables are basically the same, which indicates that the regression results are robust. In summary, the benchmark regression results validate Hypothesis 1, that FTZ presents a significant positive effect on the low carbon productivity of all enterprises. Specifically, considering the time effect, after the implementation of FTZ policy, the low-carbon productivity of enterprises increased by about 14 per cent on average, and considering the scale effect, the low-carbon productivity of enterprises increased by about 21 per cent on average.

4.2. Robustness Test

4.2.1. Parallel Trend Test

A statistical method used to compare whether there is a significant difference in the trends of two or more groups of data over time. To improve the reliability of the study results. By testing whether the trends of the two groups of data before the intervention are parallel or not, we exclude the trend changes due to other factors, so as to more accurately assess the effect of the FTZ policy on enterprises.

$$\sum_{s=1}^5 \varphi_{pre_s} D_{pre_s} + \varphi_{current} D_{current} + \sum_{s=1}^5 \varphi_{post_s} D_{post_s} + \varphi X_{i,t} + \mu_i + \theta_t + \varepsilon_{i,t} \quad (2)$$

In this equation, D_{pre_s} 、 $D_{current}$ 、 D_{post_s} denote the interaction terms with the policy dummy variables for the years before, at the time of, and after policy implementation, φ_{pre_s} 、 $\varphi_{current}$ 、 φ_{post_s} denote the corresponding coefficients, θ_t and μ_i denote the time and firm size fixed effects, respectively, β_0 indicates constant term coefficients, ε_{it} is the error term.

Figure 1 reflects the policy dynamic effect estimates and their confidence intervals at the 95 per cent confidence level. According to Figure 1, the coefficients corresponding to the period before the implementation of the FTZ policy to one year after its implementation have not passed the significance test, indicating that there is no significant difference between the CTFP of the treatment group and the control group before the implementation of the (FTZ) policy, which means that the trend of change in the CTFP of the treatment group and the control group in the period fulfils the parallel trend assumption. From the perspective of dynamic effect, in the second year of FTZ policy implementation, the coefficient has passed the significance test and shows a certain upward trend, and over time, the coefficient is still positively significant and passes the test, reflecting that the establishment of the FTZ has played a propelling role in the enhancement of the low-carbon productivity of enterprises, and has improved their green production capacity.

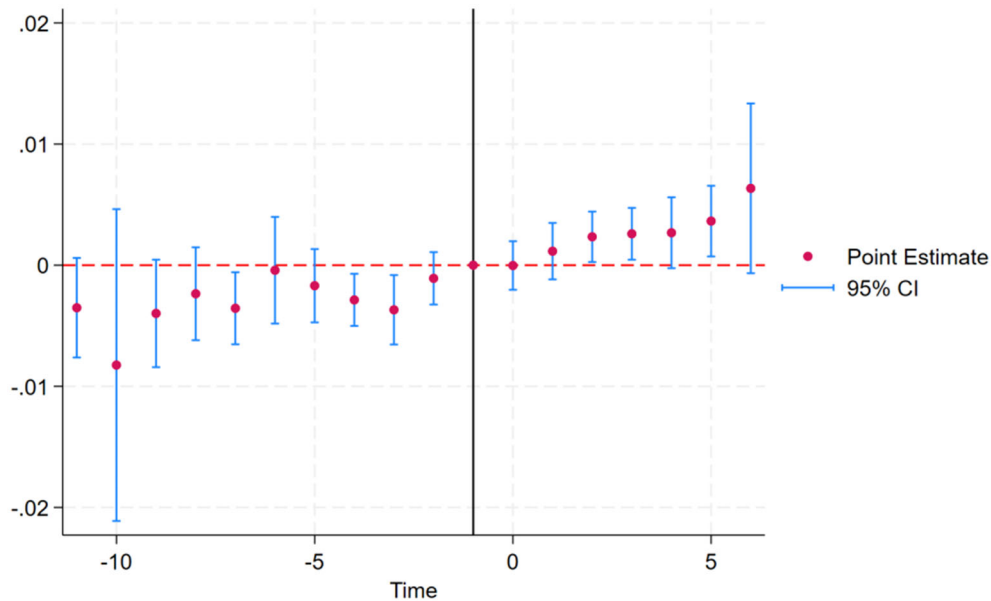


Figure 1. Graphical representation of estimated dynamic effects of policies

4.2.2. Tailoring

Table 3. Regression results from robustness tests

VARIABLES	(1) y	(2) y	(3) y
FTZ	0.0014*** (0.000)	0.0011** (0.000)	0.0013*** (0.000)
tl	0.0081*** (0.002)	0.0039** (0.002)	0.0085*** (0.002)
tang	-0.0053*** (0.002)	0.0133*** (0.002)	-0.0061*** (0.002)
cr	0.0048*** (0.002)	-0.0082*** (0.002)	0.0062*** (0.002)
cflow	0.0139*** (0.003)	0.0100*** (0.003)	0.0122*** (0.003)
inv	-0.0466*** (0.003)	-0.0327*** (0.004)	-0.0477*** (0.004)
tobin	0.0001 (0.000)	0.0003 (0.000)	-0.0001 (0.000)
roa	0.0589*** (0.005)	-0.0578*** (0.006)	0.0580*** (0.006)
size	-0.0019*** (0.000)	-0.0000 (0.000)	-0.0022*** (0.000)
lnage	0.0061*** (0.001)	-0.0006 (0.001)	0.0079*** (0.001)
Constant	1.0372*** (0.009)	1.0165*** (0.009)	1.0405*** (0.011)
Observations	16,505	12,897	14,184
R-squared	0.212	0.219	0.211

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Tailoring is used to reduce the impact of extreme values on the results of data analysis and to improve the reliability of the data and the robustness of the model by replacing or removing outliers. In order to remove the adverse effects of extreme values on the study sample, this paper chooses 1% and 99% as the percentile of the shrinkage, and performs the shrinkage treatment on the 10 control variables of TFPCH, *tl*, *tang*, *cr*, *cflow*, *inv*, *tobin*, *roa*, *size*, and *lnage* by taking the 1% quartile of each variable as the boundaries of the shrinkage, and replacing the processed result with the original variables. Values in the data below 1% were replaced with values in the 1% quartile, and values above 99% were replaced with values in the 99% quartile. The estimation results in column (1) of Table 3 show that the coefficient estimates of the policy dummy variables are still positive at the 1 per cent significance level after excluding extreme values, again indicating that the conclusions of this paper are robust.

4.2.3. Changing the window period

Adopting the research methodology of John Smith & Emily Johnson [41], the window period is changed, and due to the missing data and computational difficulties of some firms after 2019, this study deletes all observations after 2019, restricts the analysis to 2019 and the time period before it, and conducts the fixed effects regression again. As shown in column (3) of Table 3, the regression coefficients of FTZ change slightly compared to the benchmark regression, indicating that the results of the study are highly robust.

4.2.4. Placebo Recommendations.

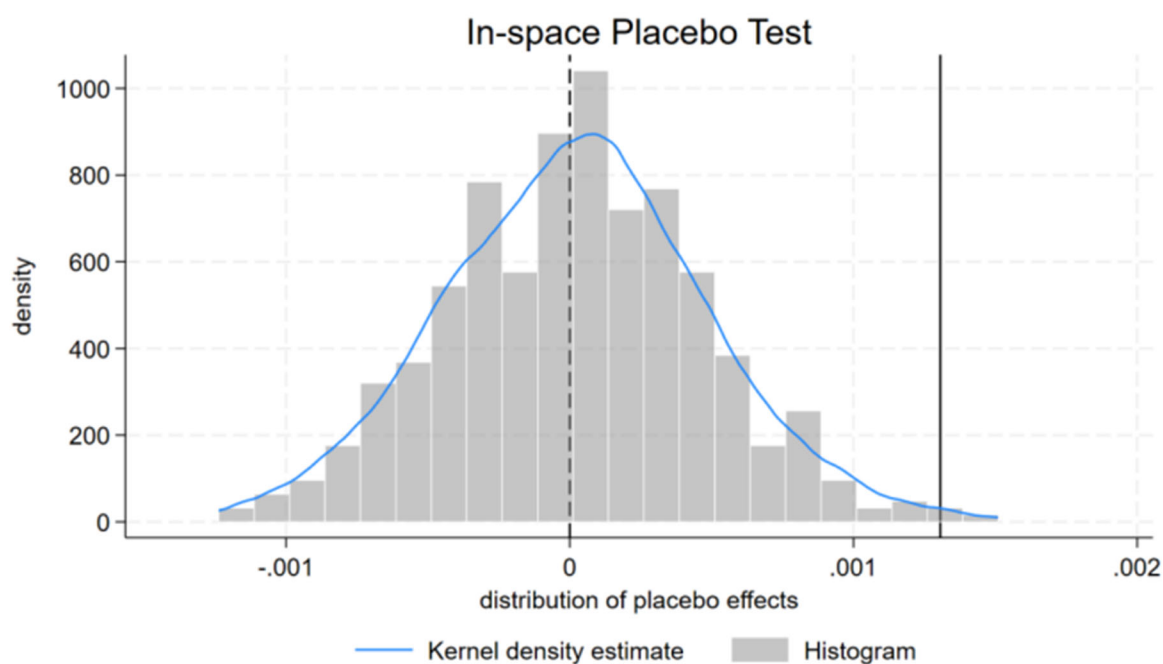


Figure 2. Graphical representation of In-space Placebo Test

To avoid baseline regression results being affected by unobservable omitted variables, spatial placebo tests (In-space Placebo Test) and mixed placebo tests (Mixed Placebo Test) are conducted. Other similar cities not affected by the policy are randomly selected as the pseudo-treatment group, a dummy treatment variable is constructed, and then a DID regression is performed. A portion of firms are then randomly selected as the pseudo-treatment group and a point in time is randomly selected as the pseudo-policy implementation time point to construct a dummy treatment variable, followed by a DID regression.

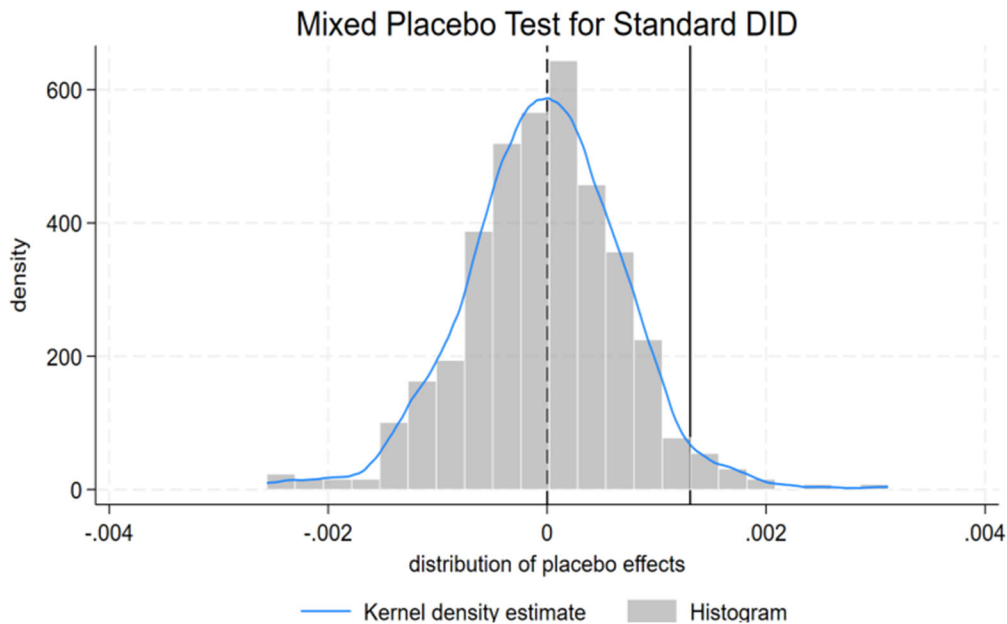


Figure 3. Graphical representation of Mixed Placebo Test

Plotting the distribution of regression coefficients and p-values of the simulated dummy treatment variables, it can be seen from the figure that most of the estimated values of the pseudo-policy dummy variables are concentrated around 0 and follow a normal distribution, and as far as the p-values are concerned, most of them are not significant at the 10 per cent level, with a mean value of 0. The fact that no significant treatment effect can be observed in these firms suggests that the results of the original study are more reliable. The above results indicate that other unobservable factors do not interfere with this study.

4.2.5. Changing the clustering hierarchy

In a double difference (DID) regression model, the significance of the estimated coefficients, as well as the magnitude of the coefficients, and the positive and negative relationships, are affected by two important factors: the setting of the fixed effects, and the estimation of the standard errors. To ensure the robustness of the results, this paper further explores the impact of different standard error clustering levels on the regression results. Specifically, this paper adopts four different standard error estimation methods, namely: clustering by stock code and year, clustering by city code, clustering by stock code, dual clustering by both stock code and year, and no clustering (default clustering) method. Each standard error estimation method corresponds to a, b, c, d, and e in Figure 5, respectively, and is designed to test the results of regression coefficients under different clustering levels.

As can be seen in Figure 5, the regression coefficients are positive and significant regardless of which standard error estimation method is used, and the magnitude of the coefficients varies less. This indicates that the promotion effect of FTZ construction policies on low-carbon production of enterprises remains consistent under different standard error clustering levels, and the significance of the regression results is not significantly affected by changes in standard error settings. This result suggests that the positive impacts of FTZ policies can be robustly identified whether the stricter clustering standard errors or the more relaxed ordinary standard errors are used, thus validating the robustness of the model results.

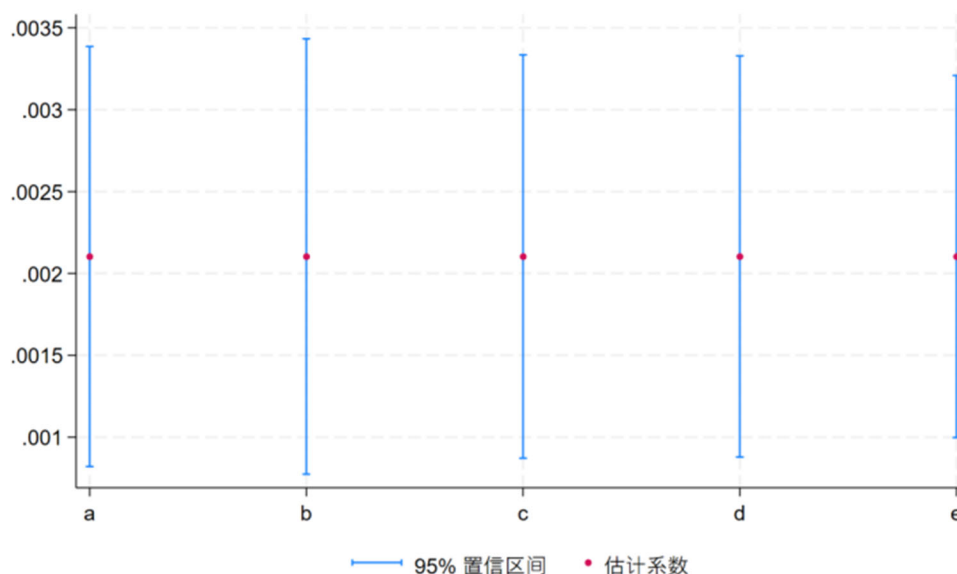


Figure 4. Graphical representation of the five altered clustering levels

In this way, after a series of tests, the results estimated from the benchmark regression above do not change substantially, confirming the high robustness of the results obtained.

4.3. Impact mechanism testing

In order to test the channel of action of the FTZ construction on the low carbon productivity of enterprises, this paper refers to the [42] mediated utility test method and analyses it using the mediated effect model. The regression results of the channel of action test are shown in Table 4: In column (2), the explanatory variable is the investment expenditure rate (*inv*), which is usually used to measure the level of capital investment of enterprises in a certain period of time. The independent variable is FTZ, the free trade zone variable, which is used to measure whether an enterprise is located in or affected by a free trade zone. The estimated coefficient of FTZ is 0.0041 and is significantly positive at the 95% level, indicating that the construction of the free trade zone enhances the enterprise's investment expenditure rate. Column (3) in the baseline regression model (1) based on the basis of the explanatory variables changed again, set to the enterprise's green innovation, with *lgp*. The natural logarithm of the number of green patent applications of enterprises is calculated to represent the level of green innovation of enterprises. The independent variable is FTZ, and the control variables are the same as those in the baseline regression model, including investment efficiency.

At this point, the estimated coefficient of FTZ is still positive and significant at the 95% level, with a specific value of 0.0495, indicating that the free trade zone promotes the green innovation activities of enterprises. Mechanism test regression results indicate that the FTZ policy promotes the development of green innovation in enterprises, which is conducive to the enhancement of low-carbon productivity, and the actual data confirm the reasonableness of the research hypothesis H3.

At a time when economic globalisation continues to deepen, the strategic significance of FTZs has become more and more prominent as the front line of the country's opening up to the outside world. With a series of unique policy advantages such as tax incentives, simplified administrative approval process, relaxation of market access standards, the FTZ is like a powerful magnet, attracting a large number of domestic and foreign investment from a steady stream of influx. The injection of these investments, like a timely rain, for the development of enterprises in the zone injected a strong financial impetus, so that enterprises in the development of the road can be lightly loaded, bold and pioneering.

Table 4. Impact mechanism regression results

VARIABLES	(1) y	(2) y	(3) y
FTZ	0.0021*** (0.001)	0.0041** (0.002)	0.0495** (0.022)
tl	0.0108*** (0.003)	0.0250*** (0.006)	-0.1039* (0.057)
tang	-0.0089*** (0.002)	-0.0830*** (0.007)	0.0148 (0.052)
cr	0.0055** (0.003)	-0.0993*** (0.006)	0.0234 (0.058)
cflow	0.0061 (0.005)	-0.0070 (0.006)	-0.0951 (0.060)
inv	-0.0512*** (0.005)		0.1700 (0.117)
tobin	0.0002 (0.000)	0.0003 (0.000)	0.0001 (0.003)
roa	0.0783*** (0.012)	0.0867*** (0.016)	0.1672 (0.151)
size	-0.0023*** (0.001)	0.0046*** (0.002)	0.0322* (0.017)
lnage	0.0069*** (0.001)	-0.0401*** (0.003)	0.0925** (0.036)
Constant	0.0429*** (0.015)	0.1119*** (0.035)	-0.5979 (0.385)
Observations	16,505	16,865	16,865
R-squared	0.185	0.569	0.698

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Heterogeneity Analysis

Firms' resource endowment, development mode, and government policies towards firms all have different impacts on their low-carbon productivity. However, parameter estimation based on the total sample cannot adequately reveal the heterogeneity of the impact of FTZs on firms' low-carbon productivity [43]. Therefore, this paper analyses heterogeneity from two perspectives: firm ownership and firm productivity.

5.1. Heterogeneity of enterprise nature

In the Chinese economic system, there are significant differences between state-owned enterprises (SOEs) and other types of enterprises (e.g., private enterprises, foreign-funded enterprises, etc.) in terms of access to resources, policy support, and market position. This heterogeneity is not only reflected in the governance structure and development mode of enterprises, but also profoundly affects their business performance and productivity. And the implementation effect and impact strength of FTZ policies are affected by enterprise ownership factors.

In order to deeply understand the differences between SOEs and other enterprises in the changes of low-carbon productivity under the implementation of FTZ policies, this report will compare the heterogeneity of SOEs and other enterprises in CTFP through data analysis, and

understanding the heterogeneity of SOEs is of great significance for formulating accurate policies, promoting SOE reforms, and enhancing the efficiency of SOEs.

Table 5. Regression results for firm nature heterogeneity

VARIABLES	(1) y	(2) y
FTZ	0.0024*** (0.001)	0.0008 (0.003)
tl	0.0099** (0.004)	0.0132 (0.009)
tang	-0.0106*** (0.003)	-0.0085 (0.009)
cr	0.0053* (0.003)	0.0096 (0.008)
cflow	0.0077 (0.005)	0.0005 (0.019)
inv	-0.0483*** (0.006)	-0.0614*** (0.015)
tobin	-0.0001 (0.000)	0.0023 (0.002)
roa	0.0812*** (0.014)	0.0734*** (0.027)
size	-0.0020** (0.001)	0.0009 (0.002)
lnage	0.0072*** (0.001)	0.0102** (0.005)
Constant	1.0379*** (0.018)	0.9569*** (0.046)
Observations	14,206	2,039
R-squared	0.171	0.254

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

As shown in the table, the results show that the pilot policy has a positive impact on the CTFP of both state-owned and non-state-owned enterprises. The original data are screened and classified based on the state and state-owned corporate shares, and classified according to the different degrees of government control of SOEs, column (1) represents the regression results for the data of non-state-owned enterprises, and column (2) represents the regression results for the data of state-owned enterprises. According to the results in column (1) of Table 5, the FTZ coefficient of non-state-owned enterprises is 0.0024 at the 5% significance level, indicating that the FTZ policy has a significant positive impact on the low-carbon productivity of non-state-owned enterprises.

The following reasons are surmised, ①policy dividends: non-state enterprises can more fully enjoy the policy dividends brought by the FTZ, such as trade facilitation, tax incentives, etc., so as to reduce operating costs and improve production efficiency.②Market mechanism: non-state-owned enterprises are more responsive to market signals, and can more quickly adjust production strategies and optimise resource allocation to adapt to the new opportunities and challenges brought by the FTZ. (iii) Innovation motivation: In the face of fierce market competition, non-state-owned enterprises are more motivated to carry out technological

innovation and management innovation, so as to improve low-carbon production efficiency. Column (2) of Table 5 shows that the FTZ coefficient of SOEs is 0.0008 at 5% significance level, indicating that the FTZ policy has a positive impact on the low carbon productivity of SOEs, but the degree of impact is smaller than that of non-SOEs. The reasons are analysed as follows, ①The dependence of SOEs on government policies is strong, and the marginal benefits brought by FTZ policies are relatively small. ②The governance structure and decision-making mechanism of SOEs are relatively rigid, which may limit their quick response and effective use of FTZ policies. (iii) SOEs bear certain social responsibilities and may need to take into account other objectives while pursuing economic benefits, thus affecting the improvement of their low-carbon productivity. It can be seen that in the case of weak government intervention (i.e., non-state-owned enterprises), the promotion effect of FTZ policies on enterprises' low-carbon productivity is more significant. Firms with a low degree of government control are likely to realise more significant productivity progress in the FTZ due to their higher flexibility and adaptability. Based on the above, hypothesis H2 is proved.

5.2. Productivity Heterogeneity

Table 6. Productivity heterogeneity regression results

VARIABLES	(1) y	(2) y
FTZ	0.0013** (0.001)	-0.0027*** (0.000)
tl	0.0134*** (0.003)	
tang	-0.0118*** (0.003)	
cr	-0.0001 (0.003)	
cflow	0.0058 (0.005)	
inv	-0.0522*** (0.006)	
tobin	0.0003 (0.000)	
roa	0.0725*** (0.010)	
size	-0.0059*** (0.001)	
lnage	0.0114*** (0.001)	
Constant	1.0998*** (0.020)	1.0144*** (0.000)
Observations	16,637	16,901
R-squared	0.694	0.003

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Technical Efficiency Change (TEC) and Technological Progress (TP) are two key components in the study of productivity. Technical Efficiency Change (TEC) reflects the efficiency with which firms utilise resources at the current level of technology, while Technological Progress (TP) reflects the movement of the technological frontier, i.e. the adoption or innovation of new technologies. Heterogeneity analyses of the two can help provide insights into the drivers of firm productivity growth and inform policy formulation.

The aim of this report is to explore the heterogeneity of firms in terms of technological efficiency progress and technological progress after the establishment of the FTA through data analysis and to analyse the impact of different characteristics on these two types of productivity growth. Subgroup regression is used to compare the differences in the role of FTZ policies on technical efficiency progress and technological progress.

In particular, column (1) represents the results of the regression of firms with technological efficiency progress after the implementation of the FTZ policy, and column (2) represents the results of the regression of firms with technological progress after the implementation of the FTZ policy. The coefficient of the explanatory variable FTZ in (1) is 0.0013 at the 5% significance level, and the effect of technological efficiency progress shows a positive correlation; the coefficient of FTZ in column (2) is -0.0027 at the 5% significance level, and the effect of technological progress shows a negative correlation. This indicates that the establishment of FTZ will significantly promote the technical efficiency progress of enterprises. With the support of FTZ policy, enterprises can utilise resources more effectively and improve operational efficiency, thus achieving the improvement of technical efficiency. In terms of production technology, it is hypothesised that ① the increased market competition brought about by the FTZ will prompt enterprises to pursue short-term economic benefits, thus neglecting the progress of carbon production technology. Enterprises may prioritise the allocation of limited resources to areas that can quickly bring economic benefits in the face of fierce market competition, and reduce investment in carbon production technology. They may be more inclined to use low-cost, high-carbon emission technologies and materials in the production process. ② Bias in technology transfer: Existing technology transfer mechanisms may favour traditional technologies and products, which already have well-established markets and supply chains. The transfer of traditional high-carbon technologies may increase, resulting in higher carbon emissions for firms. ③ Complexity of policy implementation: The policy framework of the FTZ may involve multiple sectors and levels, making coordination difficult, leading to higher administrative costs and uncertainty for enterprises in implementing carbon reduction measures.

6. Conclusions and Policy Recommendations

6.1. Conclusion

Based on the panel data of 17,277 enterprises from 2009 to 2020, this paper examines the relationship between the construction of FTZs and the level of low-carbon productivity of enterprises by using the panel fixed-effects and double-difference methods. The results of the study show that: ① The FTZ policy has a significant promotional effect on the low-carbon productivity of enterprises, which is mainly realised through investment increase and technological progress. ② The construction of FTZ not only promotes the expansion of economic scale, but also plays a positive role in controlling carbon emissions, promoting the optimisation and upgrading of industrial structure, and promoting the application of clean energy, which lays a solid foundation for the sustainable development of the economy. ③ After

regressing the grouping of enterprises with different ownership, it is found that there are differences in the responses of enterprises with different ownership to the FTZ policy, and enterprises with less government control, i.e., enterprises of non-state nature, benefit more significantly. ④ After further heterogeneity test, it is found that the establishment of this FTZ will significantly promote the technological efficiency progress of enterprises, but it will lead to higher technological costs of enterprises.

6.2. Policy Recommendations

Based on the above research conclusions, in order to better utilise the promotional effect of FTZ policies on the low-carbon production efficiency of enterprises of different ownership, this paper has the following policy insights:

6.2.1. First, establish a sound policy system for green and low-carbon development.

Firstly, formulate a green and low-carbon development plan. The FTZ should formulate a green and low-carbon development plan in accordance with the national carbon peak and carbon neutrality targets, and take into account the actual situation of each region, so as to clearly define the targets, paths and measures for low-carbon development. Secondly, it should explore the implementation of special fiscal and tax policies, and give preferential policies such as tax exemptions and financial subsidies to enterprises adopting low-carbon technologies and implementing energy-saving and carbon-reducing measures, so as to reduce the cost of low-carbon transformation for enterprises. Finally, actively develop green finance and encourage financial institutions to develop green credit, green bonds and other financial products to provide financial support for the low-carbon transformation of enterprises.

6.2.2. Second, optimise policy support, strengthen policy synergy, and form a synergy to promote the vigorous development of non-SOEs.

Accelerate the pace of market-oriented reform of SOEs, optimise their governance structure, and enhance decision-making efficiency so that SOEs can respond to market changes more flexibly. To this end, it should (1) increase policy support for non-SOEs, especially in key areas such as financing and technological innovation, and create a fairer and more equitable market environment for them. This will provide strong support for non-state enterprises and enable them to spread their wings in market competition. (2) At the same time, non-SOEs should be encouraged to actively participate in the construction of the FTZ and be provided with the necessary policy guidance and consulting services to help them thrive in the hot land of the FTZ and jointly promote low-carbon productivity. (3) Formulate and implement more precise policy measures, and tailor differentiated policy programmes to address the characteristics of enterprises of different ownership.

Through the fine-tuned design of policies, each type of enterprise will be provided with a policy environment suitable for its development. At the same time, the synergy between FTZ policies and other relevant policies will be strengthened to form a policy synergy, which will jointly promote the continuous improvement of low-carbon production efficiency of enterprises. This policy synergy will bring together a powerful force to promote green development. Improve the performance appraisal system of state-owned enterprises, innovatively incorporate carbon emission indicators into it, so as to guide state-owned enterprises to actively improve low-carbon production efficiency and walk in the forefront of green development.

6.2.3. Thirdly, improving the monitoring mechanism and promoting transparent fulfilment of responsibilities.

(1) On the part of enterprises, a sound monitoring and reporting mechanism for carbon emissions by enterprises has been established to strengthen the comprehensive supervision of carbon emissions by enterprises. Through this mechanism, the carbon emissions of enterprises can be grasped in real time to ensure that enterprises fulfil their environmental responsibilities.

Enterprises are encouraged to make carbon disclosure and increase transparency, so that they can take the initiative to publicise their green development results. This will enhance the enterprises' sense of social responsibility and facilitate public monitoring of their fulfilment of social responsibility, and jointly promote the development of society as a whole in a greener and more sustainable direction. (2) For FTZs, in the context of economic globalisation and regional economic integration, and as an important method and approach for high-quality economic development in the construction of FTZs, the government should pay more attention to the constraining effect of CTFP on the high-quality development of FTZs, incorporate environmental factors into the evaluation and management system of the construction of FTZs, and run the concept of green development through the whole process of the construction of FTZs, so as to push forward the change in the mode of economic growth from factor-driven to CTFP-driven change.

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