The Impact of the Establishment of National High-tech Zones on Total Factor Productivity of Chinese Enterprises

Wang Mingyi, and Liu Xiaoyu*

School of International Trade and Economics, Shandong University of Finance and Economics, Jinan, China

Abstract: *The National High-tech Zone (NHTZs) is an important strategic platform for cultivating high-tech industries and realizing high-quality economic development in China. Based on the combined data from 2006 to 2014 of the industrial enterprise database, the customs database, and the China Development Zones Audit and Announcement Catalogue (abbreviated asthe Catalogue), this paper systematically investigates the influence of the construction of NHTZs on enterprise's total factor productivity (TFP). Results show that NHTZs have a positive impact on the TFP of enterprises in the zone, and this conclusion is still valid after considering endogeneity problems. Furthermore, the above productivity effects of NHTZs are heterogeneous in terms of enterprise ownership, external environment and establishment time, and NHTZs have greater stimulation effects on enterprise productivity after comparing with other types of functional zones. An investigation of the specific mechanisms at play shows that NHTZs promote the TFP of enterprises in the zone through the release of preferential policies, strengthening the "technology spillover effects" of imported intermediate goods, enhancing enterprise's innovation ability and attracting talent. In addition, based on the decomposition of industry productivity, this paper also investigates the impact of NHTZs on changes in industry productivity and finds that NHTZs promote the overall productivity of specific industries mainly by stimulating the productivity improvement of incumbent enterprises and expanding the market share of high-productivity enterprises. Moreover, the preferential policies of NHTZs do not significantly stimulate high-productivity enterprises to enter the zones, nor do they cause low-productivity enterprises to exit. This research is helpful in objectively evaluating the economic effects of the NHTZs in China and in providing a theoretical basis for its further adjustment.*

Keywords: *National High-tech Zones (NHTZs), total factor productivity (TFP), difference-in-differences, changes in industry productivity*

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1. Introduction

Since instituting its reform and opening up, China has made remarkable achievements in economic growth and scientific and technological development. Among them, the establishment and development of NHTZs is a notable highlight. According to the preliminary calculations of the Ministry of Science and Technology, the operating revenue of 169 NHTZs exceeded 47.8 trillion yuan in 2021, an increase of 11.7% year-over-year, and total profits reached 4.1 trillion yuan, an increase of 17.3% year-over- year.

* CONTACT: Wang Mingyi, email: wangmingyi2005@sina.com.

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Furthermore with only 0.1% of its total land area, the NHTZs have created about 13% of China's GDP in 2021.

In recent years, a number of Chinese enterprises with global influence, such as Huawei, Tencent, Alibaba, and Baidu, have emerged in NHTZs, and a number of world-class industrial clusters including photovoltaic, wind power, and modern energy vehicles (such as the brand of BYD) have sprung up. With a focus on business incubation and endogenous growth, NHTZs have many advantages in supporting "mass entrepreneurship and innovation." According to the *2020 Comprehensive Development and Data Analysis Report of NHTZs* released by the Torch Center of Ministry of Science and Technology, by the end of 2020 there were 739 national science and technology business incubators in the 169 NHTZs, accounting for 56.6% of the total number of national incubators of the country.

After years of development, NHTZs have made remarkable achievements in institutional reform, scientific and technological innovation, and industrial development, and they have successfully explored an effective way to connect science and technology directly with the economy (Lu and Zhang, 2006). At present, as China attempts to build a modern socialist country, the Chinese government views the development of NHTZs in order to implement the two characteristics of "high" and "new" and to build themselves into "high-quality development pilot zones" and "innovation-driven development demonstration zones" as a primary task (Xiao et al., 2021).

All this comes at a time when the TFP of Chinese enterprises has not been high for a long time (Lin et al., 2018). However, the question of how to improve TFP quickly is of great significance to the smooth implementation of China's innovation-driven strategy and even the high-quality development of the economy. A natural question is thus whether the construction of NHTZs has promoted TFP of enterprises in the zones? If the answer is yes, through which channels do NHTZs play a positive role, and what are the problems to be solved in the construction process?

A thorough clarification of the above problems would provide new ideas for reference and path support for the improvement of the TFP of Chinese enterprises and would also provide a theoretical basis for the future development direction of NHTZs. In view of this, based on the combined data of the industrial enterprise database, the customs database and the *Catalogue* from 2006 to 2014, with 62 NHTZs as research objects, this paper systematically investigates the influence of the construction of NHTZs on local enterprise's TFP using a difference-in-differences (DID) method.

In fact, since the establishment of the first national development zone[1], academic research on various types of economic function zones has proceeded uninterrupted. Most scholars do not distinguish the function and positioning of each type of the function zones and regard each function zone as a whole, merely using DID method to evaluate the policy effects of economic function zone from the perspective of region and enterprise respectively. At the regional level, Zhou et al. (2018) found that development zones have effectively promoted the upgrading of regional manufacturing industry by promoting industrial structure optimization, and Kong and Chai (2021) found that provincial development zones promoted the improvement of urban economic efficiency vis-à-vis "upgrading" policy.

From the perspective of enterprise, studies on the economic effects of development zones can be roughly divided into two groups. One uses DID method to evaluate the effects of the establishment of development zones on enterprise performance, and most of these studies find that this effect is positive. For example, Zhang et al. (2016) found that the development zones significantly promoted the employment and sales growth of enterprises and provided "high-quality"[2] environmental factors for enterprise growth, similarly to Li and Wu (2018). Furthermore, Lin et al. (2018) believe that the

[1] China's first national development zone was established in September 1984 in Dalian, mainly engaged in petrochemical, electronic information and equipment manufacturing industries.

[2] In the early stage, it refers to tax and subsidy preferences, and in the later stage, it mainly refers to the spillover effects of agglomeration economy in the zones.

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establishment of economic and technological development zones not only has a positive impact on enterprises in the zone but also has a positive spillover effect on enterprises outside the zone. However, some scholars point out that the preferential policies of development zones not only crowd out enterprise performance in surrounding zones (Bao and Tang, 2016) but also inhibit enterprises' innovation abilities (Wu and Li, 2017). The other group of literature focuses on the application of the Combes et al.'s (2012) "unconditional distribution characteristics-parameter correspondence" analysis method to the study of development zone productivity to identify the existence of agglomeration and selection effects. These studies have shown that enterprises located in development zones have higher productivity and that this advantage is mainly due to both agglomeration and selection effects (Wang and Zhang, 2016; Sheng and Zhang, 2018). In addition, a small number of scholars have investigated the impact of development zone construction on enterprise productivity from the perspectives of industry differences (Yuan et al., 2015), marketization degree (Tan and Zhang, 2019), and urban population density (Yang and Huang, 2018).

Different from other types of function zones, NHTZs are advanced development zones based on both high and new technology that rely on intellectual resource advantages such as intensive intelligence, information resources, industrial bases, and entrepreneurial atmospheres, with the goal of developing high technology and realizing industrialization. With the dual role of "industrial zone" and "science and technology park", NHTZs are of vital importance to enhancing China's economic strength and scientific and technological competitiveness.

At present, most literature on NHTZs is concentrated on the city level. Some studies show that as a "special economic zone" and "policy test field" in their respective regions, NHTZs significantly promote the growth of per capita regional GDP (Liu and Zhao, 2015) and have a positive impact on the improvement of cities' TFP (Tan and Zhang, 2018). In addition, the construction of high-tech zones promotes the evolution of urban agglomeration into innovative multi-center spatial structure modes and improves the innovation capacity and industrial level of the cities (Zhang and Gao, 2019; Li and Yang, 2019).

However, some scholars have indicated that NHTZs still drive the economic growth of their cities only through attracting factor agglomeration and fail to realize the transformation to innovation-driven development (Huang et al., 2022). Cao (2020) and Li et al. (2021) also support a similar view that the establishment of NHTZs has not promoted the high-quality development of regional economies but instead have had a negative impact on urban TFP. In addition, although high-tech zones can attract factor agglomeration to a certain extent, some scholars believe that China's high-tech zones are only "cluster in shape but not in spirit" and thus fail to achieve a real sense of industrial cluster and fail to promote the improvement of quality and the level of inter-industry cooperation and association (Yuan and Zhu, 2018). Factors such as "return to the traditional system", "reliance on the original development path", "locking of the low-end of the value chain", and "enterprise clustering" have created serious obstacles to the transformation of NHTZs, and these can hardly be changed in a short time (Lu and Zhang, 2006). Thus, so the role of NHTZs in promoting high-tech industry innovation cannot be fully exerted.

Apart from the above literature, only a few studies have focused on the firm level. Wang and Xu (2020) found that the establishment of NHTZs is obviously conducive to enterprises' innovation performance, and Zhang et al. (2021) also obtained a similar conclusion based on the study of the "promoting construction by upgrading" policy in provincial high-tech zones.

Based on the existing representative literature, it is therefore not difficult to find that many research results have been obtained that are related to the economic growth, industrial optimization, and innovation performance of various function zones. However, although some studies have investigated the productivity effects of function zones, most of them have used cities as the research objects (Tan and Zhang, 2018; Li et al., 2021). Scholars generally investigate the impact of function zone construction on

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urban economic growth and urban TFP, and few papers evaluate policy effects[3] at the level of enterprise TFP. The productivity level and innovation ability of enterprises are crucial micro-foundations for promoting high-quality regional economic development and realizing industrial transformation and upgrade. Moreover, since urban TFP is obtained by the weighted accumulation of enterprises TFP, it is of greater practical significance to study TFP at the enterprise level compared to the city level. Hence, investigating the effects and mechanisms of the NHTZs on enterprise TFP is conducive to exploring and fundamentally evaluating the economic effect of this policy's implementation.

The existing literature of functional zones generally does not distinguish between types of functional zones but rather investigates functional zones as a whole (Tan and Zhang, 2019; Yuan et al., 2015). However, due to the different functions and positioning of various economic functional zones, the enterprise performance of different functional zones can be quite different (Sheng and Zhang, 2018). If we do not distinguish between types, it may therefore be difficult to identify the differences in the policy effects of each functional zone, which is not conducive to the positioning and future development of new functional zones. For example, NHTZs may have higher economic and social benefits than other functional zones, and enterprises in these zones are high-tech enterprises rather than other types, which means that policy decisions in the zones directly affect the technological progress and TFP improvement of enterprises. Therefore, it is more practically significant to investigate the productivity effect of enterprises in NHTZs.

Compared to previous studies, the marginal contributions of this paper are as follows.

First, this paper evaluates the economic performance of NHTZs systematically and objectively from the perspective of micro enterprises against the background of the "new normal" Chinese economic development and the increasingly complex external economic environment. The paper not only provides a theoretical basis for evaluating the implementation effects of the high-tech zones policies but also provides evidence and policy implications for accelerating the output performance improvement and R&D and innovation upgrading of Chinese enterprises. Through the detailed analysis of incentive policies, institutional subsidies, and business environments in the regions, we hope to help stimulate the vitality of enterprises as market subjects and let enterprises play a leading role in the construction of regional innovation growth poles.

Second, in this paper, the impact of high-tech zone policy on enterprises TFP is evaluated by precisely identifying whether the enterprises are located in a zone. This quasi-natural experiment is constructed by taking the enterprises in high-tech zones as the treatment group and the enterprises outside the zones with same relative development trends as the control group. Most of the existing literature takes the cities where high-tech zones are located as research objects (Li et al., 2021; Wang and Xu, 2020) and assumes that enterprises in the city are included in the treatment group as long as the city establishes an NHTZ. Since high-tech zones only occupy a small part of a city's area, taking the whole city as a research object will necessarily include a large number of enterprises outside high-tech zones in the treatment group even though these enterprises do not actually enjoy the high-tech zones policy. Thus there will be obvious errors in the estimation results.

Lin et al. (2018) identified whether an enterprise was in a high-tech zone by matching postal codes. Because there are some missing postal codes in the industrial enterprise database[4], however, some samples would be missed by using the postal code for identification. In addition, some scholars identify zones by comparing the four boundaries information of function zones and the latitude and

[3] The policies referred to in this article are all strategies for establishing high-tech zones, namely the establishment of NHTZs, which is determined by the DID method. Considering that NHTZs inevitably had some preferential policies when they were established, this article uses DID method to examine the impact effects of these policies that were effective at the time of establishment, specifically including investment and tax incentives, financing convenience, etc.

[4] Approximately 15.89% of enterprises have missing postal codes during the sample period.

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longitude information of enterprises' boundaries (Schminke and Van, 2013; Lu et al., 2015; Zheng et al., 2017). But this method is relatively complex and has the problem of systematic bias in the process of longitude and latitude analysis (Tan and Zhang, 2019). In light of this, this paper uses a relatively simple and effective method: Matching the industrial enterprise database and the customs database to obtain enterprises' customs code information[5], where the fifth digit represents the economic region code of an enterprise's place of registration. Unambiguously, an enterprise is located in an NHTZs if this value is 3[6]. In conclusion, this paper divides the treatment and control groups by most accurately identifying whether an enterprise is located in a zone.

Third, based on the investigation of the productivity effect of high-tech zones, this paper also finds that the promotion effect of NHTZs on local enterprise TFP is significantly higher than that of other functional zones, which supports the strategic positioning of NHTZs as "high-quality development pilot zones" and "innovation-driven development demonstration zones".

Fourth, by decomposing TFP at the industry level, this paper further investigates the impact of high-tech zone construction on productivity changes under different industries and analyzes the dynamic impact of different enterprise states on industrial productivity. We show that the level effects and scale effects generated by the establishment of NHTZs are larger than the market entry and exit effects of enterprises on the whole, which means that high-tech zones significantly enhance an industry's TFP by promoting enterprises' own productivity improvement and expanding their market share.

The remainder of this paper is arranged as follows: Section 2 is an institutional background and theoretical analysis; Section 3 is an econometric model and data description; Section 4 is an empirical results analysis; Section 5 is a heterogeneity investigation; Section 6 is an influential mechanism analysis; Section 7 further discusses the impact of high-tech zone policies on changes in industrial productivity, and Section 8 presents the research conclusions.

2. Analysis of Institutional Background and a Theoretical Mechanism

2.1 The Institutional Background of NHTZs

Building NHTZs is a major strategic plan enacted by the CPC Central Committee and the State Council to develop high-tech industries and adjust industrial structures, to promote the transformation of traditional industries, and to enhance international competitiveness. Since the first NHTZ, the Beijing High-tech Industry Development Zone, was approved in Zhongguancun in May 1988, NHTZs have experienced two phases of construction booms, the first in 1991-1992, and the second in 2010-2018, during which 51 and 112 NHTZs were approved, respectively. In August 1988, China's high-tech industrialization development plan, the Torch Plan, was implemented, and the establishment of NHTZs was clearly included as an important part. The first batch of NHTZs are mostly located in provincial, sub-provincial, or relatively developed cities. After 2009, a large number of provincial high-tech zones have been earmarked for upgrades.

Up to now, China has approved the establishment of 173 NHTZs. During the sample period of interest in this paper, a total of 62 NHTZs were approved in different regions in different years.The detailed information can be found in *the Catalogue*[7]. After more than 30 years of development, these NHTZs have become an important carrier for China to implement its innovation-driven development

[5] It is estimated that the proportion of enterprises engaged in foreign trade business in the industrial enterprise database is 71.25%. That is, most enterprises are engaged in some type of import and export business.

[6] An enterprise's customs code consists of 10 digits. The first to the fourth digits represent the administrative region code of the enterprise's place of registration, and the fifth digit represents the economic region code of the enterprise's place of registration. 1 stands for Special Economic Zone; 2 stands for Economic and Technological Development Zone; 3 stands for National High-tech Zone; 4 stands for Bonded Area; 5 stands for Export Processing Zone/Zhuhai-Macao Cross-border Industrial Park; 6 stands for Bonded Port Area/Comprehensive Bonded Zone; 7 stands for Bonded Logistics Park; 9 stands for all others.

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strategy. With the accelerated evolution of a new round of scientific and technological revolution and industrial transformation, China's economy has shifted from a stage of high-speed growth to a stage of high-quality development. The country has an increasingly urgent demand to transform its development mode, optimize its economic structure, and transform the driving force of its growth. In this context, NHTZs have also entered a new stage of "innovation-driven, high-quality development". "Opinions on Promoting the High-quality Development of NHTZs" (*The Opinions*) issued in 2020 proposed 18 specific measures from six aspects, for comprehensively deploying the development of NHTZs. The *Opinions* made it clear that China should strengthen the Party's unified leadership over NHTZs, firmly establish the new development concept, focus on improving independent innovation capacity, enhance the level of industrial development modernization, and build the NHTZs into "high-quality development pilot zones" and "innovation-driven development demonstration zones".

2.2 The Mechanisms of NHTZs' Effects on Enterprise's TFP

(i) The productivity effect of NHTZ. NHTZs are state-level science and technology industrial parks approved by the State Council that are built as a result of both government and market demand. However, the government has played a leading role in the construction and development of NHTZs and provided a series of special policies for enterprises in the zones. As early as 1991, the government issued "Regulations on Tax Policies of NHTZs", pointing out that "Enterprises identified in the zone shall pay income tax at a reduced rate of 15%", and "If the output value of export products of enterprises in the zone reaches more than 70% of the total output value in the current year, the income tax shall be levied at a reduced rate of 10% after verification by tax authorities". *The Opinions* also proposed that in addition to traditional transportation facilities and electric power facilities, full attention should be paid to institutional environment and policy environment, and enough support should be given to the innovation of enterprises in the zone, including innovation subsidies, tax incentives, and fee reductions.

In a market economy environment, fiscal subsidies and tax incentives are common means of government policy support, which are crucial for enterprises to improve quality and efficiency (Harris and Trainor, 2015). The purpose of fiscal subsidies is to improve the market competition environment (Ren and Lu, 2014). By directly increasing enterprise's capital in order to alleviate the shortage of capital, optimize resource allocation, and help enterprise's production and operation activities become more flexible, more resources can be actively and efficiently invested in enterprise's R&D and innovation activities. What's more, government subsidies can help enterprises spend more capital on employing senior R&D talent and building core competitiveness so that enterprises can increase innovation performance and productivity through economies of scale. As for tax incentives, they can not only indirectly help enterprises obtain cost advantages, effectively alleviate financing constraints, reduce enterprise's survival pressure, and enhance their ability to resist risks but can also further strengthen regional agglomeration economies to help enterprises bring more profitable profits and improve their productivity (Brinkman et al., 2015), which is also one of the driving forces for enterprise development and upgrading. Additionally, NHTZs further deepen the reforms of "decentralization, management, and service", relax market access, simplify approval procedures, optimize the business environment, and minimize direct government intervention in the market so as to stimulate innovation and let enterprises play a leading role in the construction of regional innovation growth poles. For any Chinese enterprise, entering an NHTZ means having the right to enjoy various preferential policies and treatments in the zone, and these benefits have attracted a large number of high-tech enterprises. Therefore, we propose:

[7] Official website address: http://www.gov.cn/xinwen/2018-03/03/content_5270330.htm.

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Hypothesis 1: NHTZs can improve enterprise TFP by virtue of their preferential policies.

(ii) The strengthening effect of high-tech zone policies on "technology spillover effects" (the ability to acquire its technology without the need for purchase) of imported intermediate goods. Generally speaking, imported intermediate goods represent a higher level of R&D and quality compared to domestic Chinese goods. However, Chinese enterprises can apply the technologies contained in intermediate goods to their own inputs and production processes so as to enhance their own R&D and innovation, technological strength, and productivity (Eaton and Kortum, 2002; Xu et al., 2017). With the gradual improvement of NHTZs and the acceleration of economic globalization, the trade and investment channels for enterprises at home and abroad are gradually expanding as well. The connectivity of infrastructure and the increasing frequency of transnational investment have broken through trade barriers among countries, allowing a larger and wider range of intermediate inputs to enter the Chinese market.

At present, intermediate goods have already become the most important part of China's imports, and the preferential policies in NHTZs are far greater than those outside the zones. In this situation, the high-tech zones can fully gather, integrate and utilize global innovation resources, provide more channels and opportunities for enterprises to import intermediate goods, continuously promote the opening up and technological cooperation of enterprises in the zones, and help enterprises shape their global competitive advantages. For enterprises in the zones, they can import more intermediate goods with high added value and high technology while enjoying generous subsidies, tax benefits, and customs clearance facilitation from the NHTZs. Then, enterprises can fully digest, absorb, recreate, and even redesign advanced technologies contained in various intermediate goods by increasing investment in order to obtain "technology spillover effects" as fully as possible, rapidly promote technological progress and R&D innovation, and improve their productivity. Therefore, we propose:

Hypothesis 2: The construction of NHTZs can accelerate the realization of "technology spillover effects" to improve enterprise TFP.

(iii) The innovation and talent agglomeration effects of high-tech zone policies. In recent years, the per capita patent output in NHTZs has continued to increase, and the output efficiency of patent achievements has been steadily growing as well, accounting for half of the innovation resources of enterprises in China. The government has also granted high-tech zones special intellectual property right incentives and protection policies to strengthen the protection of enterprises' patented technologies in order to overcome market failures such as intellectual property theft.

In addition, according to the survey data of the Torch Center, more than 99% of NHTZs have established flexible policies to attract talent, more than 95.3% of NHTZs have established special talent plans based on their own industrial characteristics and development directions, and more than 79.9% of NHTZs have experimented with individual income tax refund policies for enterprises' scientific and technological personnel. Furthermore, NHTZs continue to improve their cultural environment construction and urban service functions, which can help them attract talent.

NHTZs attract talent with excellent policies and preferential treatments, but they retain talent with high-quality services. To this end they have gradually built up a large and risk-taking team of innovators and have become China's highland of technological prowess. In addition, NHTZs have gathered a large number of scientific and technological personnel as well as R&D personnel to provide enterprises with continuous supply of high-quality talent. By developing new products and technologies through R&D activities, enterprise's technological progress and output levels can grow, which further promotes the innovation-driven development of high-tech industries and the innovative growth of local economies (Zhang et al., 2020). Therefore, we propose:

Hypothesis 3: The construction of NHTZs can improve enterprise's TFP through "innovation and talent agglomeration effects".

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3. Research Design

3.1 Measurement Model Setting

In order to investigate the impact of NHTZs on enterprise's TFP, we construct the following baseline regression model:

$$TFP_{ijct}=\alpha+\beta treat_{it}+\gamma X_{it}+\lambda_i+\lambda_t+\varepsilon_{ijct} \quad (1)$$

where TFP_{ijct} represents the TFP of enterprise i in city c belonging to industry j in year t, and $treat_{it}$ represents the dummy variable of whether enterprise i is located in an NHTZ in year t. X_{it} stands for a series of firm-level control variables, λ_i is firm fixed effects, λ_t is year fixed effects, and ε_{ijct} is a random error term. We focus on the value of β, which measures the impact effect of NHTZs on the TFP of local enterprises. If β is positive, this indicates that the establishment of NHTZs effectively promoted the improvement of enterprise productivity. Additionally, the standard errors of regression coefficients of each variable in formula (1) are clustered at the industry level to eliminate possible serial correlation problems.

3.2 Data Sources and Processing

This paper uses data from the China industrial enterprise database, China customs database, and t*he Catalogue* from 2006 to 2014[8].

(i) Data of NHTZs. The data of NHTZs are from *the Catalogue* jointly issued by the National Development and Reform Commission, the Ministry of Science and Technology, and then Ministry of Land and Resources. The data record all types of national and provincial development zones that have been officially approved by March 2018, including Economic and Technological Development Zones, High-tech Industry Development Zones, Export Processing Zones and Bonded Zones, etc., covering the name of development zone, approval time, approved area, leading industries and other information. During the sample period from 2006 to 2014, total of 62 NHTZs were successively established in different regions (including the upgrading of provincial high-tech zones to NHTZs). At the same time, some enterprises transform from enterprises outside the zone to enterprises in the zone, which provides a good "quasi-natural experiment" for this paper to evaluate the impact of the construction of NHTZs on enterprise's productivity.

(ii) Industrial enterprise data. The industrial enterprise database contains a lot of information about enterprise's operation and finance in each year, which is one of the most commonly used micro enterprise databases. Due to problems such as false data positives and missing samples, the following procedures should be performed before using the database: Firstly, delete the data missing key information of enterprise's productivity measurement (employees number, net fixed assets, investment income, industry, etc.). Secondly, refer to Brandt et al. (2017), delete the data of enterprises with less than 8 employees. Thirdly, according to Feenstra et al. (2014) and following the general accounting standards, exclude abnormal data such as current assets or fixed assets larger than total assets, missing enterprise code and invalid establishment time (such as the opening time later than the current year). After the above steps of data processing, the enterprise-level TFP can be calculated.

(iii) China customs database. It records the detailed information of import and export transactions of customs trading enterprises in each year, including enterprise code, enterprise name, 8-bit HS code of import and export products, product name, import and export amount, export destination country, and trade mode. This paper mainly uses the 10-bit enterprise customs code to identify high-tech zones, and refers to Tian and Yu (2012)'s method to match the customs database and the industrial enterprise database: We start matching by enterprise name and year, and then conduct secondary matching based

[8] This period was selected because no new NHTZs were established from 2000 to 2006 and because the industrial enterprise database samples after 2014 are seriously missing.

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on enterprise postcode, the last seven digits of the phone number and year, so as to obtain the research samples containing the import and export information and enterprise's operation information.

3.3 Variables Construction

(1) Enterprise's TFP. There are many measurement methods of enterprise's TFP, including traditional OLS method, OP method (Olley and Pakes, 1996), LP method (Levinsohn and Petrin, 2003) and ACF method (Ackerberg et al., 2015). Traditional OLS method uses "Solow residual" to estimate enterprise productivity, but it faces the problems of simultaneity bias and sample selection bias (Lu and Lian, 2012). OP method, LP method and ACF method can effectively solve the above problems. Wooldridge (2009) even proposed a one-step estimation method based on the framework of GMM. In this paper, the OP method is used to measure the TFP of enterprises in baseline regression. It is assumed that enterprises make investment decisions according to the current productivity situation, so the current investment level of enterprises is used as the proxy variable of unobservable productivity. Besides, in order to prevent errors caused by the selection of measurement method, this paper also uses TFP estimated by LP method and GMM method as explained variables for robustness test.

(ii) Dummy variable of NHTZs ($treat_{it}$). $treat_{it}$ in formula (1) is the core explanatory variable in this paper, which is used to identify whether enterprise i in year t is located in NHTZs. This paper uses customs database information to identify enterprises in the zone. Specifically: Firstly, match industrial enterprise database with customs database to obtain the 10-bit customs registration code of enterprise (consisting of Arabic numerals and capital English letters); secondly, the fifth digit represents the economic region code of enterprise's registration place, which means that the enterprise is located in NHTZs if the value is 3.

At the same time, the interaction item also needs to identify the establishment time of NHTZs, and the values are assigned respectively for the year before establishment, the year of establishment and the year after establishment. After comprehensively considering the object and time of policy implementation, this paper assigns 1 to the sample of enterprises in the zone in the year when the high-tech zones were established and the year after it, and assigns 0 to the sample of other enterprises. Finally, the core explanatory variable of this paper $treat_{it}$ is obtained.

(iii) Control variables. Referring to the existing studies on enterprise's TFP, this paper includes enterprise age (*age*), salary payable to staff (*wage*), enterprise scale (*size*), total output (*sale*), foreign investment (*fdi*), capital labor ratio (*KL*), profit margin (*profit*) and industrial concentration ratio (*HHI*) as control variables in formula (1). Table 1 reports the construction methods and descriptive statistics of the above variables.

Table 1: Descriptive Statistics of Indicators

Variable	Symbol	Construction method	Obs.	Mean.	Std.	Min.	Max.
Enterprise's TFP	*tfp_op*	Measured by the OP method	545,444	1.2754	0.8706	-3.0935	6.5658
	lntfp	Measured by the LP method	541,473	2.3834	0.8942	-2.7132	8.1052
	tfp_wrdg	Measured by the Wrdg method	541,473	3.5322	1.1104	0.1828	8.2723
Dummy variable of high-tech zones	*treat*	Enterprise-year interaction term	545,444	0.0289	0.1676	0	1
Enterprise age	*age*	Current year-Setting year+1	545,444	10.4927	6.5717	2	43
Salary payable	*wage*	ln (salary payable to staff)	545,444	6.3238	4.0703	0	12.3328
Enterprise scale	*size*	ln (total assets)	545,444	10.9239	1.4873	7.8943	15.1505
Total output	*sale*	ln (operating revenue)	545,444	11.2532	1.3708	8.6015	15.2659

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Table 1 Continued

Variable	Symbol	Construction method	Obs.	Mean.	Std.	Min.	Max.
Foreign investment	*fdi*	ln (Foreign, Hong Kong, Macao and Taiwan capital +1)	545,444	2.8669	4.4918	0	13.11
Industrial concentration ratio	*HHI*	Herfindahl index	527,817	0.1234	0.1419	0.0165	1
Capital labor ratio	*KL*	ln (Fixed assets/number of staffs)	545,444	5.4668	1.1954	0.2929	12.4425
Profit margin	*profit*	Operating profit/operating revenue	544,891	0.0369	0.0867	-0.3222	0.3118

4. Empirical Results Analysis

4.1 Baseline Regression Results

Table 2 reports the results of the full-sample estimation of formula (1). Column (1) is for a univariate regression, and the coefficient of NHTZs is positive and statistically significant after controlling the firm fixed effects and year fixed effects, indicating that the establishment of NHTZs did stimulate the improvement of enterprise's TFP. Based on column (1), column (2) adds control variables for firm characteristics to control the interference of firm-level factors on TFP. What's more, considering the influence of industry and regional potential factors on enterprise productivity, columns (3) and (4) further control the industry fixed effects and city-year fixed effects. The results show that in either case, the estimated coefficients are positive and significant at the 1% level, which gives us strong statistical evidence to reject the null hypothesis that Hypothesis 1 is false.

In terms of control variables, the coefficients of enterprise age (*age*), enterprise output (*sale*), capital labor ratio (*KL*), profit margin (*profit*) and industrial concentration ratio (*HHI*) are significantly positive, which means that the longer the enterprise age, the higher ratio of output and capital, the higher profit margin and the stronger industry monopoly degree, the higher TFP of the enterprise will be. The coefficients of enterprise scale (*size*) and foreign investment (*fdi*) are significantly negative, indicating that enterprise scale and foreign direct investment (FDI) will inhibit the improvement of enterprise's TFP.

In this regard, this paper believes that the possible reason is that, with the expansion of the enterprise scale, its monopoly of the market will be stronger, and the enterprise will gradually lose the motivation to enhance its productivity level. FDI has an inhibitory effect on enterprise's TFP, consisting with Lin et al. (2018), which may be caused by the situation that "competition effect" of foreign capital entry is greater than the "technology spillover effects". Besides, the coefficient sign of salary payable to staff (*wage*) is uncertain, which may be related to the ownership of enterprises.

Table 2: Baseline Regression Results

Dependent variable: *tfp_op*	(1)	(2)	(3)	(4)
treat	0.1257***	0.0547***	0.0452***	0.0469***
	(0.0385)	(0.0051)	(0.0037)	(0.0039)
age		0.0013***	0.0015***	0.0015***
		(0.0003)	(0.0003)	(0.0003)
wage		-0.0051***	-0.0071***	-0.0078***
		(0.0016)	(0.0017)	(0.0016)
size		-0.7053***	-0.7051***	-0.7059***
		(0.0051)	(0.0055)	(0.0055)
sale		0.9771***	0.9763***	0.9778***
		(0.0030)	(0.0028)	(0.0029)
fdi		-0.0036***	-0.0036***	-0.0048***
		(0.0004)	(0.0004)	(0.0005)

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Table 2 Continued

Dependent variable: *tfp_op*	(1)	(2)	(3)	(4)
HHI		0.0641**	0.0247*	0.0115**
		(0.0300)	(0.0122)	(0.0136)
KL		0.4364***	0.4407***	0.4417***
		(0.0036)	(0.0037)	(0.0037)
profit		0.1550***	0.1620***	0.1609***
		(0.0210)	(0.0217)	(0.0213)
Constant	1.2718***	-4.3872***	-4.3881***	-4.3929***
	(0.0368)	(0.0229)	(0.0301)	(0.0297)
Firm fixed effect	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
Industry fixed effect	N	N	Y	Y
City-year fixed effect	N	N	N	Y
Obs.	545,436	527,272	527,272	527,166
R^2	0.0973	0.9285	0.9298	0.9306

Note: (1) Robust standard errors clustered at city level in parentheses; (2) *, **, and *** indicate significance at 10%, 5%, and 1% respectively. The same applies to the following tables.

4.2 Endogeneity

(i) Sample selection bias. When using a DID method to test the effects of policy implementation, the individual characteristics of the treatment and control groups should be as consistent as possible. Since the research objects of this paper are micro enterprises in different regions and industries, however, in our case the individual characteristics of the treatment and control groups cannot be completely consistent. Therefore, to eliminate the influence of selection bias, we use data after Propensity Score Matching (PSM) to conduct the estimation again so that the treatment and control groups meet this common trend assumption. We used the nearest neighbor matching method and constructed a logit model.

Table 3 and Figure 1 report the balance test results and Kernel density maps of the characteristic variables of the treatment and control groups before and after matching. After using the PSM method for matching, the standard deviations of each variable were very close to 0 (less than 5%), and the productivity differences between the treatment and control groups were a good fit in each interval, showing an ideal parallel development trend on the whole. These results indicate that after PSM matching, the data for the treatment and control groups were more or less balanced, which negates the effects of any systematic differences in individual characteristics between the two groups.

The DID estimation results after matching are shown in column (1) of Table 4. The coefficient of the dummy variable for NHTZs is still positive and statistically significant, which indicates that our above conclusion is still valid after using the PSM method to exclude individual characteristics differences. The coefficient value of *treat* after eliminating sample selection bias is slightly larger than that in the baseline regression, which means that the promoting effect of high-tech zones on enterprise productivity would be underestimated if sample selection bias were not considered.

Table 3: Results of the PSM Balance Test

Variable	Unmatched	Mean			%reduct	t-test		V(T)/ V(C)
	Matched	Treated	Control	%bias	bias	T	p>t	
age	U	10.74	10.517	3.6		4.18	0.000	0.81*
	M	10.74	10.801	-1.0	73	-0.83	0.406	0.76*
wage	U	6.7063	6.3404	8.8		11.05	0.000	1.09*
	M	6.7063	6.6661	1.0	89	0.85	0.398	1.05*

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Table 3 Continued

Variable	Unmatched	Mean			%reduct	t-test		V(T)/ V(C)
	Matched	Treated	Control	%bias	bias	T	p>t	
size	U	11.642	10.928	47.7		59.57	0.000	1.07*
	M	11.642	11.651	-0.6	98.8	-0.52	0.604	1.07*
sale	U	11.59	11.264	22.8		29.38	0.000	1.21*
	M	11.59	11.59	0.0	100	-0.01	0.996	1.01
fdi	U	3.9308	2.8326	22.8		30.02	0.000	1.31*
	M	3.9308	3.9183	0.3	98.9	0.22	0.828	1.03
HHI	U	0.09587	0.12422	-24.2		-24.57	0.000	0.34*
	M	0.09587	0.09266	2.7	88.7	3.34	0.001	0.96*
KL	U	6.1992	5.4615	65.0		76.86	0.000	0.84*
	M	6.1992	6.1824	1.5	97.7	1.33	0.183	0.92*
profit	U	0.05058	0.03664	13.6		19.77	0.000	1.89*
	M	0.05058	0.04875	1.8	86.9	1.49	0.136	1.43*

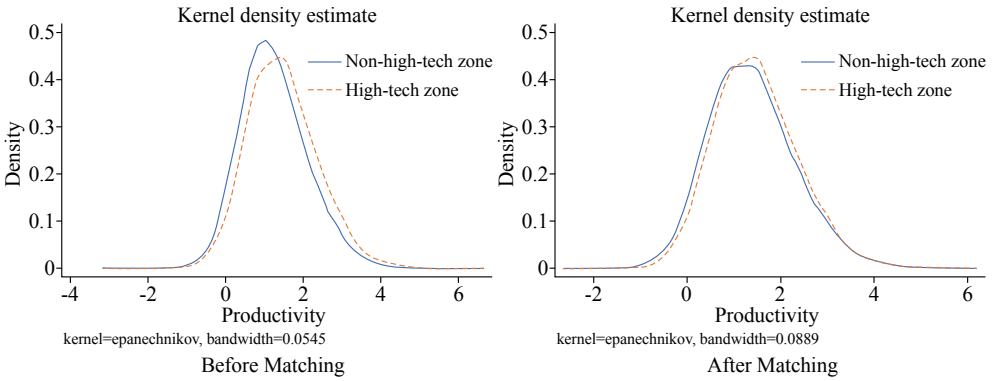

Figure 1: The Fit between the Treatment Group and Control Group before and after Matching

Note: The drawing is based on data matching results, the same as below.

(ii) Self-selection bias. In the above, we use the database information matched between industrial enterprise database and customs database to identify whether the enterprise is in NHTZs. However, there are a small number of enterprises in the industrial enterprise database that are not engaged in import and export business, and it is likely to produce sample self-selection bias if these enterprises are simply eliminated. For this problem, Heckman two-step method is used in this part. In the first step, we take enterprise age, enterprise scale, FDI and enterprise ownership as identifying variables, use Probit model to investigate whether the enterprise is engaged in import and export business, and obtain Inverse Mills Ratio (IMR) based on the fitting value of dependent variable. In the second step, formula (1) is regressed again after controlling IMR.

The regression results of columns (2) and (3) of Table 4 show that IMR is significantly negative at the 1% level, indicating that the samples have a certain degree of self-selection bias. After dealing with the self-selection problem, the sign and significance of core explanatory variable *treat* are still consistent with those in baseline regression. Therefore, this paper believes that the self-selection problem of samples does not cause substantial interference to the core conclusion, and the core conclusion of this paper is still robust.

(iii) Instrumental variable method. Although the above DID, PSM-DID and Heckman two-step method have alleviated the endogeneity problems caused by non-observed omitted variables and sample selection bias, the endogeneity problems caused by reverse causality may still exist. NHTZs are starting

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to be established in cities with better economic and technological development, where companies are likely to be more productive. In view of this, referring to Wang and Lu (2019), this part uses instrumental variables to deal with the endogeneity problem.

The effectiveness of instrumental variables depends on whether they satisfy both correlation and exogeneity conditions (Acemoglu et al., 2001). In this paper, relief amplitude (RDLS) of the city where enterprises are located is taken as the instrumental variable *IV_RDLS* (Lin and Tan, 2019), which is reasonable. On the one hand, as a considerable factor to study the density of population and labor force, RDLS has a great impact on regional infrastructure construction. The larger RDLS is, the less convenient the traffic will be, which not only increases the cost of local infrastructure, but also affects the quality of electronic network signals and operation costs (Liu and Ma, 2020). In this regard, the location of NHTZs will fully consider regional RDLS, which satisfies the correlation condition of instrumental variable (IV) method. On the other hand, the RDLS of a region is jointly determined by the highest and lowest elevations of the region, the average area and the total area of the region, which is a natural and objective geographical factor. Therefore, this index does not have a direct impact on enterprise's productivity and satisfies the exogeneity condition.

The 2-stage Least Squares Estimation (2SLS) method is used for IVs, and the estimation results are shown in columns (4) and (5) of Table 4. The regression results of the first stage show that the regression coefficient of instrumental variable *IV_RDLS* is highly and significantly negative at the level of 1%, which means that the regions with less RDLS are more conducive to construct NHTZs, so as to verify the correlation between IVs and endogenous variables. In the second stage regression, the estimated coefficient of core explanatory variable *treat* is significantly positive, and the P-values of Wald and LM tests indicate that there is no weak correlation and unrecognized problem.

Table 4: Endogeneity Test Results

Variable	(1)	(2)	(3)	(4)	(5)
	PSM+DID	Heckman two-step estimation		Instrumental variable method (2SLS)	
		Step 1	Step 2	Step 1	Step 2
IV_RDLS				-0.0022*** (0.0013)	
treat	0.0578*** (0.0074)		0.0762*** (0.0028)		2.7834*** (0.8522)
age		0.0073*** (0.0004)	0.0003*** (0.0002)		
size		0.1436*** (0.0013)	-0.6561*** (0.0009)		
fdi		0.0867*** (0.0004)	-0.0132*** (0.0014)		
ownership		-0.8252*** (0.0122)			
IMR[9]			-0.1476*** (0.0089)		
Control variables	Y	N	Y	Y	Y
Constant	-4.3323*** (0.027)	-2.6221*** (0.0104)	-4.202*** (0.0227)	-0.0471*** (0.0024)	-4.2623*** (0.0413)
Wald F				134.896 (0.0000)	
LM				58.142 (0.0000)	
Firm fixed effect	Y	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y	Y
Obs.	84,262	1,082,832	211,030	462,473	462,473
R^2	0.9252	0.1102	0.9122	0.0161	0.6648

[9] We also calculated the variance inflation factor of IMR (VIFIMR=9.17), and found that there was no serious collinearity problem.

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What's more, it should be point out that the coefficient of *treat* is obviously larger than that in baseline regression. This indicates that, in general, there is no reverse causality between enterprise's productivity and the NHTZs dummy variable, otherwise the absolute value of the coefficient of core explanatory variable should decrease (Lin et al., 2018). In a word, the estimation results of the IV method again show that the construction of NHTZs significantly improves enterprise's TFP.

4.3 Robustness Test

(i) Parallel trend test. An essential prerequisite for using DID model is that there is no systematic difference between treatment group and control group before policy implementation. Therefore, this part tests the applicability of DID based on parallel trends. According to Figure 2, it is no difficult to find that the confidence interval of the estimated coefficient contains the value of 0 before the establishment of NHTZs, which indicates that there is no significant difference in the development trend between treatment group and control group[10].

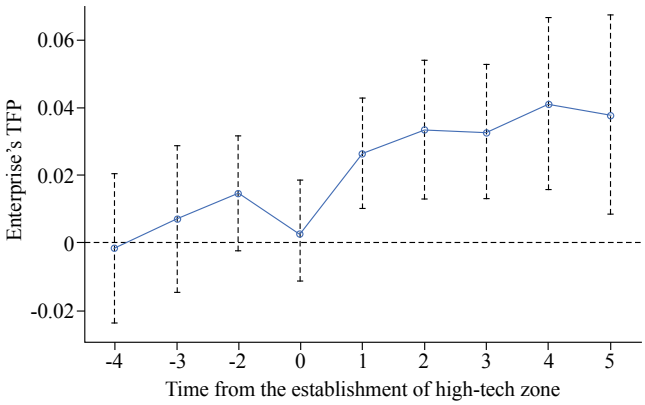

Figure 2: Parallel Trend Test

(ii) Adjust the measurement method of enterprise's TFP. In addition to the OP method used in baseline regression above, LP method and ACF method are also commonly used in the current academic community to measure TFP. Wooldridge (2009) improved the OP and LP methods and proposed a one-step estimation method based on GMM. This method has two advantages: On the one hand, it overcomes the potential identification problem proposed by ACF in the first step estimation; on the other hand, robust standard errors can be obtained when considering serial correlation and heteroscedasticity (Lu and Lian, 2012). In this view, LP method and GMM method are used to re-measure enterprise's TFP in this part, and then formula (1) is re-estimated. The regression results are shown in columns (1) and (2) of Table 5. It can be found that the coefficient and significance of NHTZs are consistent with the regression results above, indicating that the core conclusion of this paper has not changed with the selection of measurement method of TFP.

(iii) Replace data samples. To overcome the sample selection problem that may arise from single sample investigation, the matching data of listed companies and customs database from 2006 to 2014 are used to re-estimate formula (1). The regression results in column (3) show that the coefficient's significance of core explanatory variable has not changed, indicating that the core conclusion of this

[10] Placebo test is also used in this paper to exclude the influence of random factors on estimation results. And the results are not reported due to space limitation, more details are available on request.

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paper is not affected by the difference in data sources.

What's more, considering that the samples of industrial enterprises from 2009 to 2010 are seriously missing, and referring to the common practice of existing literature, the samples from 2009 to 2010 are removed here to re-estimate formula (1). It can be found that the coefficient of NHTZs in column (4) is still significantly positive, meaning that the basic conclusion is not affected by missing samples and remains robust.

(iv) Re-identify NHTZs at city level. The above method is identified according to the customs code of enterprise, but it is aimed at enterprises engaged in import and export business, which means that the above empirical analysis does not investigate non-traded enterprises. In order to prevent sample selection problems from affecting the robustness of research conclusions, the method of Li et al. (2021) is referred to for identification here. If the city where the enterprise is located establishes a NHTZ in that year, the value is set as 1; otherwise, the value is set as 0, so as to obtain the core explanatory variable *treat2*. Then, formula (1) is re-estimated and the corresponding regression results are shown in Column (5).

It can be seen that the coefficient of *treat2* is significantly negative at the level of 1%, indicating that taking the cities to which enterprises belong as treatment group will cause serious misjudgment in the estimation results. Considering that high-tech zones only occupy a small part of the city area, most enterprises in the city are not in the zone, so they cannot enjoy the preferential policies of the zone. Therefore, if these enterprises are included in treatment group, the productivity effect of high-tech zones' policies will be seriously underestimated. Comparatively speaking, the identification method used in this paper is more scientific and advanced.

(v) Re-identify NHTZs using enterprise's postal code[11]. In addition to the two methods used above to identify high-tech zones, the practice of Lin et al. (2018) is also used here to identify whether an enterprise is located in development zones by matching the postal code of enterprise with that of high-tech zones. For the case of multiple codes in one zone, it is considered that the enterprise is located in the zone if its postal code corresponds to one of the postal codes. The regression results of formula (1) are reported in column (6), and the coefficient of interaction term *treat3* is still significantly positive, indicating that the core conclusion of this paper is still robust.

(vi) Consider disruptions from the Belt and Road Initiative. The Belt and Road Initiative was put forward in 2013. In this paper, some enterprises belong to both the cities with NHTZs and the cities along the Belt and Road Initiative[12]. As a result, enterprises in these cities are affected by the institutional dividends of NHTZs and the Belt and Road Initiative in some years, which may interfere with the conclusions. In view of this, the dummy variable of Belt and Road Initiative (*brcity*) is added in formula (1), and the value of cities along the Belt and Road Initiative in 2013 and later years is 1, otherwise it is 0, so as to control the influence of Belt and Road Initiative on the estimation results of this paper.

As reported in column (7), the regression coefficient of dummy variable *brcity* is positive and significant at 1% level, meaning that the Belt and Road Initiative can significantly improve the TFP of enterprises in cities along the "Belt and Road". What's more, it is also discovered that the coefficient of core explanatory variable is significantly positive and its absolute value is smaller than that in baseline regression, which indicates that the impact of NHTZs on enterprise's TFP would be overestimated if the influence of the Belt and Road Initiative is not excluded.

[11] In addition to using the above three methods to identify whether an enterprise is located in NHTZs, this paper also identifies by comparing the four boundaries information of high-tech zones and the latitude and longitude information of enterprise's boundary, and finds that the coefficient of core explanatory variable *treat* is still significantly positive.

[12] By 2014, cities with NHTZs and along the Belt and Road Initiative are as follows: Tianjin, Hohhot, Dalian, Changchun, Harbin, Shanghai, Nanjing, Suzhou, Ningbo, Hefei, Fuzhou, Xiamen, Quanzhou, Nanchang, Qingdao, Yantai, Zhengzhou, Wuhan, Changsha, Guangzhou, Shenzhen, Nanning, Haikou, Chongqing, Chengdu, Kunming, Xian, Lanzhou, Xining, Yinchuan, Urumqi.

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Table 5: Robustness Analysis Results

Variable	(1) Measured by LP method	(2) Measured by GMM method	(3) Use public company data	(4) Exclude samples from 2009-2010	(5) Identify at city level	(6) Identify by postal code	(7) Effect of the "Belt and Road Initiative"
treat	0.1082*** (0.0101)	0.0335*** (0.0032)	0.0562*** (0.0124)	0.0558*** (0.0052)			0.0550*** (0.0051)
treat2					-0.0172*** (0.0036)		
treat3						0.0771*** (0.0093)	
brcity							0.0198*** (0.0049)
Control variables	Y	Y	Y	Y	Y	Y	Y
Constant	-2.1434*** (0.0459)	-5.2731*** (0.0152)	-7.5073*** (0.1951)	-4.3876*** (0.0228)	-4.3752*** (0.0227)	-4.5771*** (0.0447)	-4.3890*** (0.0230)
Firm fixed effect	Y	Y	Y	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y	Y	Y	Y
Obs.	523,509	523,509	6,022	460,250	527,272	551,661	527,272
R^2	0.7425	0.9832	0.9790	0.9273	0.9284	0.8577	0.9291

5. Heterogeneity

5.1 Heterogeneity Testing of Enterprise Ownership in High-tech Zones

Considering that enterprises with different ownership have differences in financing constraints, market share, and degrees of policy preference, the institutional dividend in a zone may have different effects on enterprises with different ownership. In view of this, the dummy variable *owner* for enterprise ownership was also constructed. If a firm is a state-owned enterprise, the variable is 1, and 0 otherwise. We then construct the interaction term *treat_owner* between high-tech zones dummy variable and enterprise ownership, and these estimation results are shown in column (1) of Table 6. Here, the coefficient of the interaction term is positive and statistically significant, indicating that NHTZs promoted the TFP of state-owned enterprises in a zone to a greater extent than for nonstate-owned enterprises. This may because state-owned enterprises in a zone typically have greater scientific research budgets and more technical talent in China (Tan and Zhang, 2018), and the implementation of preferential policies in a zone makes it easier for such enterprises to give full play to these advantages and stimulate faster improvement of their TFP by directly improving factor allocation efficiency and technological level.

5.2 Heterogeneity Test of External Environment of High-tech Zones

In view of the great differences in resource endowment and location advantages between coastal regions and inland regions, this paper refers to the division method of Jiang et al. (2021) and divides cities that have NHTZs into coastal cities and non-coastal cities according to location. First, we set the dummy variable *seacity*: Set as 1 if there is a coastal city; otherwise it is set as 0. And then we construct the interaction term *treat_seacity* between high-tech zones dummy variable and location dummy variable. According to the regression results in column (2), it is not difficult to see that the promotion effect of NHTZs on enterprise's productivity is more significant in coastal areas. A possible reason is that the transportation and infrastructure in coastal areas are generally well-developed and complete than inland areas, and coastal areas usually obtain more financial subsidies supported by policies. Therefore, enterprises in the zone in coastal areas can take advantage of their innate advantages to strengthen

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domestic and foreign learning and communication, absorb the advanced technology and experience at a faster speed, and quickly improve their productivity.

At the same time, if a National High-tech Zone is located in provincial capital city or municipality directly under the central government, such cities may have advantages over non-provincial-capital cities in economic development, infrastructure construction, talent agglomeration and policy implementation, which would lead to different impacts on enterprise's productivity. In order to test whether the difference exists, this part sets up the dummy variable *capital* of provincial capital city, and then constructs the interaction term *treat_capital* between high-tech zones dummy variable and *capital*. As shown in column (3), the coefficient of the interaction term is significantly positive at 1% level, meaning that NHTZs located in provincial capitals with more developed economic conditions have a greater role in promoting enterprise's productivity, which is consistent with Zhou et al. (2018).

In addition to the influence of location and economic conditions, differences in government capacity and efficiency are also considerable factors causing differences in implementation effect of industrial policies. An efficient government can usually effectively allocate resources and create a fair and just market competition environment, which is beneficial to eliminate backward and inefficient industries, promote the growth of high-efficiency enterprises, and provide guarantee for the success of industrial policies. In this regard, this part refers to Tang et al. (2014) and uses the *China Provincial Local Government Efficiency Measurement Report* published by Beijing Normal University. We first set dummy variable according to whether the city's efficiency is higher than the average value of the government efficiency index in the current year, and then constructed the interaction term *treat_efficient* between the dummy variable of NHTZs and government efficiency, aiming to investigate the moderating effect of government efficiency on "the productivity effect" of NHTZs.

According to the regression results in column (4), the coefficient of the interaction term is 0.03 and highly significant at the statistical level of 1%, indicating that government efficiency plays a positive regulating role in the impact of NHTZs on enterprise's productivity. In other words, the higher efficiency of the local government, the more it can promote the implementation of high-tech zones policies, and the more beneficial it is to improve enterprise's productivity.

5.3 Heterogeneity Test on the Establishment Time of High-tech Zones

NHTZs may need to go through a transition stage from establishment to full play, especially in the initial stage of establishment, facing urgent problems such as investment attraction, resource integration, talents introduction, and system construction. For high-tech zones with a short establishment time, there are few enterprises in the zone, production factors and infrastructure are only "simple accumulation" in space, with insufficient correlation with enterprises. Besides, they lack experience in policy supporting measures and implementation, so they can only rely on preferential policies to attract enterprises. With the gradual maturity of high-tech zones, the agglomeration effect becomes more and more enhanced, and the increase in enterprise number and correlation degree between them gradually intensify the competitive environment of enterprises, which will "forcing" enterprises to improve efficiency (Zheng et al., 2008).

In this view, this part distinguishes the kinds of NHTZs according to the years of their establishment (Tan and Zhang, 2019). The NHTZs established for 5 years or more (established in 2010 or before) are called "mature" high-tech zones, and the NHTZs established after 2010 are called "growth" high-tech zones. Specifically, set the growth cycle dummy variable *grow* (with "mature" high-tech zone as 1), and then construct the interaction term between *treat* and *grow*. As shown from the regression results in column (5), the coefficient of *treat_grow* is positive and passes the significance test of 5%, meaning that the "mature" NHTZs established in the early stage have a more significant promoting effect on enterprise's productivity, which is consistent with the research conclusions of Tan and Zhang (2019).

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In addition, to further test the validity and credibility of research conclusions, other types of function zones[13] are included in the research objects and investigated in two steps. In the first step, we added all function zones into treatment group and set dummy variable $treat_{all}$. That is, the enterprise located in any function zones is set as 1, otherwise it is set as 0. And then we regress formula (1) to test the productivity effect of economic function zones. In the second step, based on the regression of the first step, we divided the types of function zones *efa*: If the enterprise is located in NHTZs, *efa* is set to 1; if the enterprise is located in other types of function zones, *efa* is set to 0. Based on the above, the interaction term efa_treat_{all} is constructed, and then $treat_{all}$ and efa_treat_{all} are substituted into formula (1) to replace *treat*, so as to investigate the differences in the impact of different types and locations of function zones on enterprise's productivity.

The estimated results of the above two steps are reported in columns (6) and (7). It can be found that the coefficients of $treat_{all}$ and efa_treat_{all} are significantly positive, which means that all types of economic function zones in China can stimulate the improvement of TFP of enterprises in the zones on the whole. More importantly, compared with other types of economic function zones, NHTZs have a more obvious stimulating effect on enterprise's TFP, which may be closely related to the strategic positioning and policy implementation of NHTZs (Lin et al., 2018).

Table 6: Heterogeneity Test Results

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Ownership type	Geographical factor	Economic condition	Government efficiency	Growth cycle	Type of function zones	
treat	0.0492***	0.0506***	0.0087*	0.0754***	0.0602***		
	(0.0043)	(0.0052)	(0.0061)	(0.0072)	(0.0073)		
treat_owner	0.0539***						
	(0.0164)						
treat_seacity		0.0195**					
		(0.0083)					
treat_capital			0.0995***				
			(0.0098)				
treat_efficient				0.0308***			
				(0.0078)			
treat_grow					0.0341**		
					(0.0089)		
$treat_{all}$						0.0342***	
						(0.0043)	
efa_treat_{all}							0.0561***
							(0.0056)
Control variables	Y	Y	Y	Y	Y	Y	Y
Constant	-4.3863***	-4.3870***	-4.3883***	-4.3873***	-4.3842***	-4.3822***	-4.2952***
	(0.0229)	(0.0229)	(0.0228)	(0.0229)	(0.0228)	(0.0229)	(0.0292)
Firm fixed effect	Y	Y	Y	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y	Y	Y	Y
Obs.	527,272	527,272	527,272	527,272	527,272	527,272	60,921
R^2	0.9285	0.9285	0.9286	0.9285	0.9285	0.9289	0.9233

[13] It includes Special Economic Zones, Economic and Technological Development Zones, Export Processing Zones, Bonded Zones, Comprehensive Bonded Zones, Bonded Logistics Parks and Border Economic Cooperation Zones.

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6. Investigation of the Mechanism of Influence

6.1 Productivity Effect of NHTZs

This section investigates whether NHTZs improve enterprise's TFP by improving the policy environment, and we examine the policy effects from the two aspects of government subsidies and corporate taxes. To be specific, referring to Shao and Bao (2012) and Lin et al. (2018), we add 1 to the government subsidy obtained by enterprises and the tax paid by enterprises respectively, and then take the natural logarithm of each to get our variables *subsidy* and *tax*. Finally, *treat_subsidy* and *treat_tax* are used as variables to measure the policy effects of government subsidies and corporate tax by interacting with the dummy variable *treat*, and the policy effect is investigated by identifying the sign of the interaction term's coefficient.

Columns (1) and (2) of Table 7 report these regression results. The coefficient of subsidy interaction term *treat_subsidy* is positive and statistically significant at the 1% level, indicating that government subsidies in high-tech zones were conducive to promoting enterprise productivity. However, the coefficient of the tax interaction term *treat_tax* is negative at the 1% significance level, meaning that increasing the tax level in high-tech zones inhibited the improvement of enterprise productivity, which is consistent with the results of most existing studies (Tan and Zhang, 2018). Thus, the estimated results imply that the establishment of NHTZs did improve the production, operation, and market competition environment of enterprises, enabled enterprises to obtain higher government subsidies and lower taxes, which in turn promoted the improvement of their TFP.

6.2 Moderating Effect of NHTZs on "Technology Spillover Effects" of Imported Intermediate Goods

The import of high-quality intermediate goods is easily imitated and learned by enterprises from other countries (Tian and Yu, 2012). In this paper, we focus on whether the establishment of NHTZs has a strengthening effect on the "import spillover effect" of intermediate goods. In order to verify this problem, the following regression formula is set:

$$TFP_{ijct}=\alpha+\beta_1 treat_{it}+\beta_2 treat_{it}\times mid_{it}+\beta_3 mid_{it}+\gamma X_{it}+\lambda_i+\lambda_t+\varepsilon_{ijct} \quad (2)$$

where $treat_{it}\times mid_{it}$ represents the interaction term between the dummy variable of NHTZs and the import intensity of intermediate goods of enterprise i in year t. The key factor is β_2, which examines the influence of the import of intermediate goods by enterprises in the zone on their productivity, so as to measure whether the promoting effect of high-tech zones on enterprise's productivity is caused by the technological learning effect of enterprises on the imported intermediate goods. If there is a positive spillover effect, β_2 should be observed to be significantly positive.

Before the regression of formula (2), the relevant data are conducted as follows. First, the matching data obtained above are divided into import trade and export trade according to trade types. Secondly, based on the method of Cheng and Yang (2022), we align the HS 6-bit product codes with the United Nations BEC codes, and select the samples with BEC codes of 111, 121, 21, 22, 31, 322, 42 and 53, to obtain the data of imported intermediate goods of enterprises. Thirdly, we summarize the intermediate goods imported by enterprises in different years, and divided them by the total import value of enterprises in the current year to obtain the import intensity *mid* of enterprise's intermediate goods. Finally, we construct the interaction term *treat_mid* between *treat* and *mid*.

The regression results are shown in column (3). It is easy to find that the coefficient of *treat_mid* is significantly positive, indicating that the establishment of NHTZs will strengthen the technological spillover effect of enterprise's import of intermediate goods. For this situation, the economic explanation is: Compared with the enterprises outside the zone, the preferential policies of NHTZs can effectively help enterprises in the zone increase their R&D investment and invest higher quality human capital (Zhou et al., 2018). As a result, enterprises in the zone can digest and absorb the advanced technology

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contained in imported intermediate goods more quickly and further promote the TFP.

Furthermore, this paper distinguishes the origin of imported intermediate goods. If intermediate imports from OECD countries[14] are set at 1 and other sources at 0. Then, we construct the interaction term *treat_mid_OECD* between *treat_mid* and *OECD* to estimate formula (2) again. The coefficient of *treat_mid_OECD* in Column (4) is significantly positive, which indicates that the positive promoting effect of high-tech zones on the productivity effect of intermediate goods from OECD countries is greater than those from other countries. In other words, the more advanced technology the imported intermediate goods contain, the more obvious stimulation effect of high-tech zones on "technology spillover effects"[15].

6.3 Innovation and Talent Agglomeration Effect of NHTZs

As the subject of innovation, enterprise's innovation capability is the key to promote industrial transformation and high-quality economic development (Wang and Xu, 2020). Enterprises increase their output level through innovative activities such as product and technological innovation. R&D innovation capability has always been regarded as an essential factor for assessing enterprise's productivity (Bustos, 2011), so this part investigates whether the construction of NHTZs can improve productivity level by stimulating enterprises to improve their R&D and innovation capability.

As the result of innovation activities, patents represent the innovation capability of enterprises (Li et al., 2016), which can be used to deeply study enterprise's innovation behaviors. In this regard, following most existing literature, this paper takes the number of enterprise's patent applications (including invention patents, utility model patents and design patents) as the standard to measure enterprise's R&D and innovation capability. As shown in column (5), the coefficient of *treat_patent* is significantly positive at the level of 1%, which means that the construction of NHTZs has enhanced enterprise's enthusiasm to engage in innovation, made them have greater expectations for the future, and further promoted their improvement of core technology and productivity.

In addition, considering that human capital and its allocative efficiency are significant sources of output growth (Qu, 2020), so the education level of employees is also an important basis for enterprise's innovation activities. Improving the education level of employees not only improves the basic knowledge and skills of employees, but also enhances their communication and coordination ability, which is conducive to the creation or adoption of new technologies, and can significantly promote the productivity growth of manufacturing enterprises. Therefore, apart from taking the number of enterprise patents as the index to assess the innovation effect of NHTZs, this paper also adds the educational background of employees into the assessment as the standard to measure the education level of employees. Specifically, based on the data of listed companies, we mark employees with bachelor's degree or above as highly educated talents, and obtain the proportion of highly educated talents *graduate* in each enterprise, and then construct the interaction term *treat_graduate* between the dummy variable of NHTZs and *graduate*.

It can be found in column (6) that the coefficient of the interaction term is significantly positive, indicating that the establishment of NHTZs has attracted more highly educated and specialized talents into the zone. Facts have proved that high-quality talents are fundamental to the survival and development of enterprises, and the input of employees with high education level can significantly improve the quality of labor force and enterprise's productivity (Cui, 2018; Vandenberghe, 2017). And with the increasing of the average education level of employees, the comprehensive productivity of enterprises basically shows a trend of gradual enhancement (Qu, 2020). Therefore, this paper can obtain: The establishment of NHTZs has strengthened the talent agglomeration of enterprises in the zone,

[14] By 2014, there have been 34 OECD members, excluding Latvia, Lithuania, Colombia and Costa Rica.
[15] The reason is the same as above, it would not be interpreted to save space in the latter part.

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continuously improved the quality of labor force, and further optimized human resource management, so as to enhance enterprise's ability on skill learning and R&D innovation, comprehensively improve their TFP and core competitiveness in the market, and create greater value in the future.

Table 7: Mechanism Test Results

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Policy effect		Spillover moderating effect		Innovation effect	Talent agglomeration effect
	Subsidy	Tax			Enterprise patent	Staff education
treat	0.0501***	0.1090***	0.0165***	0.0173**	0.0613***	0.0252***
	(0.0052)	(0.0058)	(0.0059)	(0.0080)	(0.0099)	(0.0211)
treat_subsidy	0.0037***					
	(0.0013)					
treat_tax		-0.0137***				
		(0.0010)				
treat_mid			0.0718***			
			(0.0082)			
treat_mid _OECD				0.0601***		
				(0.0123)		
treat_patent					0.0222***	
					(0.0084)	
treat_graduate						0.0020***
						(0.0005)
Control variables	Y	Y	Y	Y	Y	Y
Constant	-4.3867***	-4.3902***	-4.3611***	-4.3597***	-4.3207***	-7.6245***
	(0.0230)	(0.0245)	(0.0256)	(0.0257)	(0.0230)	(0.2246)
Firm fixed effect	Y	Y	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y	Y	Y
Obs.	527,272	455,778	314,632	314,632	97,303	3,247
R^2	0.9285	0.9278	0.9300	0.9300	0.9264	0.9794

7. Further Discussion: The Impact of NHTZ Policies on Industrial Productivity Changes

The above analysis shows that the construction of NHTZs significantly promoted the improvement of TFP for existing enterprises in the zones. However, it did not consider the impact of market behaviors such as enterprise entry or exit that could have been caused by relevant policy, nor did it consider the impact of factor allocation changes caused by the expansion or contraction of the market share of existing enterprises. In fact, with the continuous release of China's high-tech zone policy, there have been a large number of enterprises entering or exiting the zones. In addition, in a fiercely competitive market environment, there must be constant changes in the market share of enterprises in the zones, which will have an impact on overall productivity in an industry.

As a result, based on the decomposition idea of Melitz and Polanec (2015) (referred to as M-P method), this paper decomposes the overall productivity change of the manufacturing industry, and then investigates the influence channels of NHTZs on the overall productivity change of the industry. According to M-P method, the growth rate of industrial TFP can be decomposed into[16]:

[16] For simplicity, the industry subscript j has been removed.

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$$\begin{aligned}\Delta\Phi_t &= \frac{1}{\Phi_{t\text{-}1}}\left(\sum_{i\in Z_t} S_{it}\varphi_{it} - \sum_{i\in Z_{t\text{-}1}} S_{it\text{-}1}\varphi_{it\text{-}1}\right) \\ &= \frac{1}{\Phi_{t\text{-}1}}\left[\sum_{i\in N_t}\overline{S}_{it}\Delta\varphi_{it} + \sum_{i\in N_t}(\overline{\varphi}_{it}-\overline{\Phi}_t)\Delta S_{it} + \sum_{i\in E_t} S_{it}(\varphi_{it}-\overline{\Phi}_t) + \sum_{i\in X_t} S_{it\text{-}1}\left(\overline{\Phi}_t-\varphi_{it\text{-}1}\right)\right]\end{aligned} \tag{3}$$

where $\Delta\Phi_t$ represents the growth rate of TFP of industry j in year t, and φ_{it} represents the TFP of enterprise i in year t. $\sum_{i\in N_t}\overline{S}_{it}\Delta\varphi_{it}$ is the level effect (also known as the within-firm effect), which measures the contribution of the existing enterprises' own productivity improvement to the overall productivity of the industry. $\sum_{i\in E_t} S_{it}(\varphi_{it}-\overline{\Phi}_t)$ is the scale effect (also known as inter-firm effect), which measures the impact of enterprise scale changes on the overall productivity of the industry. The expansion of enterprises with high-productivity and the reduction of enterprises with low-productivity would improve the overall productivity of the industry. $\sum_{i\in E_t} S_{it}(\varphi_{it}-\overline{\Phi}_t)$ is the entry effect, which measures the contribution of newly entered enterprises to industrial productivity in the current year. And the entry of high-productivity enterprises would improve the overall productivity of the industry, while the entry of low-productivity enterprises would reduce the overall productivity of the industry. $\sum_{i\in X_t} S_{it\text{-}1}\left(\overline{\Phi}_t-\varphi_{it\text{-}1}\right)$ is exit effect, which measures the contribution of newly exited enterprises to industrial productivity in the current year. And the entry of low-productivity enterprises would eventually improve the overall productivity of the industry, while the exit of high-productivity enterprises would help reduce the overall productivity of the industry.

The regression results of the construction impact of NHTZs on the overall productivity of industry are shown in Table 8. Where column (1) reports the influence of high-tech zones on the change of the industrial overall productivity. The coefficient of the dummy variable of high-tech zones is significantly positive at the level of 1%, indicating that the construction of high-tech zones significantly drives the improvement of industrial overall productivity.

Columns (2)-(4) report the results of the impact of high-tech zones on the decomposition terms of industrial overall productivity. The results of column (2) show that the construction of high-tech zones promotes the improvement of the TFP of existing enterprises in the zone, which is consistent with the conclusion above. The coefficient of the dummy variable in column (3) is significantly positive, indicating that the high-tech zones policy optimizes the allocative efficiency of factors among enterprises by promoting the expansion of enterprises with high-productivity and the reduction of enterprises with low-productivity. In column (4), the regression coefficient of the dummy variable is positive but not significant, indicating that the construction of NHTZs has not significantly stimulated the market entry of high-productivity enterprises. This situation means that the high-tech zones policies are attractive to all kinds of enterprises with productivity differences, and also verifies that there is no enterprise sample selection problem in the construction process of NHTZs. Besides, the regression results in column (5) show that the high-tech zones policy has not promoted the market exit of low-productivity enterprises.

Furthermore, according to the coefficients of dummy variables in columns (3)-(5), it can be roughly estimated that the reallocation efficiency coefficient of high-tech zones policy is negative[17], which means that the scale effect and entry effect caused by preferential policies of NHTZs are not enough to offset the negative impact caused by the exit effect. In other words, the preferential policies of NHTZs keep many low-productivity enterprises in the zone, accounting for a large amount of resources, which limits the market share of the newly-entered high-productivity enterprises and reduces the resource allocation efficiency of the industry.

[17] Since the sample period of this paper is short and few enterprises enter or exit from the zone in the same year, so the sample is insufficient and the regression coefficient of the effect of high-tech zones on industry reallocation cannot be estimated. However, based on the regression coefficients of dummy variables in columns (3)-(5) of Table 8, it can be roughly inferred that the sum of the three effects is negative.

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Table 8: Test Results for Further Discussion

Variable	(1)	(2)	(3)	(4)	(5)
	TFP growth rate	Level effect	Scale effect	Entry effect	Exit effect
treat	0.2789***	0.0061**	0.0077**	0.0126	-0.0283***
	(0.0681)	(0.0024)	(0.0036)	(0.0158)	(0.0078)
Control variables	Y	Y	Y	Y	Y
Constant	-0.0382	-0.0661***	-0.0034	0.6216***	-0.3317***
	(0.1121)	(0.0073)	(0.0062)	(0.0849)	(0.0523)
Firm fixed effect	Y	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y	Y
Obs.	308,060	308,060	308,060	17,964	41,042
R^2	0.4182	0.0587	0.0174	0.3755	0.4070

8. Conclusion

NHTZs are an important strategic platform for cultivating high-tech industries and realizing industrialization in China. Based on the combined data of the industrial enterprise database, the customs database, and *the Catalogue* from 2006 to 2014, this paper systematically investigated the influence of the construction of NHTZs on enterprise's TFP.

Our research findings are as follows. (i) NHTZs had a positive impact on the TFP of enterprises in the zones, and this conclusion is still robust after considering a possible source of endogeneity. (ii) Heterogeneity analysis showed that the productivity effect of NHTZs was better for state-owned enterprises, regions with more developed economies and more efficient governments, and "mature" zones with longer times in existence. Moreover, NHTZs had greater stimulation effects on enterprise productivity than other types of function zones. (iii) Our mechanism investigation showed that NHTZs promoted the TFP of enterprises in the zones through the release of preferential policies, strengthening the "technology spillover effects" of imported intermediate goods, enhancing enterprises' innovation ability, and gathering talent. (iv) The establishment of NHTZs significantly improved the TFP of China's industries on the whole, which was mainly achieved by promoting the productivity improvement of local enterprises and optimizing their factor allocation efficiency. However, the policies of high-tech zones did not promote the entrance of high-productivity enterprises and the exit of low-productivity enterprises via market competition, which therefore decreased the efficiency of industrial resource allocation.

This paper used enterprises' customs codes for the first time to identify enterprises in NHTZs most accurately, and focused on the micro perspective of enterprise's TFP, which provides a new method of evaluating the policy effect of NHTZs, with obvious policy implications. (i) The governments should provide a better policy environment for enterprises in high-tech zones and further deepen the reform of "decentralization, management, and service". They should provide greater tax and business facilitation for enterprises, give priority support to enterprises eligible for inclusion in the state key laboratories and national technology innovation centers, and strengthen the pilot project of innovation policy in some high-tech zones. (ii) The relevant departments should continue to guide enterprises in the zone to increase their R&D investment and improve their R&D and intellectual property management systems. In addition, the high-tech zones should seek to attract talent from all over the world and to cooperate with local universities to stimulate innovation and talent agglomeration to a greater extent. (iii) The relevant departments should also actively promote NHTZs to carry out various forms of international cooperation, encourage local enterprises to "go out" to strengthen foreign trade and expand overseas markets, and make full use of the "technology spillover strengthening effect" of high-tech zones to

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promote talent exchange, technology exchange, and cross-border cooperation among enterprises. (iv) NHTZs should improve the market competition mechanism and law of "survival of the fittest" and should make every effort to stimulate a large number of high-productivity enterprises to enter the zones while accelerating the guidance for low-productivity enterprises to exit the market in order to optimize the efficiency of resource allocation among enterprises in the zones.

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