Hindawi
Discrete Dynamics in Nature and Society
Volume 2023, Article ID 2736630, 15 pages
https://doi.org/10.1155/2023/2736630

Research Article

An Empirical Analysis of the Impact of the China Free Trade Zone on the Level of Human Capital Based on the Asymptotic PSM-DID Model

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Received 12 November 2022; Revised 18 April 2023; Accepted 17 May 2023; Published 3 June 2023

Academic Editor: Sundarapandian Vaidyanathan

The article selects relevant data from 283 cities in China from 2000 to 2020 and verifies the impact of the establishment of free trade zones on human capital levels based on the asymptotic PSM-DID model. It is found that the establishment of FTZs can significantly contribute to the improvement of regional human capital levels, but the promotion effect has a certain lag. Finally, the article gives constructive suggestions based on the empirical results.

1. Introduction

As the Chinese economy continues to rapidly develop, in order to better stimulate market vitality and social creativity, China has undertaken a series of domestic deepening reform measures and external globalization strategies, seeking new economic growth points and improving the quality of economic growth through high-level opening-up. The emergence of free trade pilot zones is an important policy for deepening internal and external reforms and plays a decisive role in China's economic resilience and sustainable development. Innovation of the human resources system is one of the important tasks of free trade zone construction, is a key means to enhance the international competitiveness of the free trade pilot zones, and is the fundamental guarantee for the high-quality development of the free trade pilot zones in China.

In recent years, more and more scholars have begun to pay attention to the research on free trade zone policies. From the perspective of innovation-driven development, the economic growth, international trade, competition, and spillover effects brought about by the establishment of free trade zones will strongly promote the improvement of regional innovation and development levels (Gao and Li [1]). Free trade zones implement the negative list access principle, while canceling the vast majority of tariff and nontariff barriers for goods, promoting the free flow of factors such as goods, capital, technology, and labor. The new classical growth model emphasizes that capital flows are the source of economic growth. Zhang and Yu [2] combined the construction of free trade zones and believed that the establishment of free trade zones could promote urban capital flows, drive technological innovation, and force domestic market-oriented reforms to improve the level of marketization, thereby affecting urban regional economic growth. Fang [3] believed that the construction of free trade zones could increase the driving force for optimizing and adjusting regional industrial structures through channels such as import expansion effects and financial agglomeration effects.

The research of the above scholars mainly focuses on the relationship between relevant policies, regional innovation, and economic growth. The establishment of a free trade zone will strongly promote the improvement of regional innovation and development levels. The implementation of a negative list model and the elimination of tariff barriers will promote factor mobility. However, the effect of human resource system innovation, as an important task of free

trade zone policy, lacks empirical evidence. Most scholars have studied the differences in human capital levels from the perspective of trade openness. However, as a high-level policy of opening to the outside world, there is little research on the free trade zone. This paper will conduct an empirical study on the impact of the establishment of a free trade zone on human capital.

The difference-in-differences (DID) method is one of the important methods for evaluating policy effects. Zhou et al. [4] used this method to explore the impact of the clean energy demonstration province policy on regional carbon emissions and economic development. Yang et al. [5] used a combination of synthetic DID and generalized synthetic control methods to evaluate the impact of the establishment of a free trade zone on urban green total factor productivity. Shao et al. [6] used the DID method to investigate the effect of the free trade zone policy on regional carbon emissions against the background of the dual carbon targets, and the results showed that the pilot policy of the free trade zone can significantly reduce regional carbon emissions. Li and Wang [7] used this method to investigate the impact of the new energy demonstration city policy on urban green vitality based on a quasi-natural experiment. Yang et al. [8] analyzed the impact of the host country's tax environment on investment efficiency based on direct investment data from countries along the belt and road.

Based on the above, this paper selects relevant data from 283 prefecture-level cities in China from 2000 to 2020 and uses propensity score matching double difference, a commonly used method for policy evaluation, to verify the causal relationship between free trade zones and human capital level in order to propose relevant suggestions to optimize the human capital resource innovation system in the construction of free trade zones, promote regional human capital investment and accumulation, drive regional innovation and development, and promote regional economic growth, thereby enhancing China's international competitiveness in the world.

The innovations in this paper mainly include the following aspects: (1) This paper verifies the causal relationship between free trade zones (FTZs) and human capital levels, expands the research on FTZs, and enriches the perspective of FTZ research. (2) The paper corrects the model for evaluating the effect of FTZs on human capital level and uses the propensity score matching double difference method to verify the impact of FTZs on human capital level. The combination of difference-in-differences with propensity score matching solves the problems of endogeneity and sample selection bias. In addition, the paper adopts the method of annual matching to avoid the problems of time mismatch and self-matching caused by mixed matching. (3) Most of the existing literature uses provincial panel data, but the establishment of FTZs is in a small area of a prefecture-level city, and the scope is relatively small. Using provincial panel data may exaggerate the effect of FTZ policies and lead to unconvincing conclusions. Therefore, this paper selects data from 283 prefecture-level cities from 2000 to 2020 to make the relationship between the two more reliable.

2. Theoretical Foundation

From a theoretical perspective, free trade can achieve efficient allocation of resources on a global scale, especially from the perspective of regional comparative advantage, by using the comparative advantages of different regions to allocate resources reasonably, achieve complementary advantages, and achieve sustainable development. The development of free trade has a certain promoting effect on the rapid and free exchange of human capital. Classical political economy emphasizes the role of material capital. American economists Schultz and Becker analyzed the promotion of human capital investment on social and economic development from macro- and microperspectives, respectively. Since 1980s, the new theory of economic growth has been concretized, and mathematical methods have been used to further explain the impact of endogenous variables such as human capital and education level on economic growth.

Currently, there is little research on the impact of the establishment of free trade zones on the level of human capital. Lv and Liu [9] verified the causal relationship between free trade zones and human capital investment and analyzed the heterogeneity of human capital investment between rural and urban areas. From the above, we can know that the establishment of free trade zones promotes institutional innovation and then promotes free trade. Although there is little research on the relationship between free trade zones and human capital, we can shift our focus to research on the relationship between trade openness and human capital level. For example, Findlay and Kierzkowski [10] introduced human capital into the H-O model, endogenizing both worker wages and education costs, and then verified that trade openness can affect workers' ability to obtain lower wages from nonskilled labor or higher wages from education investment. Since then, the literature on the relationship between trade openness and human capital has continued to increase. According to existing literature [11], the impact mechanism of trade openness on human capital level can be summarized into four aspects: mainly wage price mechanism, technological progress mechanism, capital input mechanism, and credit constraint mechanism. For the wage price mechanism, scholars believe that trade openness promotes the increase in the ratio of high-skilled labor wages to low-skilled labor wages, followed by the promotion of human capital investment and the accumulation of human capital. For the technological progress mechanism, Acemoglu [12] believes that foreign trade will cause the skill required for a certain job to increase, and correspondingly, talent will continue to improve its skills. Chen and Zhao [13] found that under the background of dual labor market, the efficiency and complexity of export technology not only benefit the investment in human capital in urban and rural areas but also help to increase investment in children's education and the long-term human capital investment of workers. The capital input mechanism is mainly that trade openness promotes cultural exchange, further affecting individual education investment in skills and knowledge, and at the same time, empirical results show that due to the opening of trade, promoting economic growth, residents'

income will also increase, and will not be limited by credit constraints, allowing residents to increase their education investment.

3. Research Design

3.1. Research Hypotheses. The formation of human capital stems from investments in human capital. Free trade pilot zones have implemented many measures in the areas of talent introduction and talent service guarantee, such as direct financial support and various forms of service guarantee including housing, medical care, and education (Tang and Wu [14]). Currently, Liu and Wang [15] have verified that the establishment of free trade zones promotes the improvement of regional innovation levels. Under the guidance of the consumption structure, new products, new services, and the diversity of foreign products and services brought about by trade liberalization have promoted the growth of effective demand. According to Keynes' theory of national income determination, the multiplier effect generated by the increase in effective demand will lead to an increase in income, which will have a positive impact on investment in human capital, ultimately affecting the level of human capital. The author also points out that the radiation-driven effect of free trade zones is conducive to improving the level of regional integration, reducing income disparities, and increasing investment willingness and level. Based on relevant research, this article puts forward the following hypotheses:

(1) The role of industrial structure upgrading in the pilot policies of free trade zones and the level of regional human capital.

Free trade zone pilot policies have an obvious promoting effect on industrial structure upgrading (Fang [3]; Li and Li [16]). On the one hand, as a high-level open policy, the free trade zone simplifies customs clearance procedures and implements a negative list management system, that is, through "rough" trade facilitation measures, breaking down trade barriers and realizing the reflow and aggregation of various factors, reducing the financing threshold for industrial development, thus promoting regional industrial division of labor and location selection (Hamada [17]; Krugman [18]; Cai and Xu [19]). On the other hand, free trade zone pilot policies are conducive to industrial agglomeration, improving labor productivity, and the cities where free trade zone pilot policies are established have radiation effects, driving the formation of industrial upgrading in surrounding cities.

Industrial structure upgrading has a certain promoting effect on the level of regional human capital. Industrial structure upgrading will provide space for the development of technology-intensive industries, and the application of advanced technology will increase the demand for labor skills, driving the improvement of the regional level of human capital. At the same time, areas with advanced production technology and generous wages are more likely to attract the gathering of human capital from surrounding areas (Ni and Ding [20]).

(2) Increasing investment in education can significantly promote the improvement of human capital.

Cities that implement policies to establish free trade zones have more complete transportation, communication, and transportation facilities, which reduce the mobility costs of individuals and make communication between regions easier, thereby having a greater impact on people's ideas and being more conducive to strengthening education investment in various regions (Lv and Liu [9]). At the same time, the free trade zone pilot policy significantly promotes regional economic growth (Heand Tang [21]), increases the income level of local residents, and enhances education investment.

Education is the main way to form human capital, and government education investment is positively correlated with the accumulation of human capital growth, and education investment has a long-term impact. The more financial investment there is in education, the more educated the population will be, and the length of time that workers receive education will increase, which is beneficial to the improvement of professional human capital. Hou and Liao [22] used the VECM model to verify that government education investment is positively correlated with the accumulation of human capital growth and that there is a stable equilibrium relationship between financial education investment and human capital. The short-term impact of financial investment in education on human capital level is less than the long-term impact.

3.2. Progressive PSM-DID Model Construction. The difference-in-differences (DID) method is commonly used to evaluate the effects of randomized or natural experiments. It evaluates the changes in the dependent variable based on the counterfactual framework of a policy occurring or not occurring. To make the model more effective, the parallel trend assumption needs to be met, which means that the average level of human capital in the control group and treatment group should have parallel trends over time in the absence of the policy trial. Therefore, the key to implementing the DID model is to find an appropriate control group that is not affected by the policy and is extremely similar to the treatment group.

To improve the reliability of the DID model, this paper uses the propensity score matching (PSM) method proposed by Heckman [23]. Theoretically, the PSM method is suitable for nonrandom data, and its theoretical framework is the counterfactual reasoning model. The selection of trial cities for the free trade experimental zone in this study is not random but related to their economic development, transportation conditions, geographical location, and other factors, indicating that the sample in this study is

nonrandom. In addition, there are significant differences between cities, making it difficult to find a control group that is very similar to the treatment group in all aspects. Therefore, the propensity score matching method can solve the problem of sample selection bias, control confounding factors, and reduce interference.

PSM can solve the problem of sample selection bias, but cannot avoid endogeneity caused by omitted variables. The DID model can solve endogeneity, but there is a problem of sample selection bias. Therefore, this study combines the PSM and DID models to verify the effects of the free trade experimental zone policy on regional human capital levels. The PSM-DID model first needs to perform propensity score matching and then conduct the DID based on the data after matching. Since the free trade experimental zones in this study were established at different times, the model used is as follows:

$$y_{it} = \beta_0 + \beta_1 \times \text{Treat}_{it} \times \text{Time}_{it} + \beta_2 \sum \text{Control}_{it} + \varepsilon_{it}, \tag{1}$$

where Control_{it} denotes the control variables, and the coefficient of the interaction term between the two β_1 denotes the net policy effect of the establishment of the FTZ which is the focus of the article.

In addition, to further validate the dynamic marginal impact of the pilot FTZ policy on regional human capital levels, the article introduces a time dummy variable based on the model, as follows:

$$y_{it} = \beta_0 + \beta_1 \times \text{Treat}_{it} + \beta_2 \times \text{Treat}_{it} \times \text{Time2015} + \cdots + \beta_7 \times \text{Treat}_{it} \times \text{Time2020} + \beta_8 \sum \text{Control}_{it} + \varepsilon_{it}, \tag{2}$$

where Time2015 and Time2020 correspond to the time dummy variables for 2015 and 2020, respectively. In the meantime, the steps for operating the multitemporal PSM-DID model are shown in Figure 1.

3.3. Description of the Data

3.3.1. Data Sources and Sample Selection. The pilot free trade zone policy was first established in 2013, followed by the establishment of six batches of free trade zones, for a total of 21 free trade zones established up to August 2022, with their establishment dates being 2013, 2015, 2017, 2018, 2019, and 2020. Given the availability of data, the article selects the period 2000–2020 as the study period. In addition, cities with FTZs established between 2018 and 2020 are set up in 2018, 2019, and 2020 as the control group due to the relatively short establishment period, which makes it difficult to reflect the effect of the pilot policies of FTZs. The establishment of the pilot free trade zone policy is only a slice of the world, and the use of provincial panel data would exaggerate the pilot free trade zone policy effect, making the findings after the PSM-DID test inaccurate and unconvincing. Therefore, the article narrows the scope of the study to prefecture-level cities. Excluding cities with more missing data (Tibetan region, Hainan region, Zhongwei city, Haidong city, Turpan city, Hami city, etc., while the article does not consider Hong Kong, Macao, and Taiwan regions at this time given the availability of data), the final sample examination period is 28 prefecture-level cities from 2000 to 2020. The study targets the first three batches of established free trade pilot zone; Pingtan city data which is seriously missing will be excluded, so the treatment group is 21 prefecture-level cities, treatment group cities, and the year of establishment as shown in Table 1. For the missing data of some prefecture-level cities, multiple interpolation methods were used to complete the data by referring to relevant literature. In addition, the GDP deflator was used to exclude the influence of price factors and make the results more convincing. The data in the article were obtained from the China Urban Yearbook, the China Regional Economic Yearbook, and provincial and municipal statistical yearbooks.

3.4. Selection of Variables

3.4.1. Explanatory Variables. Education is the most important component of human capital, and a higher level of education represents a higher level of education investment. Educational investment is the main way to accumulate human capital, and therefore, the level of education can naturally measure the stock of human capital for individuals or economies. Domestic scholars generally use the average years of education to measure it, but considering the large amount of missing data, this article refers to Lan et al.'s [24] indicator for measuring the level of human capital, selecting the number of students in ordinary high schools as a proxy variable for the level of human capital.

3.4.2. Core Explanatory Variables. We refer to the cities that established free trade zones during the sample period as the treatment group, and we set "treat" to 1 for this group, while "treat" is set to 0 for the nontreatment group. This is followed by the time variable, which is a dummy variable that looks at whether the city is in the year of policy implementation and beyond. If the city has an FTZ in the period under consideration, then the FTZ is assigned a value of 1 for the year in which it was established and for the years that follow; for example, if the Shanghai FTZ was established in 2013, then the Time variable should be assigned a value of 1 for the year in which it was established and 0 for the year before 2013. Measuring the year in which a city was subject to policy implementation and subsequent years requires the use of the interaction between time variables and group variables Treat × Time, which is also the core explanatory variable of the article.

3.4.3. Matching Variables. Based on propensity score matching, the study applies the asymptotic double difference method to reduce the initial differences between the treatment group and the control group, and selects factors that may affect the establishment of pilot free trade zones as much as possible. The establishment of free trade zones is mainly influenced by national policies, geographical location, labor

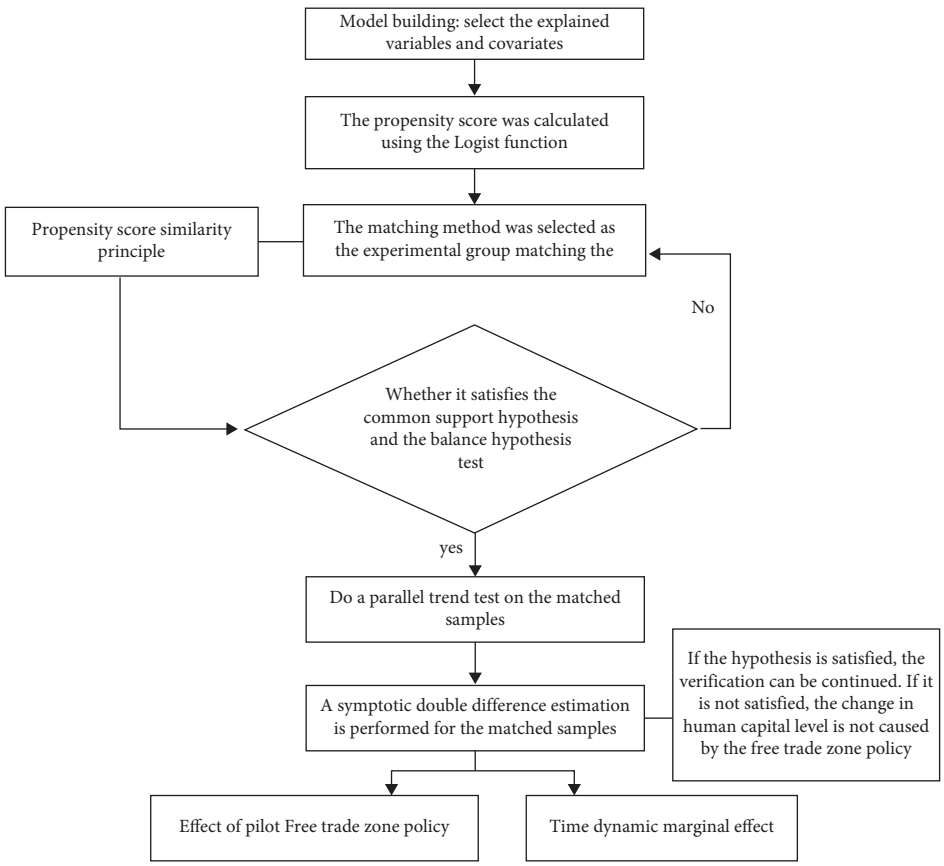

Figure 1: Multiphase PSM-DID model operational steps.

Table 1: The establishment time of the free trade zones and their affiliated provinces.

Year of establishment	Province	Area
2013	Shanghai	Waigaoqiao free trade zone, Waigaoqiao tax preparation logistics park, Yangshan tax preparation port area, Pudong airport comprehensive free trade zone
2015	Guangdong	Nansha new area, Guangzhou; Shekou, Qianhai, Shenzhen; Hengqin new area, Zhuhai
	Fujian	Fuzhou, Xiamen, Pingtan
	Tianjin	Tianjin port, Tianjin airport, Binhai new area central business district
	Shanghai	Lujiazui financial district, Jinqiao development district, Zhangjiang high-tech district
2017	Liaoning	Dalian, Shenyang, Yingkou
	Zhejiang	Zhoushan outlying islands, northern Zhoushan island, southern Zhoushan island
	Henan	Zhengzhou, Kaifeng, Luoyang
	Hubei	Wuhan, Yichang, Xiangyang
	Chongqing	Liangjiang area, Xiyong area, Guoyuan port area
	Sichuan	Chengdu new talented area, Chengdu Qingbaijiang railway port, Sichuan south Lingang
	Shaanxi	Central area, Xi'an international port area, Yangling demonstration zone
2018	Hainan	The whole island of Hainan
2019	Guangxi	Nanning, Qinzhou port, Chongzuo
	Shandong	Jinan, Qingdao, Yantai
	Jiangsu	Nanjing, Suzhou, Lianyungang
	Yunnan	Kunming, Honghe, Dehong
	Heilongjiang	Harbin, Heihe, Suifenhe
	Hebei	Xiong'an, Zhengding, Caofeidian, and Daxing airports
	Shanghai	Lingang new area
2020	Beijing	Haidian district, Changping district, Zhongguancun, Shunyi district, Chaoyang district, Tongzhou subcentre, Daxing district
	Hunan	Changsha, Yueyang, Chenzhou
	Anhui	Hefei, Wuhu, Bengbu

resources, etc. Drawing on the indicator selection of Ye [25], this study selects seven variables: employment level, regional economic development, service industry development level, government size, financial development level, real estate investment, and degree of opening to the outside world. Among them, the employment level is represented by the number of employed people, the regional economic development level is measured by the gross regional product, the service industry development level is measured by the proportion of the tertiary industry to the regional GDP, the financial development level is measured by the balance of deposits of financial institutions, and the degree of opening to the outside world is measured by the ratio of total import and export trade to regional GDP in each city.

3.4.4. Control Variables. This article considers indicators that affect human capital level as control variables. Human capital is formed through human capital investment, with investment sources mainly from government and individual inputs, as well as externalities of human capital. This article selects these control variables for the following reasons:

Education expenditure: education is the main way to form human capital, and fiscal education expenditure provides financial support for educational activities. Hou and Liao [22] used the VECM model to verify that government education investment is positively correlated with human capital accumulation and that there is a stable equilibrium relationship between fiscal education investment and human capital. The short-term impact of education fiscal investment on human capital levels is less than the long-term impact.

Development level of financial institutions: finance is also an important source of education investment, representing the market force, providing important funding sources for various market entities to invest in education, and allowing various entities to rationally finance to meet their own education investment needs. Yang et al. [26] verify that financial development can promote human capital accumulation from the perspective of modern human capital investment theory and based on the dual role of "government-market" in China.

Degree of openness to the outside world: Wen and Dai [11] verify that the impact mechanism of trade openness on human capital level mainly comes from four aspects: wage price mechanism, technological progress mechanism, capital investment mechanism, and credit constraint mechanism. The greater the degree of openness to the outside world, the more conducive it is to attracting talent.

Actual average employee salary: income level determines the resource capacity available to society and families for education investment and is an important determinant of human capital level.

Real estate investment amount: Li [27] has proposed that the high-speed growth of real estate investment in the labor cost-effectiveness mechanism significantly promotes regional labor wages, and the increase in wages will promote the growth of human capital investment.

Level of economic development: in general, the level of economic development is directly proportional to the degree of talent agglomeration.

Employment scale: the larger the number of employment positions, the easier it is to attract out-of-town employees, gradually forming a talent agglomeration.

Among them, the employment scale uses the number of employed persons as a proxy variable, and the development level of the service industry uses the proportion of the tertiary industry to the regional GDP as its proxy variable. For the missing data, multiple imputations are used to fill in the missing values, and logarithmic transformation is applied to real estate investment, regional GDP, and employment scale to eliminate price factors. Table 2 is the variable index required in this paper.

4. Analysis of the Empirical Results

4.1. Descriptive Analysis. The selected indicators were first analyzed descriptively. According to Table 3, there are 5,502 samples in the control group and 441 samples in the experimental group in cities without free trade zones. The average level of human capital in the control group is 2.956, while in cities with free trade zones, i.e., the experimental group, the average human capital level is 3.419. Compared to the control group, the experimental group has a significantly higher level of human capital. Based on this observation, this paper puts forth the preliminary hypothesis that the policy of setting up a free trade zone can improve the level of human capital, and the next step is to test this hypothesis.

4.2. Propensity Score Matching Results. The paper draws on the results of propensity score matching from Becker and Ichino [28], Blundell and Costa Dias [29], and Heyman et al. [30], using kernel matching and a year-by-year matching approach. In addition, to reduce the interference of subjective selection factors on the evaluation of the FTZ policy, this paper refers to Zhang and Yu's [2] research on the factors affecting the pilot FTZs and selects real estate investment, level of service industry, regional economic development level, government size, level of financial development, basic medical facilities, and employment level as matching variables. Taking 2013 as an example, the matching method uses kernel matching and combines observable matching variables to first calculate the predicted probability values of the FTZ policy for each city using a logistic model and then finds a unique control city without an FTZ for each city with an FTZ policy (the treatment group). After matching, samples that were not successfully matched were removed, and finally, the corresponding control cities were found for the treatment group cities in 2013. Using the same method, for cities with FTZs in other years, the corresponding control cities were found for the treatment group cities in the respective years. Table 4 shows the results of the balance hypothesis test after

Table 2: Variable description.

Variable type	Variable name	Variable definition
Explanatory variables	Human capital level	The logarithmic form of the number of students enrolled in ordinary high schools
Core explanatory variables	Time variable	$Time_{it}$ (it is 0 before the implementation of the pilot free trade zone, and 1 for all other years)
	Group variable	$Treat_{it}$ (a binary variable that takes the value of 1 if the city is designated as a pilot zone for the free trade area, and 0 otherwise)
	Interaction term between time and group variables	$Time_{it} \times Treat_{it}$
Matching variables	Employment development level	Logarithmic form of the number of employed population
	The level of regional economic development	Logarithmic form of gross regional product (GRP)
	The level of development in the service sector	The proportion of the tertiary industry in the gross regional product (GRP)
	The size of government	Logarithmic form of fiscal expenditure
	Financial development level	Logarithmic form of year-end deposits balance of financial institutions
	Real estate investment	Logarithmic form of real estate investment
	The degree of openness to the outside world	The proportion of import and export trade volume to gross regional product (GRP)
Control variables	Government spending on education	Logarithmic form of education expenditure
	Level of financial development	Logarithmic form of deposits balance of financial institutions
	The degree of openness to the outside world	The proportion of import and export trade volume to gross regional product (GRP)
	Average salary of employees	Logarithmic form of average employee salary
	Real estate investment	Logarithmic form of real estate investment amount
	Gross regional product (GRP)	Logarithmic form of gross regional product (GRP)
	Employment scale	Logarithmic form of the number of employed population
	Level of service sector development	The proportion of the tertiary industry in gross regional product (GRP)

Table 3: Comparison of samples from the treatment and control groups.

Variable name	Treatment group sample (N = 441)		Control group sample (N = 5502)	
	Mean	SD	Mean	SD
Ln number of students in general secondary schools	3.419	0.812	2.956	0.69
Ln gross regional product	16.794	1.129	15.523	1.027
The tertiary sector as a proportion of regional GDP	0.459	0.097	0.379	0.089
Ln real estate investment	14.613	1.519	12.761	1.574
Degree of openness to the outside world	0.604	0.754	0.178	0.454
Ln average wage of employees	10.129	0.608	9.937	0.651
Ln financial expenditure	14.706	1.299	13.563	1.111
Ln balance of deposits with financial institutions at the end of the year	8.042	1.408	6.448	1.179
Ln education expenditure	12.805	1.254	11.878	1.092
Ln number of persons employed in the unit	4.611	0.978	3.407	0.712

matching. Considering that a year-by-year matching approach was used in the study, only the test results for 2018 are reported in the main text. It can be observed from Table 4 that the standardized deviation absolute values of the 7 covariates such as employment scale and real estate investment are all within 10%, and after matching, their standardized deviation is significantly reduced, indicating that the matching variables and matching method used in the paper are reasonable and effective. At the same time, from the change in t-statistics, it can be seen that the P values of the matching variables before matching significantly reject the null hypothesis at the 1% significance level, indicating that there are significant differences in the 7 matching variables before matching. However, the P values after matching are 0.927, 0.911, 0.897, 0.752, 0.965, 0.981, and 0.962, respectively, and cannot reject the null hypothesis, indicating that there are no significant differences in the 7 matching variables between the treatment and control groups after matching. Through the balance test, the reliability of the subsequent experiments can be ensured.

Subsequently, the balance test graph based on propensity score matching also shows that, as can be observed from Figure 2, before PSM matching, the standardized deviations

Table 4: Balance test.

Variables	Unmatched Matched	Mean Treated	Mean Control	% reduction % bias	% reduction Bias	t test t	t test $P>t$	$V(T)/V(C)$
Ln number of people employed in the unit	U	4.900	3.539	151.300		7.700	0.000	1.820
	M	4.526	4.497	3.100	97.900	0.090	0.927	0.930
Ln real estate investment	U	15.505	13.906	138.600		6.010	0.000	0.920
	M	15.178	15.134	3.800	97.200	0.110	0.911	0.940
Ln balance of deposits with financial institutions at the end of the year	U	8.929	7.395	144.900		7.380	0.000	1.820
	M	8.493	8.447	4.400	97.000	0.130	0.897	0.930
Ln financial expenditure	U	15.718	14.639	132.100		7.010	0.000	2.130
	M	15.382	15.303	9.700	92.700	0.320	0.752	1.490
Degree of openness to the outside world	U	0.456	0.140	96.500		5.900	0.000	3.54*
	M	0.382	0.376	2.000	97.900	0.040	0.965	0.800
Level of service industry development	U	0.535	0.455	95.100		4.480	0.000	1.340
	M	0.506	0.505	0.800	99.200	0.020	0.981	0.860
Ln gross regional product	U	17.537	16.257	140.300		6.630	0.000	1.360
	M	17.192	17.207	−1.600	98.800	−0.050	0.962	0.870

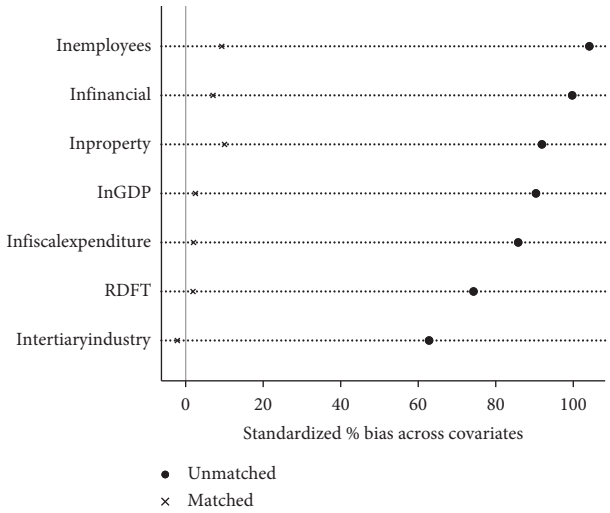

Figure 2: Plot of standardized deviations of covariates.

of the indicator variables deviate far from the zero vertical line, and their values are scattered. After matching, the standardized deviations of the covariates are clustered around the zero level, and the seven matched variables including employment size, financial institution development level, regional GDP, real estate investment, government size, service industry development level, and openness to the outside world have achieved satisfactory matching results. This result indicates that the differences between the treatment and control groups are relatively reduced after PSM matching, and meet the conditions of the balance test.

4.3. Parallel Trend Test. The overall steps of the parallel trend test are as follows: For the treatment group, according to the time when the free trade zone was established in each city, the treatment variable for policy effectiveness, preintervention, and postintervention is generated. Taking the Shanghai free trade zone as an example, the year of its establishment was 2013, and the treatment variable for policy effectiveness (current = 0) is set as 1. The variables for preintervention and postintervention are named pre_1, pre_2, post_1, and post_2, respectively, according to the principle mentioned above. Based on the policy intervention time of the treatment group, the core explanatory variables selected are preintervention variables for 10 periods, postintervention variables for 5 periods, and the year of the policy intervention. In addition, to avoid the issue of multicollinearity, the variable for preintervention period 1 is not considered, and the city and time effects are fixed when conducting the parallel trend test.

Figure 3 shows the parallel trend test diagram. It shows that "current = 0" represents the starting point of the policy intervention, which is on the left side of the zero axis. The coefficients for all variables are significantly different from zero, indicating that there is no significant trend difference between the treatment and control groups before the establishment of the free trade zone. On the right side of the zero axis, the coefficients for the fourth and fifth years after the policy intervention are significantly different from zero. Therefore, the article concludes that the parallel trend hypothesis is satisfied and that the effect of the free trade zone policy on the level of human capital has a significant positive impact, which can be further verified using the difference-in-differences method.

4.4. Average Impact Effects. The following analysis will use the asymptotic double difference fixed effect model to verify the effects of various pilot policies in each free trade zone, using a multiperiod DID method due to the different times of policy implementation. In the asymptotic double difference, the logarithmic form of the number of high school students is used as a proxy variable for human capital, which is the dependent variable in the article. The interaction term between the treatment group and policy effectiveness is used as the core explanatory variable. Factors that affect the level of human capital are used as control variables. Two experiments are conducted, one with the inclusion of control variables and one without. The results are shown in Table 5.

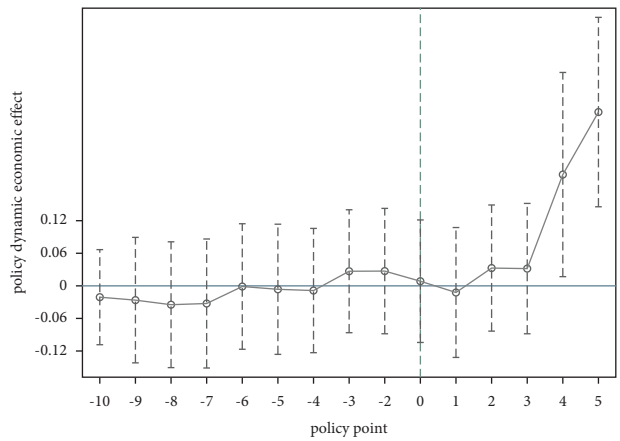

Figure 3: Parallel trend test chart.

Table 5: Baseline regression model.

Variables	Ln number of students enrolled in general secondary schools	Ln number of students enrolled in general secondary schools
Treat ∗ Time	0.056** (2.42)	0.035* (1.69)
Ln gross regional product		−0.002 (−0.05)
Level of service industry development		0.579*** (8.02)
Ln real estate investment		0.008 (1.11)
Ln average wage of employees		−0.282*** (−13.66)
Openness to foreign trade		−0.021*** (−3.2)
Ln number of people employed in the unit		0.038*** (3.26)
Ln education expenditure		0.391*** (21.48)
Ln year-end financial institution deposit balances		−0.033 (−1.64)
Constant term	3.153*** (1175.41)	1.004 (1.51)
Time fixed effects	Control	Control
Urban fixed effects	Control	Control
Sample size	4003	4003
R-squared	0.9227	0.9366

The asterisks in Table 5 represent the significance level, and the values in parentheses represent the t-values of the variables.

Table 5 shows the results of the baseline regression model. In the first type of model in the table, which is the asymptotic double difference without the inclusion of control variables, the interaction term between the treatment group and the policy effectiveness is significantly different from zero at the 5% significance level, and its coefficient is positive. In the second type of model, which is the asymptotic double difference with the inclusion of control variables, the interaction term between the treatment group and the policy effectiveness is significantly different from zero at the 10% significance level, and its sign is also positive. Although the coefficient of the interaction term in the model with control variables is smaller than that in the model without control variables, the results suggest that regardless of the inclusion of control variables, there is a clear causal relationship between the establishment of free trade zones and regional human capital levels. In general, free trade zone policies have a significant positive effect on regional human capital levels.

In addition, the regression results in Table 5 indicate that the control variables have different effects on regional human capital. First, the coefficient of education expenditure is significantly positive at the 1% level, indicating that a higher proportion of education expenditure is favorable for improving the level of regional human capital. Human capital is formed through investment in human capital, which is mainly measured by cultural and educational expenditures. Education expenditure is an important way of investing in human capital, and an increase in education expenditure means an increase in investment in human capital, which inevitably leads to an increase in the level of human capital (Lv and Liu [9]). The coefficient of the proportion of the tertiary industry is significantly positive, indicating that the rapid development of the service industry promotes the improvement of regional human capital. The coefficient of population density is significantly positive at the 1% level, indicating that the growth of the population in a certain area will also bring about an increase in the level of human capital, known as the demographic dividend. Second, trade openness can promote the shift

of production and exports to technology-intensive products, thus increasing the proportion of skilled labor in the total population (Flug and Galor [31]). If the coefficient of trade openness is negative at the 1% level while controlling for the impact of urban employment size, the impact of trade openness on human capital is negative, indicating that trade openness has not brought about an increase in the level of human capital in various cities. When controlling for urban employment size, the coefficients of trade openness are negative, while the coefficient of employment size is significantly positive at the 1% level. The coefficient of the average salary level of employees is significantly negative at the 1% level, indicating that the increase in average employee wages has not led to an increase in the level of human capital. This may be because the average employee wage cannot truly reflect income inequality, which seriously hinders residents with lower initial wealth levels from investing in human capital (Chao and Shen [32]). Moreover, given the availability of data, the employee average wage indicator in the article only measures the overall level of a region, and there may be a phenomenon of excessive income inequality among employees within the region. On the other hand, the establishment of the free trade zone will inevitably lead to an increase in the degree of trade openness, and the increase in income from exports will raise the opportunity cost of school education, leading to more young people dropping out of school (Atkin [33]).

4.5. Dynamic Analysis. Based on the results of the above tests, it can be seen that the pilot FTZ policy have a positive contribution to the level of human capital. The following test examines the dynamic policy effects of the pilot free trade zone to analyze how the establishment of the free trade zone policy has evolved to affect the level of human capital.

The article draws on the methodology of Dai and Cao [34] (2015) and sets up to denote the effect of policy implementation in the first year of the point in time; post_1 denotes the effect of policy implementation in the second year of the pilot and so on, with the article examining the effect of policy implementation pilots up to the fifth year. Table 6 presents the regression results, and the article uses the model without the inclusion of control variables as a control for both models controlling for time and individual fixed effects. As can be seen in Table 6, in the model without the inclusion of control variables, the coefficients are not significant from the first to the third year of the FTZ policy pilot, but in the fourth year of the FTZ policy implementation, the coefficient is positive at the 5% level of significance, and in the fifth year of the FTZ policy pilot, its coefficient is positive at the 1% level of significance, indicating that the FTZ policy pilot can This indicates that the pilot FTZ policy can improve the level of regional human capital, and the effect becomes more obvious over time, indicating that the impact of the pilot FTZ policy on the level of regional human capital has a lagging effect. However, after adding the control variables, the results in Table 6 show that the coefficient of the interaction term $\text{Time}_{it} \times \text{Treat}_{it}$ is not significant within 1–4 years after the establishment of the pilot FTZ policy but five years after the establishment of the pilot FTZ policy, the effect of the pilot FTZ policy on the regional human capital level shows a significant boosting effect, i.e., the boosting effect of the pilot FTZ on the human capital level has a significant lag. Therefore, as the pilot FTZ is set up as a slice of the city, it is not able to quickly boost the human capital of the city through the radiation effect in a short period. After the inclusion of the control variables, the effects of the pilot policy are largely the same, both showing a significant boost to human capital levels in the fourth and fifth years of the pilot free trade zone policy, but this boost has a significant lag. The reason for this is that the FTZ has a relatively small jurisdiction compared to a city, transport facilities are not perfect, and the import and export demand of the FTZ is not stable, the radiation effect of the FTZ is not obvious in the early stages of establishment, and the measures to introduce talents are relatively imperfect, so the ability to attract talents is not very strong.

4.6. Placebo Test

4.6.1. Stochastic Pseudo-Processing Variables and Stochastic Pseudopolicy Dummy Variables. To verify the robustness of the PSM-DID results, the method of placebo tests proposed by Huang et al. [35] was used in this study. Specifically, the policy implementation time points of the free trade zone experiment studied in the article were in 2013, 2015, and 2017, and the policy timing was not a traditional "one-size-fits-all" approach. Therefore, the article first randomly generated pseudotreatment groups, then generated pseudopolicy dummy variables, and finally stored the estimated coefficients, standard errors, and P values from 500 regressions. Since the data used in the article is panel data, only one period of data is retained at first. In this case, we selected the data from the year 2000. Then, 21 samples are randomly drawn from it (there were 21 treatment groups in the article). The city names of the selected samples are retained, and then one-to-many matching is performed based on the city names of the data after propensity score matching. The matched samples are the pseudotreatment group" samples in the article, and the unmatched ones are the control group samples. In the real experiment, there were a total of 283 cities in the control and treatment groups, with 21 cities in the treatment group and 262 cities in the control group. The sample data after propensity score matching is then randomly shuffled using random numbers in Stata software, and a pseudopolicy dummy variable sample is generated by randomly selecting one year from the 283 prefecture-level cities. The pseudotreatment group and pseudopolicy dummy variable samples are then merged, and the control variables are selected for regression. The coefficient matrix, standard error matrix, and P value matrix are set up, and the results of 500 regressions are assigned to the corresponding positions in the matrices. The P values are then calculated and assigned to the matrix, and the results are presented in the form of images.

Table 6: Dynamic analysis.

Variables	Ln number of students enrolled in general secondary schools	Ln number of students enrolled in general secondary schools
Post1	−0.001 (−0.030)	0.002 (0.070)
Post2	0.044 (1.020)	0.029 (0.730)
Post3	0.043 (0.940)	0.048 (1.150)
Post4	0.214** (2.460)	0.107 (1.350)
Post5	0.329*** (4.150)	0.187*** (2.590)
_cons	3.153*** (1182)	0.975*** (4.570)
Control variables	No	Yes
Time fixed effects	Control	Control
Urban fixed effects	Control	Control
Sample size	4061	4061
R-squared	0.9236	0.9267

Figure 4 displays the distribution of the estimated coefficients and corresponding *P* values for the 500 placebo virtual policy variables. The horizontal dashed line indicates the significance level of 0.1. As can be seen from the figure, most of the estimated coefficients are centered around zero, and the majority of the *P* values are greater than 0.1 (i.e., not significant at the 10% level), indicating that the estimated results are unlikely to be due to chance and that the positive effect of the free trade zone on human capital is not driven by other policies or random factors. The 500 regression coefficients at different (policy implementation) times are also plotted as a kernel density graph. According to Table 5, the coefficient of the core explanatory variable is 0.035, with a standard deviation of 1.69, indicating that the increase in human capital is due to the establishment of the free trade zone pilot.

4.6.2. When the Replacement Treatment Group Policy Occurred. To eliminate the interference of other factors on human capital, this article changes the time of establishment of the FTZ policy. For the case of multiple time points in the article, it is assumed that the actual time for all prefecture-level cities to establish the FTZ is advanced by 3 periods, 4 periods, and 5 periods, and the establishment time of the FTZ pilot zone is uniformly set as 2010. Individual fixed effects and time fixed effects are simultaneously controlled to examine whether the coefficients of the interaction term between the treatment group and the policy time variable are significant in different situations. As shown in Table 7, regardless of whether the FTZ policy is uniformly established in 2010 or advanced by 3 periods, 4 periods, or 5 periods, the *P* values of the interaction term between the treatment group and the policy variable are all greater than 0.05, indicating that the null hypothesis of the interaction term coefficient being 0 cannot be rejected. This indicates that the results of this study are robust and that the establishment of the FTZ pilot zone has had an impact on human capital levels.

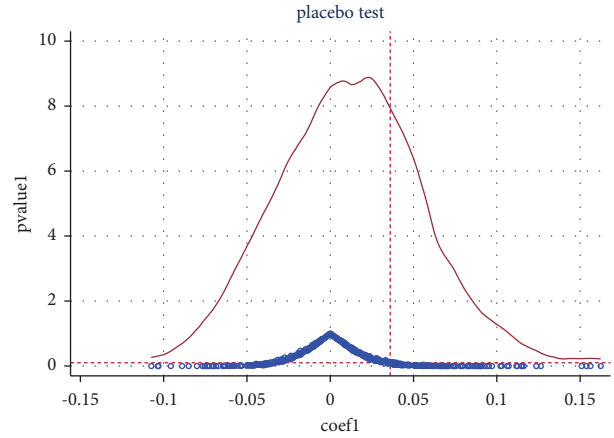

Figure 4: Placebo test chart.

4.7. Robustness Tests

4.7.1. Changing the Matching Method. In addition, to ensure the reliability of the results, the paper used a different matching method. First, the nearest neighbor one-to-ten matching method was used. Table 8 shows the results of using seven matching variables, including employment size, regional GDP, government finance scale, service industry development level, real estate investment, financial institution development level, and degree of openness to foreign trade, to find a new control group for analysis while controlling for individual fixed effects and time fixed effects. The coefficients of the core explanatory variables and control variables in the model are positive and significant at the 5% level, indicating that the experiment with the changed propensity score matching method (nearest neighbor one-to-ten matching) still shows that the establishment of free trade zones can promote the improvement of regional human capital levels. The paper also validated the original data using the nearest neighbor caliper matching method, and the coefficient of the interaction term between the treatment group and the policy timing is positive at the 10% level of significance, indicating that the conclusion drawn using the radius matching method is still valid. Furthermore, the paper validated the original data using the radius matching method, and the coefficient of the interaction term between the treatment group and the policy timing is significant at the 1% level, indicating that the conclusion drawn using the radius matching method is still valid.

4.7.2. Replacement of Explanatory Variables. Robustness tests can also be conducted by replacing the dependent variable to test the sensitivity of the results. Following the method of Liang and Ji [36], some studies have used the number of regular high school teachers as a measure of human capital. Therefore, in the robustness test, the dependent variable will be replaced with the number of regular high school teachers, and it will be processed logarithmically. The same kernel matching method will be used, and the matching variables of employment scale, regional GDP, government fiscal scale, service industry development level,

Table 7: Placebo test results.

	Uniform time	Policy advanced 3 periods	Policy advanced 4 periods	Policy brought forward 5 periods
$Treat_{it} \times Time_{it}$	0.013 (0.280)	0.032 (0.730)	0.025 (0.560)	0.021 (0.450)
Constant term	1.014 (0.700)	1.013 (0.700)	1.014 (0.700)	1.016 (0.700)
Control variables	Control	Control	Control	Control
Individual fixed effects	Control	Control	Control	Control
Time fixed effects	Control	Control	Control	Control
*R*_squared	0.926	0.937	0.936	0.936

Table 8: PSM-DID results for the replacement matching method.

	N (10)	*N* (6) caliper (0.1)	Radius matching
Treat ∗ policy	0.047** (2.380)	0.038* (1.850)	0.057*** (3.010)
Constant term	1.665* (1.680)	−1.494 (−1.330)	1.037 (1.590)
Control variables	Control	Control	Control
Individual fixed effects	Control	Control	Control
Time fixed effects	Control	Control	Control
Sample size	1977	1466	4184
*R*_squared	0.946	0.952	0.939

Table 9: Analysis of PSM-DID results for replacement of explanatory variables.

Variables	(1) ln number of full-time teachers in general secondary schools	(2) ln number of full-time teachers in general secondary schools
Treat ∗ policy	0.061*** (3.437)	0.036** (2.34)
Constant term	9.678*** (4600)	8.797*** (17.750)
Control variables	No control	Control
Individual fixed effects	Control	Control
Time fixed effects	Control	Control
Sample size	3986	3986
*R*_squared	0.9448	0.9586

Table 10: Heterogeneity analysis.

	East	Western	Central region
Treat ∗ time	0.078*** (3.44)	0.082* (1.87)	0.081** (1.97)
Constant term	−2.758* (−1.8)	4.268** (2.41)	2.804 (1.59)
Control variables	Control	Control	Control
Individual fixed effects	Control	Control	Control
Time fixed effects	Control	Control	Control
*R*_squared	0.962	0.959	0.964

real estate investment, financial institution development level, and degree of openness to foreign trade will be used as control variables. Individual fixed effects and time fixed effects will also be controlled, and the same control variables will be used to perform a difference-in-differences analysis. In addition, a model without control variables will be included for comparison. If the results are consistent with the previous findings, it indicates that the results are robust, i.e., the pilot policy of the free trade experimental zone helps to promote the improvement of human capital.

Table 9 presents the results of the difference-in-differences regression analysis using logarithmically transformed regular high school teacher numbers as the dependent variable after PSM matching. From the table, we can clearly conclude the following: When no control variables are added, the coefficient of the interaction term between the treatment group and policy time is 0.061 and is significantly positive at the 1% level, indicating that the pilot policy of the free trade experimental zone has a positive effect on the improvement of regional human capital. In the model with control variables, the coefficient of the interaction term between the treatment group and policy time decreases slightly to 0.036, but its value remains positive at the 5% significance level. Overall, the regression results using the alternative dependent variable are consistent with the previous findings, indicating that the results are robust.

4.8. Heterogeneity Analysis. In this study, geographical division rules were used to classify regions into the eastern, central, and western regions, and further PSM-DID tests were conducted for each region to perform heterogeneity analysis. Table 10 shows that in the western region, the policy effect of the establishment of free trade zones on human capital level is the strongest, followed by the central region, and the eastern region has the weakest effect. The reason for this may be that the eastern region is generally more developed, and its natural resources, economic development, and talent introduction policies have already played a significant role in attracting talent. On the other hand, the western and central regions are relatively less developed, and the establishment of free trade zones promoting free trade openness could have significant effects to these regions.

5. Conclusions and Recommendations

When analyzing the impact of a free trade zone on human capital levels, descriptive analysis and PSM-DID models were first used to study the human capital levels of cities that have established free trade zones. The results of the descriptive statistics showed that the average human capital level in the control group sample was 2.956, while the average human capital level in the treatment group sample was 3.419, indicating that the human capital level in the treatment group was significantly higher than that in the control group.

Next, seven matching variables, including employment scale, financial institution development level, regional GDP, real estate investment, government size, service industry development level, and degree of openness to the outside world, were used for propensity score matching, and the results showed that the balance test was met. Parallel trend tests were then conducted using graphical methods and regression methods to eliminate interference from other factors on human capital levels. The results showed that the coefficients of "current = 0," which represents the starting point of policy establishment on the zero coordinate axis, were not significantly different from 0, indicating that there was no significant difference in the trend of change between the experimental and control groups before policy implementation.

The average policy effect was then estimated, and the results showed that regardless of whether the control variables were added, the core explanatory variable coefficient was significantly positive at the 10% level, indicating that there was a significant positive promoting effect of free trade zone policy on regional human capital levels overall. The dynamic effect analysis demonstrated that the free trade zone had a significant lag effect on human capital levels. In addition, the impact of free trade zone policies on human capital levels varies in different regions, and there are different policy effects. Among them, the promotion effect of free trade zones on human capital levels is most significant in Western regions, followed by central regions, and finally in eastern regions. Therefore, in the future development path of free trade zones, it is necessary to continuously improve regional infrastructure, promote mutual exchange between regions, and place emphasis on education to increase personal and national investment in education. Secondly, innovative enterprises should be continuously introduced to increase employment demand, and relevant policies should be used to attract talent. Finally, development plans should be formulated based on the geographical location and endowments of each region. The policy effects of free trade zones in economically developed regions are not very significant compared to other regions. This may be due to the fact that these regions have inherent advantages that are attractive enough to attract talent, resulting in saturation. In the future, free trade zones in economically developed regions will need to explore other systems to better drive surrounding areas.

The construction of free trade zones needs to continuously improve the institutional mechanisms and attempt to integrate with other systems into a management approach, form a service model, and create an external image. They should focus on establishing a sound joint conference system at a high level and frequency, building a scientific and efficient coordination mechanism and a unified planning and development mechanism, and piloting in some areas within the zone to delegate fiscal and property rights to the zone for management, clarifying the relationship between public service and market supervision responsibilities, and streamlining management, investment, and distribution mechanisms. The successful experience of pilot projects should be replicated and promoted within the zone while also being tailored to local conditions and complemented by improved management mechanisms to stimulate reform and innovation.

Innovation in free trade zone regional alliance management mechanisms should focus on encouraging free trade zones to strengthen cooperation based on economic regions, establishing a long-term assessment and evaluation mechanism for free trade zones and an important landmark achievement award system, implementing a differentiated industrial development strategy, establishing a comprehensive human resource training and exchange mechanism, actively participating in cadres' two-way job rotations with free trade zones in more open areas to promote alignment of ideology and concepts with those in more open areas, establishing a training base for serving enterprises, allowing cadres to follow and learn from the staff of enterprises, deepening their understanding of enterprise needs as ordinary employees, and establishing a personnel exchange mechanism with city-level units to truly achieve the attraction, retention, and effective utilization of innovative talents. In addition, in order to better develop each city, the cities where the free trade zones are located should increase their measures for attracting talents, expand the radiation effect of the free trade zones, promote the human capital levels of surrounding areas, improve infrastructure, and strengthen communication and cooperation between regions.

Data Availability

The data are available from the China Urban Yearbook, the China Regional Economic Yearbook, and provincial and municipal statistical yearbooks.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This research was funded by the General Projects of the National Social Science Foundation of China (grant number: 21BGL120), Provincial Quality Project Teaching Research Project (grant number: 2022jyxm030), Key Project of Natural Science Foundation of Anhui University (grant numbers: KJ2020A0017 and KJ2021A0481), Anhui Provincial Natural Science Foundation (grant number: 2108085MA04),

and Anhui University of Finance and Economics Quality Engineering Project (grant number: acszjyyb2022008).

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