ISSN 2616-5902 Vol. 6, Issue 10: 225-232, DOI: 10.25236/AJBM.2024.061033

Threshold Effect Test of Cross-Border E-Commerce Promoting the Improvement of Urban Logistics Capacity

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Abstract: *The comprehensive pilot zone for cross-border e-commerce undertakes the important task of exploring new modes and new forms of business, which is of great significance in promoting the transformation and upgrading of the city's logistics industry. The article employs Chinese city panel data to construct a multi-period DID model and a threshold effect model for empirical testing, based on whether a city is set up as a comprehensive cross-border e-commerce pilot zone as a quasi-natural experiment. It is found that the establishment of comprehensive cross-border e-commerce pilot zones has a positive impact on the improvement of logistics capacity at the city level in China. The comprehensive cross-border e-commerce pilot zone effectively reduces logistics costs and improves the speed and service quality of urban logistics by means of integrating logistics resources, improving the level of information technology, and strengthening international cooperation. When the population size of the city reaches a certain threshold, the logistics capacity improvement effect of the cross-border e-commerce comprehensive pilot zone is significant.*

Keywords: *cross-border e-commerce comprehensive pilot zones; logistics capacity; threshold effect*

1. Introduction

As a fundamental national industry and service sector, the pace and quality of logistics development have emerged as key indicators assessing economic strength. Logistics capacity, in particular, stands as a paramount benchmark reflecting the industry's development level. China's Comprehensive Pilot Zone for Cross-border E-commerce represents a designated urban region aimed at pioneering and early-adopting cross-border e-commerce practices. It endeavors to pilot technical standards, business procedures, regulatory frameworks, and informatization efforts pertaining to cross-border e-commerce transactions, payments, logistics, customs clearance, tax rebates, and remittance settlements. Since 2015, 165 comprehensive pilot zones have been established across 31 provinces (cities) in China. The Ministry of Commerce, General Administration of Customs, State Administration of Taxation, and other relevant departments have introduced a series of policies and initiatives to support these zones, with the most salient benefits focusing on four key areas: tax exemption without invoices, approved income tax collection, streamlined customs clearance procedures, and relaxed import supervision.

In order to promote the healthy and rapid development of cross-border e-commerce in China, the State supports cross-border e-commerce retail and export enterprises in their policies to strengthen cooperation with overseas enterprises, integrate into the overseas retail system through the modes of regulated "overseas warehouses", experiential shops and distribution shops, and gradually realise the standardisation of operation, specialisation of management, intensive logistics and production, and scientific supervision. Encourage comprehensive foreign trade service enterprises to provide cross-border e-commerce enterprises with a full range of services such as customs clearance, logistics, warehousing, financing, etc., and support enterprises to establish a global logistics supply chain and an offshore logistics service system. With the successive establishment of cross-border e-commerce pilot zones, the logistics scale effect continues to improve. Logistics structural adjustment has been accelerated, the proportion of railway freight volume in the transport structure has been steadily increased, the average annual growth rate of multimodal freight volume has exceeded 20%, and the storage structure has been gradually optimised, with the rapid development of high-end standard warehouses and intelligent three-dimensional warehouses. These remarkable changes have obviously improved the logistics capacity. The city logistics has gained tremendous development momentum, and the improvement of the city's logistics capacity will be accelerated.

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2. Literature review

2.1 Relevant studies on urban logistics, logistics capacity

Regarding the literature related to logistics capacity, some scholars have studied in terms of scale effect, Li Han and Leng Xuan (2023) found that the market scale effect can improve the marginal logistics and distribution efficiency through sharing logistics facilities and centralised distribution of express delivery[1] . Zhang Xuan et al. (2016) found that most of the domestic and foreign regions in the New Silk Road Economic Belt showed an increasing trend of returns to scale after excluding the influence of environmental factors, indicating that the logistics capacity is more affected by scale efficiency, so improving scale efficiency will help to improve the logistics capacity[2] . Guo Xi et al. (2024) found that the policy of "transferring public transport to railway" can improve logistics capacity by changing the transport mode preference of logistics enterprises and enhancing the substitution of railway transport for road transport through double difference model, generalised double difference model and mediation effect model[3] .

2.2 Relevant studies on cross-border e-commerce and cross-border e-commerce pilot zones in China

For the research related to cross-border e-commerce and cross-border pilot zones, scholars have made relevant explanations from different perspectives. At the trade level, Ju Xuenan et al. (2020) analysed the impact of different types of trade costs on the scale and structure of export trade from the dual perspectives of export destination countries and export production places, and analysed that cross-border e-commerce overcame the obstacles of many trade cost factors and expanded trade boundaries, while cross-border e-commerce provided new opportunities for international trade for non-coastal provinces and high-value-added industries[4] . Hongsheng Zhang and Gangjian Pan (2021) studied the impact of cross-border e-commerce on China's bilateral trade costs based on the 2012 cross-border e-commerce (CBEC)-related policies as a proposed natural experiment by measuring bilateral asymmetric trade costs and identifying the treatment groups by using a variety of methods, such as the CBEC policy list, and found that cross-border e-commerce significantly reduces China's export and import trade costs[5] .

In terms of institutional innovation, Ma Shuzhong and Guo Jiwen (2022) quantitatively assessed the impact of institutional innovations related to the Pilot Zone on regional cross-border e-commerce exports by using the double-difference-in-differences (DID) method, and found that the establishment of the Pilot Zone increased cross-border e-commerce exports of various industries within the city by an average of about 21 per cent, and this boosting effect was further enhanced following the introduction of the "no invoice tax exemption" policy. This effect was further enhanced after the introduction of the "no invoice tax exemption" policy[6] .

At the level of regional coordination,Ma Shuzhong et al. (2024), by combining cross-border e-commerce waybill data and nighttime lighting raster data to explore the impact of cross-border e-commerce on the coordinated development of municipal regions, found that the development of cross-border e-commerce in cities can enhance their internal coordinated development, and the conclusion remains robust after using two types of instrumental variables, namely the average distance between the city and the cross-border e-commerce integrated pilot zone and the attention to the cross-border e-commerce platform[7] . Liu Yurong et al. (2023) examine the impact of cross-border e-commerce on the agglomeration of productive service industries using the double-difference method based on a quasi-natural experiment in a comprehensive cross-border e-commerce test zone. It is found that cross-border e-commerce can significantly improve the level of specialised agglomeration of productive service industries, promote the optimisation and upgrading of regional industries, and facilitate the coordinated development of productive service industries among regions[8] .

2.3 Studies related to cross-border e-commerce and logistics capacity

Regarding the research on the relationship between cross-border e-commerce and logistics, Zhang Xiaheng (2020) found that the clearance capacity of cross-border logistics is negatively correlated with the probability of cross-border e-commerce supervision, and the supervision cost of cross-border e-commerce is negatively correlated with the probability of cross-border logistics' active co-operation[9] . He Jiang and Qian Huimin (2019) found that cross-border e-commerce is mainly affected by its own factors, while cross-border logistics is more affected by cross-border e-commerce, the relationship between cross-border logistics and cross-border e-commerce is also mainly in the same direction of change, and the growth of cross-border logistics has no obvious reverse inhibition effect on the growth of

ISSN 2616-5902 Vol. 6, Issue 10: 225-232, DOI: 10.25236/AJBM.2024.061033

cross-border e-commerce in the short term[10] .

2.4 Literature review

The aforementioned literature has delved into various facets of the impact of pilot zones and urban logistics, yet a notable gap exists in bridging these two domains to examine the consequences of establishing cross-border e-commerce pilot zones on urban logistics. Additionally, the preponderance of literature tends to concentrate on the relationship between cross-border e-commerce pilot zones and cross-border logistics, with comparatively scarce research addressing the correlation between these zones and urban logistics. In fostering the advancement of both cross-border e-commerce and urban logistics, pilot zones occupy a pivotal position. The Party Central Committee and the State Council have underscored the significance of cross-border e-commerce as an emerging business model in recent times, and the beneficial influence of institutional innovations in comprehensive pilot zones on China's cross-border e-commerce exports has been validated. In comparison to existing literature, this paper's marginal contribution primarily resides in investigating the comprehensive influence of establishing cross-border e-commerce pilot zones on urban logistics capabilities and assessing whether there exists a threshold effect in the impact of these zones on urban logistics.

3. Theoretical analysis

3.1 Analysis of the impact of cross-border e-commerce pilot zones on logistics capacity

The comprehensive pilot zone for cross-border e-commerce, as a systematic innovation for early and pilot implementation, aims to crack the deep-rooted contradictions and institutional difficulties in the development of cross-border e-commerce, create a complete industrial chain and ecological chain of cross-border e-commerce, and gradually form a set of management system and rules to adapt to and lead the development of cross-border e-commerce globally, so as to provide a reproducible and scalable experience for the promotion of healthy development of cross-border e-commerce in China. At the same time, the system innovation and facilitation measures in "customs", "inspection", "remittance" and "tax" in the pilot zone have effectively reduced the cost of export for enterprises. Measures to effectively reduce the export barriers of enterprises (Ma Shuzhong and Guo Jiwen, 2022)[6] , expanding the volume of trade and exports, forming a certain economy of scale effect. This economy of scale effect to a certain extent integrates the dispersed transport, warehousing and distribution capacity, improves the efficiency of resource utilisation, promotes cost reduction and efficiency in logistics, and at the same time brings about structural cost reductions, resulting in a continuous improvement of logistics scale efficiency.

In addition, compared with traditional trade, the threshold of cross-border trade practitioners in the pilot zones is greatly reduced, and the digital platform simplifies the trade process while not requiring a high level of foreign trade knowledge reserves (Guo Chaoxian et al., 2020; Lin Xiaoyi et al., 2024)[11-12] . The establishment of comprehensive pilot zones for cross-border e-commerce has also boosted inter-regional industrial restructuring and industrial transfer. As an important industrial policy, comprehensive pilot zones effectively play the decisive role of the market in resource allocation, and promote the optimisation and upgrading of the industrial structure (Han YH et al., 2017)[13] , introduce more enterprises into underdeveloped areas, and drive the comprehensive development of various industries.

3.2 Threshold effects of population size

The impact of the establishment of the comprehensive test zone on the city's logistics capacity may not be presented in a linear manner. Sufficient high-quality talents can provide labour support for cross-border e-commerce industry development, innovation and entrepreneurship, in order to safeguard the operation and communication in cross-border e-commerce transactions. With the increase of population size, the logistics capacity will gradually increase when it brings a certain amount of business. Population size directly affects the amount of logistics demand, and densely populated areas usually bring more consumption, which requires more logistics services to satisfy these demands, while the population distribution, demographic structure, and demographic change trends also have a significant impact on logistics capacity. Less populated areas, on the other hand, lead to a lack of labour resources while the demand for logistics services is also relatively reduced. The establishment of cross-border e-commerce pilot zones has brought a lot of logistics dividends to the region, but the business volume brought by the small population size does not enable the pilot zones to better enhance their logistics

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capacity. Therefore, when the population reaches a certain size and brings logistics demand across a certain threshold, the impact of the cross-border e-commerce pilot zone on the city's logistics capacity will show a significant leap and fully emerge.

4. Empirical tests

4.1 Econometric modelling

Drawing on the methodology of Ma Shuzhong and Guo Jiwen (2022)[6] , a double difference model is used to analyse the impact of the establishment of cross-border e-commerce comprehensive pilot zones on the logistics capacity of each prefecture-level city. The comprehensive pilot zone cities are taken as the treatment group, and the non-comprehensive pilot zone cities are taken as the control group. The model assesses the impact of the policy by comparing the changes in logistics capacity in affected and unaffected areas before and after the implementation of the comprehensive cross-border e-commerce pilot zone policy. The impact of the establishment of the comprehensive pilot zone on the logistics capacity of prefecture-level cities. The specific model is as follows:

$$Y_{i,t} = \alpha_0 + \alpha_1 DID_{i,t} + \alpha_2 X_{i,t} + \lambda_i + \mu_t + \varepsilon_{i,t}$$

Of these, the$i$ and$t$ denote each prefecture-level city and year, respectively;$Y_{i,t}$ represents the logistics capacity of prefecture-level cities; the core explanatory variable$DID_{i,t}$ represents the first$i$ region in the first$t$ Whether or not a comprehensive pilot zone for cross-border e-commerce is established in the year, with 1 for establishment and 0 vice versa;X is a series of control variables;λ andμ represent individual fixed effects and time fixed effects, respectively;ε is a random perturbation term;α_0, theα_1 andα_2 each represent the intercept term and the regression coefficients for each variable.

In the process of studying the impact of cross-border e-commerce on the logistics capacity of prefecture-level cities, the threshold effect model can be used to explore the heterogeneity of policy impacts under different conditions. The threshold effect model can reveal whether there is a significant difference in the impact on logistics capacity when certain variables exceed a specific threshold. In order to explore whether the degree of impact of the establishment of cross-border e-commerce pilot zones on the logistics capacity of prefecture-level cities changes within the range of intervals with different population densities, this paper adopts the panel threshold model for empirical analysis. The model is as follows:

$$Y_{i,t} = \varphi_0 + \varphi_1 DID_{i,t} \times I(Pop_{i,t} \le \theta_{i,t}) + \varphi_2 DID_{i,t} \times I(Pop_{i,t} > \theta_{i,t}) + \varphi_3 X_{i,t} + \lambda_i + \mu_t + \varepsilon_{i,t}$$

whereφ_0 is the intercept term, andφ_1, φ_2, andφ_3 represent the regression coefficients of each variable, respectively;I () is the indicator function, assigned a value of 1 when the indicator condition is met, and 0 otherwise; the meaning of the rest of the variables is the same as the above model.

4.2 Data sources, selection of variables and calculations

4.2.1 Data sources

Panel data of 300 prefecture-level cities across China from 2010-2019 are selected, and the data used are from the 2010-2019 China Urban Statistical Yearbook, and the logistic capacity indicators are from the CHFs database as well as the statistical yearbooks of each region.

4.2.2 Selection of variables

The explanatory variable is logistics capacity (Logistics). Drawing on the entropy method calculation method in Zhu Xi'an and Wei (2015)[14] , the 2010-2019 logistics capacity composite index of each city is obtained by processing data on logistics infrastructure, logistics industry employees, total passenger volume, and freight turnover in various prefecture level cities, which is used as a double-difference explanatory variable.

This paper constructs a DID dummy explanatory variable based on whether the city has implemented a comprehensive cross-border e-commerce pilot zone, with 1 for policy implementation and 0 for non-implementation.

In addition to the main explanatory variables of the model the dummy variable of whether the policy is implemented or not, the control variables are borrowed from the studies of Wen Yanbing et al. (2022)[15] to include the control variables affecting the logistics capacity such as the economic level (ln

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el), the industrial structure (structural), the distribution of the population (ln urban), and the ability to innovate (ln tech), in order to alleviate the omitted variable bias. Among them, the economic level is expressed by GDP in natural logarithm, the industrial structure is expressed by the value added of tertiary industry divided by GDP, the population distribution is expressed by population density in logarithm, and the innovation capacity is expressed by government research expenditure in logarithm.

4.3 Empirical results and analyses

4.3.1 Descriptive statistics

The descriptive statistics of every variable in the text are shown in Table 1.

Table 1: Descriptive statistics

variable name	sample size	average value	variance (statistics)	minimum value	maximum values
Logistics	3000	0.081	0.071	0	0.86
DID	3000	0.039	0.194	0	1
ln el	2871	16.496	0.943	13.855	19.76
structure	2621	15.538	1.065	12.689	19.504
ln urban	2858	5.721	0.976	1.733	9.055
ln tech	2847	5.686	1.385	2.079	10.924

4.3.2 Benchmark regression

Table 2 shows the regression results of the degree of impact of the establishment of cross-border e-commerce pilot zones on logistics capacity. In order to ensure the accuracy of the empirical results, this paper adopts the stepwise regression method for the analysis, column 1 is the regression results without adding any control variables and controlling the double fixed effects of individual time points, column 2 to column 5 are the gradual addition of control variables on the basis of the first step. As shown in the table below, the regression coefficients of DID are all significant at the 5% level both in the direct regression and in the gradual addition of control variables, indicating that the establishment of the cross-border e-commerce pilot zone has played a positive and stable role in promoting the logistics capacity, and the theoretical analyses in this paper have been verified. The R^2 values of all models are high (R^2 close to 0.944), with high explanatory power, indicating that the models have strong explanatory power for the explained variables.

Table 2: Benchmark regression

	(1)	(2)	(3)	(4)	(5)
	Logistics	Logistics	Logistics	Logistics	Logistics
DID	0.020**	0.020**	0.020**	0.019**	0.018**
	(2.295)	(2.327)	(2.485)	(2.375)	(2.375)
ln el		0.006*	0.005	0.004	0.004
		(1.673)	(1.063)	(0.732)	(0.865)
structure			0.001	0.001	0.001
			(0.215)	(0.208)	(0.217)
ln urban				0.022**	0.022**
				(2.183)	(2.150)
ln tech					0.000
					(0.135)
constant term (math.)	0.080***	-0.019	-0.016	-0.118	-0.125
	(233.576)	(-0.308)	(-0.240)	(-1.222)	(-1.313)
urban fixed effect	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES
N	3000	2870	2620	2575	2557
R2	0.942	0.943	0.944	0.944	0.944

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4.3.3 Threshold effect

In order to explore the variability of the degree of impact of the establishment of cross-border e-commerce pilot zones on logistics capacity under different population densities, this part uses the number of population at the end of the year as the threshold variable to analyse the threshold effect. In order to avoid the influence of artificial values, this paper adopts the threshold model proposed by Hansen for the analysis, and sets 400 network search points to test the repetition by 300 times of the bootstrap method. The results of threshold self-sampling test are shown in Table 3, and the results of threshold effect test are shown in Table 4.

It is shown in Table 3 that firstly, the test was conducted using triple threshold and it was found that the p-value was 0.587 which indicates that there is no triple threshold. Secondly, the test was conducted using double threshold and the p-value was found to be 0.350 which indicates that there is no double threshold. Lastly, the test was conducted using single threshold and it was found that the p-value was significant at less than 5 per cent level, which indicates that there is a single threshold feature of population density and that the single threshold value is 7.158.

As shown in Table 4, when the population density is lower than the threshold value of 7.158, the regression coefficient of the establishment of cross-border e-commerce pilot zones for logistics capacity is 0.004 and insignificant, while when the population density is higher than the threshold value the impact coefficient increases significantly to 0.066 and is significant at the level of 1 per cent, which implies that the level of the population density affects the degree of impact of the establishment of cross-border e-commerce pilot zones for logistics capacity.

The results of this threshold test are of great economic significance. Firstly, it reveals the contribution of population size to the improvement of logistics capacity, which provides an important reference for the government to formulate relevant policies. Secondly, it highlights the important role of the cross-border e-commerce pilot zone policy in promoting the development of the logistics industry, which provides strong support for the continuous optimisation and promotion of the policy. When formulating the cross-border e-commerce pilot zone policy, the city's population size factor should be fully considered to ensure that the policy can maximise its effect. The government should increase investment in logistics infrastructure construction in cities with large population sizes to enhance the overall development of the logistics industry. At the same time, logistics enterprises should seize the opportunities brought by the cross-border e-commerce pilot zone policy, strengthen technological innovation and service upgrading, and improve their competitiveness.

Table 3: Threshold self-sampling test results

Threshold type	threshold value	RSS	MSE	F-statistic	P-value	Threshold 10 percent	Threshold 5 percent	Threshold 1 percent
single threshold	7.158	0.544	0.003	16.39	0.033	8.013	12.776	20.658
double threshold	6.251	0.542	0.003	0.74	0.350	1.200	1.492	1.933
the three thresholds	5.926	0.540	0.003	0.81	0.660	2.267	2.564	3.251

Table 4: Threshold effect test results

variant	threshold range	Logistics
DID	Pop≤ 7.158	0.004
		(0.53)
	Pop> 7.158	0.066***
		(5.86)
constant term (math.)		-0.508
		(-1.33)
control variable		YES
urban fixed effect		YES
Year fixed effects		YES
R^2		0.401

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5. Conclusions and recommendations

5.1 Main findings

In the face of the changing international development environment, the establishment of comprehensive pilot zones for cross-border e-commerce is an important initiative to deepen reform and opening up, and has great potential in promoting the development of urban logistics capacity. This paper takes the comprehensive pilot zone for cross-border e-commerce and urban logistics capacity as the research object, and empirically tests the effect of comprehensive pilot zone for cross-border e-commerce on urban logistics by constructing multi-period DID model and threshold effect model using the panel data of each prefecture-level city in China during 2010-2019, and the research results show that the establishment of comprehensive pilot zone for cross-border e-commerce significantly improves the urban logistics capacity. The test based on the threshold effect model shows that after the population size of the city where the cross-border e-commerce pilot zone is set up reaches the threshold, the establishment of the pilot zone in the region has a significant impact on the city's logistics capacity. The positioning of cross-border e-commerce pilot zones is based on the regional economic aggregate, industrial spatial layout, infrastructure connectivity and population distribution, etc., and combined with the basic pattern of "ten vertical and ten horizontal" transport corridors and domestic logistics corridors, the cities with certain basic conditions are selected as the pilot zones, which ensures the basic logistics transport and efficiency.

5.2 Related recommendations

Based on the conclusions of this paper, in order to better enhance the role of comprehensive pilot zones for cross-border e-commerce on the improvement of urban logistics capacity, the following aspects are proposed to enhance the recommendations.

Firstly, relying on the construction of cross-border e-commerce pilot zones, improve the city's logistics infrastructure. First, the construction of a complete network infrastructure to improve the level of logistics intelligence. The construction of intelligent logistics centres, intelligent warehouses and intelligent sorting systems and other infrastructure, through the use of big data, the Internet of Things and artificial intelligence and other technologies, real-time collection and transmission of logistics information, and improve the automation level of logistics operations. At the same time, the use of big data technology makes logistics information gradually share, through the processing and analysis of multi-dimensional data, logistics enterprises can obtain more comprehensive logistics information to enhance the level of decision-making intelligence. Second, the use of transport capacity to expand logistics capacity. The railway sector plays the role of 40 railway logistics centres across the country, accelerates the development of logistics turnkey, tailors logistics solutions for enterprises, promotes the transformation of railway transport from traditional "station-to-station" to "door-to-door" logistics services, and has signed a cumulative total of 330 million tonnes of contracted freight volume for logistics turnkey. A total of 330 million tonnes of contracted transport volume has been signed. Cross-border e-commerce pilot zones to improve the transport capacity to a large extent, but also to promote the logistics capacity to improve logistics efficiency.

Second, give full play to the role of urban population size, relying on cross-border e-commerce to enhance logistics capacity. To begin with, the expansion of urban population size will significantly increase logistics demand. With the increase of urban population, the demand for consumption and the demand for goods transport will also grow accordingly, which directly promotes the development of the logistics industry. Through the cross-border e-commerce platform, we are able to respond quickly to market demand and provide a richer and more diverse selection of goods, while ensuring the efficient transport and timely delivery of goods. Furthermore, population scale efficiency affects the location and planning of logistics nodes. Areas with high population density are often the preferred location for logistics nodes because of the high demand in these areas, while the infrastructure is more complete, which is conducive to efficient logistics transport. The development of cross-border e-commerce necessarily takes into account the fact that in order to enhance the shopping experience of consumers, it is possible to invest in the construction of modern logistics centres equipped with the most advanced automated sorting and packaging equipment. These equipments not only improve work efficiency, but also reduce human errors and ensure the quality and safety of goods. Multiple front warehouses should also be set up to facilitate rapid response to the demand for orders from neighbouring areas and to achieve same-day or next-day delivery services.

ISSN 2616-5902 Vol. 6, Issue 10: 225-232, DOI: 10.25236/AJBM.2024.061033

Acknowledgements

We appreciate the financial support from Innovation and Entrepreneurship Training Program for College Students in Jiangsu Province, China (Grant number: 202313982047Y). We also appreciate the financial support from University Philosophy and Social Science Project of Jiangsu Provincial Department of Education (Grant number: 2023SJYB0923).

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