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Research Article

The Spillover Effect of Institutionalized Opening-up: Evidence from China's Free Trade Zones

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Abstract

As a reform experimental field for establishing high-level mechanisms facing the external world, fully releasing the spillover effects of the free trade zone is an important task for China to achieve technological leapfrog development at present. This paper takes the establishment of China's free trade zones as a natural experiment, using panel data of 283 Chinese cities from 2012 to 2023, and adopting the multi-period difference-difference method to conduct an empirical study on the technological spillover effects and their influencing mechanisms of free trade zones (FTZs) under the background of institutional openness. The research finds that the establishment of free trade zones has promoted the improvement of the technological spillover level of cities. After establishing free trade pilot zones, the local technological spillover level increased by approximately 15.8% on average. The mechanism test results show that free trade zones mainly affect the technological spillover of cities by enhancing regional resilience and promoting innovation agglomeration effects. Heterogeneity analysis reveals that the technological spillover effects of free trade zones are more significant in central cities and cities with developed transportation. The research conclusions of this paper have clear policy implications and provide reference for developing countries to achieve higher levels of openness.

Keywords

Institutional Opening-up, Free Trade Pilot Zones, Technology Spillover

1. Introduction

The new trade theory holds that trade openness is an important factor in promoting a country's technological progress and economic development [8]. The experience of China's reform and opening up over the past 40 years has shown that through import and export trade to introduce advanced technological concepts and management experiences, it is the most common force for the formation and development of technology spillover effects. In the era of economic globalization, all countries have been included in the international division of labor, and through trade exchanges to absorb advanced foreign technologies has gradually become a way to fully release the late-mover advantages of developing countries and further narrow the gap with developed countries. The Free Trade Zone (FTZ) serves as an important platform for China's institutional opening-up [11]. By fully leveraging the institutional benefits of the FTZ to promote the spillover effects of trade technologies, it is a crucial measure for developing countries to achieve a significant leap in their technological capabilities.

Institutional opening-up serves as a distinct symbol and necessary path for China to enhance its opening-up level on a larger scale, at a deeper level, and in a broader range during

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the new era. It achieves this by continuously aligning domestic systems and rules with high-standard international economic and trade rules, thereby advancing strategic opening-up through institutional innovation [1]. And FTZ, as the carriers of institutional opening-up, represent China's expansion from traditional "border opening-up" to "domestic opening-up" [7]. Since the establishment of the first FTZ in 2013, after several rounds of expansion, it has been ten years since then. Currently, China's free trade pilot zones have been established in batches a total of eight times, and the number has reached 23.. Under the new dual circulation development pattern, deeply exploring how FTZ can continue to promote the technological spillover effect of trade by leveraging their institutional opening-up advantages and injecting new development potential into the region is not only an urgent need for China to promote high-level opening-up, but also a profound reflection on more developing countries to achieve higher levels of opening-up while aligning with and promoting the spillover of technological resources.

As the new form of opening up being implemented in China [6], institutional opening-up is an essential route for China to advance high-level opening-up and high-quality development, and a key step toward building a new type of international economic relations and a new international economic order [10]. Focusing on the economic consequences of FTZ, the research has found that FTZ can enhance the scale and quality of a city's export trade [21], and promote enterprise internationalization [20].

In technology management, overexposure has emerged as a commonly acknowledged phenomenon, denoting the diffusion of innovation from a given region to neighboring or other areas [13]. With the implementation of China's "bringing in" and "going out" strategies, technological overexposure has become an important way for China to acquire advanced technological knowledge [4]. Ashraf et al.[2] finds that greenfield investment and cross-border mergers and acquisitions differ in their capacity to generate reverse technology spillovers. Casu et al.[3] evaluates the establishment of the Single Market in 1992 on the cross-border advantages of integration in terms of technology spillovers.

From the current research on institutional-type opening-up in China, the focus has mainly been on the impacts of institutional-type opening-up on economic growth, import and export trade, technological levels, etc. However, there are still insufficient studies on the influence of free trade zones on the spillover effects of import and export technologies from the perspective of "spillover". With institutional opening-up progressively entering a new phase characterized by deeper integration and innovation-driven leadership, free trade zones have proactively built up fresh competitive strengths at the institutional level. Against this backdrop, does the establishment of FTZ under institutional-type opening-up promote the formation and development of technological spillovers in cities? What is the transmission mechanism? And what are the heterogeneous effects on the spillover effects of import and export technologies? Can it affect the technological spillover effects of surrounding cities? These are the urgent issues that our country needs to address in leading comprehensive reform with high-level institutional-type opening-up.

The main contributions of this paper are as follows: Firstly, in terms of research perspective, this paper is the first to evaluate the promoting effect of FTZ on urban technological spillover, which to some extent enriches the assessment scope of the economic effects of institutional-type opening-up. Secondly, in terms of research content, this paper, based on the perspective of regional resilience enhancement effect and innovation aggregation effect, deeply analyzes the path by which the construction of FTZ promotes the level of urban technological spillover. Thirdly, in terms of the analysis of the differences in the impact of the system, this paper conducts test and analysis around the differences in urban scale and urban transportation network. This paper comprehensively reveals the institutional dividends of FTZ, which is conducive to a deeper exploration of the impact path of building FTZ on stimulating urban technological spillover, and provides certain practical basis for achieving high-level opening-up.

2. Policy Background

The FTZ is based on rules and follows the principle of mutual benefit. It breaks constraints by exploring innovative regulatory models, optimizing the business environment, and promoting the facilitation of trade and investment. In 2013, the State Council officially established the first FTZ in Shanghai. In 2015, the State Council approved the establishment of the second batch of FTZs in Guangdong, Tianjin and Fujian. In 2017, the third batch of FTZ were established in provinces such as Zhejiang, Sichuan and Chongqing, gradually expanding from the coast to the inland. In 2018, the entire island of Hainan was included in the FTZ scope. In 2019, 2020 and 2023, the fifth, sixth and seventh batches of FTZ were approved, covering basically the entire country. As China steadily expands the FTZ in batches, following the principle of pioneering and trying first, and then proceeding step by step, the role of the FTZ has been effectively utilized, forming a system framework that is in line with international investment, personnel mobility, logistics transportation and trade circulation rules, and achieving remarkable reform and opening-up results.

3. Theoretical Basis

3.1. Direct Effect

The establishment of FTZ is a beneficial exploration in China's institutional-oriented opening-up reform process, and it is also a reform experimental field for the transformation of China's economic system and structure [9]. It provides policy in-

centives and environmental support for the technology spillover among various regions. On one hand, FTZ usually introduce a series of preferential policies, including tax incentives, simplified procedures, investment facilitation, and research and development subsidies, which significantly reduce the cost of trade barriers and the threshold for investment access, further attracting more enterprises to settle in the FTZ, and encouraging enterprises within the FTZ to drive the flow and transfer of technologies through cooperative research and development, technical exchanges, etc. On the other hand, the openness of FTZ enables enterprises to enter the international market more easily, providing more realistic market demand feedback for the pilot enterprises [17], reducing the communication and information costs of the market to a certain extent, generating trade creation effects and trade transfer effects for the region, and driving a virtuous competition in technological research and innovation in the surrounding areas, further attracting the inflow of high-end talents, and helping to promote the sharing and externalization of technology. Therefore, this article proposes:

H1: The construction of the FTZ has promoted the technological spillover of the city.

3.2. Indirect Effect

As an important medium for ensuring the stable operation of China's trade activities, FTZ have provided a favorable institutional environment by releasing institutional dividends, thereby strengthening regional resilience. From the perspective of opening up to the outside world, FTZ aim to further enhance investment liberalization and reduce market access barriers [12], becoming the forefront of China's innovation-driven and open cooperation [16]. They promote the acceleration of capital, technology, and services from global to China, enabling the adjustment and optimization of regional economic structure and growth mode, helping domestic related industries extend to the high-end industrial chain, providing institutional guarantees for enhancing urban resilience and achieving overall leapfrog growth of the entire industry and economy, promoting collaborative cooperation and technology sharing among enterprises within and between industries, and realizing the spillover and dissemination of technology. From the perspective of internal reform, the construction of FTZ institutional systems benefits from the advantages of pilot trials of the system, by optimizing the foreign trade business environment of the city, driving the flow of internal factors to high-tech and high-value-added sectors for efficient allocation [14], thereby promoting the optimization of the regional economic structure and the formation of industrial agglomeration, achieving a significant increase in overall synergy and strengthening the overall regional resilience and risk-resistance capacity, enabling the region to be more adaptable and timely resume production and operation when facing shocks, further providing risk management for attracting talents and sharing knowledge, and thereby enhancing the spillover effect.

The Free Trade Zone (FTZ) is centered around institutional innovation. From a macro perspective, the FTZ pilot program is a kind of induced institutional change that emerges from economic activities. Through the large-scale implementation of "delegation, management, and service" reforms, functional transformation has enabled the government to cut down its intervention in market participants, fully leveraging the decisive role of the market mechanism in the allocation of innovation factors, thereby stimulating market vitality and innovation enthusiasm, accelerating the construction of a favorable competitive order and human capital incentive mechanism, and enhancing the technological spillover effect of trade [18]. From a micro perspective, by introducing policy preferences such as fiscal subsidies and tax incentives in fields like high-tech, the construction of the FTZ provides financial support for innovation activities [19], while the optimization of the management policies for the entry and exit of technical talents provides talent support for technological innovation, achieving the aggregation of funds, talents, and other innovation factors, helping enterprises transform their innovation ideas to better adapt to the new market environment, thereby forming a more active innovation aggregation ecosystem and accelerating the dissemination and spillover of science and technology within the market. Therefore, this article proposes:

H2: FTZ promotes technological spillover in cities through the regional resilience enhancement effect and the innovation aggregation effect.

4. Empirical Strategy

4.1. Empirical Methodology

Considering that the free trade zones are constructed in batches, this paper uses the multi-period difference-in-differences method to identify the impact relationship between the construction of the FTZ and the technology spillover under the institutional openness. The baseline regression model is as follows:

$$SPILL_{it} = \beta_0 + \beta_1 FTZ_{it} + \gamma Control_{it} + \mu_i + \upsilon_t + \varepsilon_{it} \quad (1)$$

Here, the subscript i denotes the city, while t denotes time. The explained variable $SPILL_{it}$ represents the level of technological spillover in the city; FTZ_{it} is a dummy variable indicating whether city i builds an FTZ in the t-th year. If an FTZ is approved for construction, its value is 1; otherwise, it is 0. Control represents the relevant city-level control variables; μ_i is the city fixed effect; υt is the year fixed effect; ε_{it} is the random error term; β_1 is the double-difference estimator, representing the technological spillover effect of the FTZ, which is the main estimated quantity of this paper; the standard errors reported in this study are clustered at the city level.

4.2. Data and Variables

4.2.1. Dependent Variables

The foreign technologies contained in trade activities possess characteristics of indirectness, abstraction and common knowledge. This may either enable domestic export trade to provide non-export sectors with the opportunity to access and learn advanced technologies, thereby triggering technological spillovers in exports. Or it may cause import trade to enhance the diversity of technology supply channels. By conducting reverse engineering, imitation innovation or joint research and development on imported products, it can then obtain technological spillovers from imports. Regarding the measurement of technological spillovers (SPILL), the technological spillovers of city i in year t are as follows:

$$SPILL_{it}^{im} = \sum_{j=1}^{12}\left(\frac{Import_{jt}}{GDP_{jt}}\right) \times S_{jt}^{d} \times D_{it} \quad (2)$$

$$SPILL_{it}^{ex} = \sum_{j=1}^{12}\left(\frac{Export_{jt}}{GDP_{jt}}\right) \times S_{jt}^{d} \times D_{it} \quad (3)$$

$$SPILL_{it} = SPILL_{it}^{im} + SPILL_{it}^{ex} \quad (4)$$

here, $SPILL_{it}^{im}$ and $SPILL_{it}^{ex}$ represent the technology spillover from the city to the outside world and the technology spillover from the city to the domestic market in year t, respectively. D_{it} represents the weight of the city i's import volume in the national import volume and the weight of the city i's export volume in the national export volume in year t. S_{it}^{d} represents the domestic R&D expenditure of country/j region in year t. $Import_{jt}$ and $Export_{jt}$ respectively represent the total import amount and total export amount of the country/j region in year t with the city i.

4.2.2. Independent Variables

This paper regards the Free Trade Zone (FTZ) system as a quasi-natural experiment. This variable is defined as the interaction term of the city dummy variable and the time dummy variable. If a certain region is approved to establish the FTZ system in a given year and thereafter, the value of FTZit is 1; otherwise, it is 0.

4.2.3. Control Variables

The control variables in this article are as follows: Population size (DEM): Represented by the number of registered residents in the city at the end of the year, and logarithmically processed here. Internet penetration rate (INFRA): Represented by the ratio of international internet users to the permanent resident population of the city. Scientific and technological level (TECH): Represented by the ratio of urban scientific and technological expenditure to urban public budget expenditure. Education expenditure (EDU): Represented by the ratio of urban education expenditure to urban public budget expenditure. Fiscal investment intensity (FIN): Represented by the ratio of urban fixed asset investment to urban public budget expenditure. Human capital level (HUM): Represented by the ratio of students with bachelor's or higher degrees in the city to the total population at the end of the year. The sample range of this article is the urban-level panel data from 2012 to 2023. The specific data are sourced from the official websites of various governments, local government work reports, the World Bank database, and the "China Urban Statistical Yearbook". Table 1 presents the results of descriptive statistics.

Table 1. *Descriptive statistics of major variables.*

Variable	*Obs*	*Mean*	*Std.dev*	*Min*	*Max*
SPILL	3396	1.203	4.106	0	48.205
FTZ	3396	0.274	0.446	0	1
DEM	3396	5.884	0.707	2.970	8.136
INFRA	3396	0.032	0.153	0	3.744
TECH	3396	0.017	0.017	0.001	0.207
EDU	3396	0.176	0.037	0	0.356
FIN	3396	4.810	2.148	0	17.168
HUM	3396	0.020	0.026	0	0.151

5. Results and Discussions

5.1. Baseline Results

The regression outcomes are reported in Table 2. The column (1) represents the results when no control variables were included in the regression. The regression coefficient of FTZ was significant at the 1% level and positive. The column (2) show the results after gradually adding control variables. The significance of the coefficient FTZ did not change and remained positive, indicating that when a city establishes a free trade zone, the average level of technology spillover in local imports and exports increased by approximately 15.8%, meaning that the construction of the FTZ significantly promoted the growth of the local technology spillover level. This is consistent with Hypothesis H1 of this paper.

Table 2. *Impact of FTZ on technology spillover.*

Variable	***SPILL***	
	(1)	**(2)**
FTZ	0.176***	0.158***
	(3.46)	(3.25)
_cons	1.155***	-14.62***
	(83.51)	(-2.66)
Controls	Yes	Yes
Year	Yes	Yes
City	Yes	Yes
N	3396	3396
R^2	0.965	0.967

Notes: 1 (***p < 0.01, **p < 0.05, *p < 0.1. 2) The numbers in parentheses represent the t-statistic. 3) Using a fixed effects model, "city" represents city-fixed effects, and "Year" represents year-fixed effects; the model setup for the subsequent tables is the same.

5.2. Parallel Trend Test

Before the implementation of the FTZ, the trend of technological spillover levels between the treatment group samples and the control group samples should be parallel, and there should be no systematic differences due to changes in time, that is, the parallel trend assumption should be met. As shown in Figure 1, before the system was put into effect, the estimated coefficient values did not pass the significance test, indicating that before the construction of the FTZ in the enterprise's city, there was no significant difference in the trend of technological spillover levels of the two groups of samples. It was found that when the FTZ system was implemented in the first year, it briefly had a policy effect but was not yet stable. In the fourth year, the coefficient of the FTZ began to be significantly positive, proving that the technological spillover effect of the FTZ has been continuously improving over the long term.

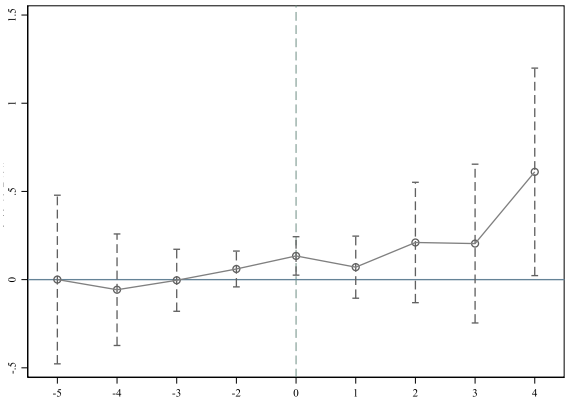


Figure 1. *Parallel trend test.*

5.3. Placebo Test

This article conducts a placebo test. First, a portion of the samples were randomly selected as the false experimental group, while the remaining cities served as the false control group. Based on this, regression was performed to obtain the relevant estimated coefficients. The above steps were repeated 500 times to obtain 500 sets of estimated coefficients and corresponding p-values, as shown in Figure 2. The regression coefficients are mostly concentrated around the 0 value and exhibit a normal distribution, while the actual coefficients differ significantly from the results of the placebo test. The influence of unobservable factors can be excluded.

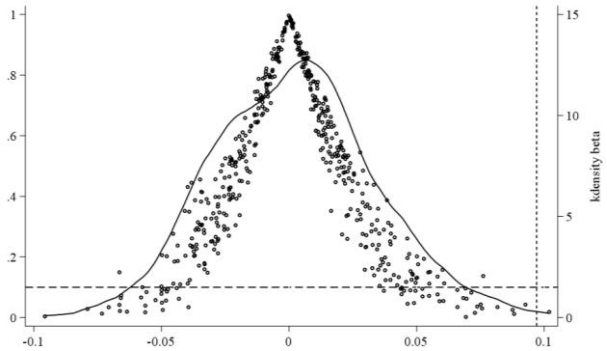


Figure 2. *Placebo test.*

5.4. Endogeneity Test

This paper conducts an endogeneity test, using the number of post stations in the Ming Dynasty of China (IV1) and the

spherical distance to Hangzhou (IV2) as instrumental variables. First, the post stations in the Ming Dynasty, as part of the ancient postal transportation system, have a close connection with modern communication infrastructure. Historically, the locations where the post stations were set up were more likely to be areas with better current information infrastructure, more efficient logistics, and prosperous trade activities. The selection of the location for FTZ may tend to favor areas with developed information, meeting the requirement of correlation. Moreover, the era of the Ming Dynasty was different from the sample period of this study, and there was no direct impact on technology spillovers, thus meeting the requirement of exogeneity.

Secondly, Hangzhou serves as the starting point of China's cross-border trade development process and has a well-developed cross-border logistics system. The closer the relevant regions are to Hangzhou, the higher their digitalization and informatization levels and external scale economies are, which are more conducive to the development of foreign trade. Moreover, the distance will have an impact through economic behaviors, but it will not change with economic development, meeting the exogenous conditions. Considering that the number of Ming Dynasty post stations and the establishment of FTZ belong to cross-sectional data, as an instrument for the FTZ system, this study further constructs the interaction between a cross-sectional instrumental variable and a time variable.

Table 3 reports the two-stage least squares (2SLS) estimation results of the impact of FTZ on urban technology spillover. The result in column (1) shows that the number of Ming Dynasty post stations and the establishment of FTZ have a significantly positive correlation, and there is a negative significant relationship with the spherical distance to Hangzhou and the establishment of FTZ. The result in column (2) is the second stage result. The selected IVs have passed the non-identification test and the weak instrument variable test, and the P value in the overidentification test is not significant, satisfying the null hypothesis that all IVs are exogenous. This indicates that FTZ still significantly enhance the level of technology spillover.

Table 3. *IV estimates.*

Variable	***FTZ***	***SPILL***
	(1)	**(2)**
IV_1:	0.156***	
	(4.65)	
IV_2:	-0.220***	
	(-9.42)	
EcoCity		1.432***
		(3.76)
Kleibergen-Paaprk LM statistic		100.191
		[0.0000]
Kleibergen-Paaprk Wald F statistic		58.272
		{19.93}
Hansen-Overid		1.146
		[0.2843]
Controls	Yes	Yes
Year	Yes	Yes
City	Yes	Yes
N	3396	3396

5.5. Robustness Test

This paper also conducts the following tests: (1) Propensity score matching. To further control the influence of sample selection bias on the level of urban technology spillover, this paper applies propensity score matching, with the propensity scores estimated via a Logit model. The obtained scores are selected for matching control group samples using the 1:1 nearest neighbor matching method, and then the matched successful samples are re-estimated through regression. (2) Removing some samples. The economic development, infrastructure and administrative authority of China's provincial capitals and municipalities directly under the Central Government are more superior. Therefore, this study removes all observations from China's centrally administered municipalities and provincial capitals before running the regression. (3) Heterogeneous treatment effect at multiple time points. Considering that the establishment time of FTZ is different and the inconsistency between time and groups leads to the emergence of Heterogeneous Treatment Effects, there is heterogeneity bias in the response of different cities to the system. To this end, this paper draws on the research of De Chaisemartin & D'Haultfoeuille [5] and uses the twowayfeweights command in Stata software for robustness testing. Among the 931 weights, there are 853 positive weights and 78 negative weights. The sum of positive weights is 1.0298, and the sum of negative weights is -0.0298, indicating that the baseline regression is affected by the negative weight problem weakly. At the same time, this paper uses the interaction weighted estimation method [15] for testing. The results in Table 4 verify the robustness of the results.

Table 4. Robustness test results.

Variable	(1) Propensity score matching	(2) Removing some samples	(3) Interaction weighted
FTZ	0.271***	0.116***	0.190***
	(3.11)	(2.68)	(2.63)
Controls	Yes	Yes	Yes
Year	Yes	Yes	Yes
City	Yes	Yes	Yes
N	1,396	3024	3396
R^2	0.983	0.964	0.969

6. Mechanism Analysis

6.1. Mechanism Verification of the Regional Resilience Enhancement Effect

Institutional opening can, through the regional resilience enhancement effect, further promote technological spillover. To verify this mechanism, this paper uses two aspects of industrial chain resilience and economic resilience as indicators reflecting regional resilience. Among them, the calculation of industrial chain resilience is through the calculation of the resilience index of recovery resistance and the transformation renewal force index, and the indicators calculated using the entropy weight method are used as the industrial chain resilience (ELA). The larger the value, the stronger the resilience of the city's industrial chain. While the calculation of urban economic resilience (RES) uses the urban innovation index (INNO-ind) measured by the "City and Industry Innovation Index" released by the Development and Industry Research Center of Fudan University. The results in Column (1) and Column (2) of Table 5 show that the establishment of FTZ has enhanced the regional resilience level. This indicates that the regional resilience enhancement effect is an effective path for FTZ to promote technological spillover.

6.2. Mechanism Verification of the Innovation Aggregation Effect

The innovation aggregation effect is an important path through which FTZ influences technological spillover. This paper uses the total number of patents obtained (INNO-pat) to measure urban innovation aggregation. Considering that the results of a single indicator regression analysis may produce errors, this paper uses the urban innovation index (INNO-ind) in the "City and Industry Innovation Index" released by the Development and Industry Research Center of Fudan University to measure. The regression results of Column (3) and Column (4) in Table 5 are the regression results of the establishment of FTZ and the innovation aggregation indicators. The coefficients are all significantly positive, indicating that FTZ promotes technological spillover through the innovation aggregation effect.

Table 5. Mediation analysis.

Variable	(1) *ELA*	(2) *RES*	(3) *INNO-pat*	(4) *INNO-ind*
FTZ	0.699***	0.657***	0.215***	0.107***
	(3.76)	(3.29)	(3.95)	(3.39)
Controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes

Variable	(1) *ELA*	(2) *RES*	(3) *INNO-pat*	(4) *INNO-ind*
N	3384	3396	3393	3396
R^2	0.772	0.840	0.771	0.721

7. Heterogeneity Analysis

7.1. Urban Scale Heterogeneity

Urban scale heterogeneity is closely related to the import and export technology spillover effects of FTZ. Based on the level of the urban sample, this paper further divides them into Central cities (including municipalities directly under the Central Government and sub-provincial cities) and Non-central cities (other cities). The regression results are shown in columns (1) and (2) of Table 6. In the sample group of Non-central cities, the coefficient of FTZ is significantly positive, while the positive promoting effect on Central cities is not significant. This indicates that compared to Central cities, the construction of FTZ has a more obvious promoting effect on the technology spillover of Non-central cities. The reason for this result may be that central cities usually already have strong innovation capabilities and technical reserves. Compared to non-central cities, their economies are more developed, geographical locations are superior, and there are certain differences in industrial structures. According to the law of diminishing marginal effect, the construction of FTZ can more promote the initial economic development of non-central cities and has a more significant driving effect on their technology spillover.

7.2. Heterogeneity of Transportation Scale

The differences in transportation networks will lead to variations in the technology spillover effects of FTZ in different cities. Based on the median value of the highway mileage indicators of each city as the dividing line, this paper further divides them into Well-developed cities and Underdeveloped cities. In columns (3) and (4) of Table 6, the coefficients of the sample group of well-developed cities are significantly positive at the 1% level, and their significance is slightly greater than that of the sample group of underdeveloped cities. This indicates that FTZ have a more significant effect on promoting technology spillover in well-developed cities. The possible reason is that well-developed cities usually have a complete logistics system, which can quickly disseminate new technologies, products and services to surrounding areas. This rapid circulation promotes the rapid application and upgrading of technology. At the same time, the well-developed transportation network is more likely to attract high-quality talents, forming a favorable innovation atmosphere.

Table 6. *Heterogeneous effects.*

Variable	*Urban scale*		*Transportation scale*	
	Central city	**Non-central cities**	**Well-developed**	**Underdeveloped**
	(1)	**(2)**	**(3)**	**(4)**
FTZ	0.477	0.100**	0.134***	0.175**
	(1.05)	(2.46)	(2.73)	(2.08)
Controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes
N	228	3168	1440	1887
R^2	0.981	0.927	0.959	0.971

8. Conclusion and Policy Implications

This article regards the implementation of FTZ as a "quasi-natural experiment", and based on the panel data of 283 cities from 2012 to 2023, it empirically examines the technological spillover effect and its mechanism of FTZ using the multi-period DID model. The research results show: (1) The establishment of FTZ can effectively enhance the technological spillover of cities. (2) The mechanism discovery reveals that the construction of FTZ can promote technological spillover through the regional resilience enhancement effect and the innovation aggregation effect; (3) The technological spillover effect of the FTZ system shows significant differences, and FTZ has a more significant technological spillover effect on non-central cities and cities with developed transportation. Based on the above research conclusions, this article puts forward the following policy implications:

First, steadily expand the layout of FTZs, further leverage their advantages in institutional innovation and institutional supply capacity. Second, actively promote self-opening of the system, and promote successful experiences and practices. Third, promote the expansion and increase of FTZs, and facilitate the wider promotion of reform experiences.

Abbreviations

FTZ Free Trade Zones

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Author Contributions

Yujing Lin: Conceptualization, Data curation, Funding acquisition, Project administration, Software, Writing – original draft, Writing – review & editing

Conflicts of Interest

The author declares no conflicts of interest.

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