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CROSS-BORDER E-COMMERCE POLICIES AND THE HIGH-QUALITY DEVELOPMENT OF URBAN ECONOMIES

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Abstract: Cross-border e-commerce has emerged as a pivotal force in China's international trade growth. Since 2015, the Chinese government has implemented city-level pilot zones to foster cross-border e-commerce, followed by a 2017 policy shift emphasizing high-quality development centered on sustainability and innovation. Leveraging panel data from 280 prefecture-level cities (2010–2021), we employ a multi-period difference-in-differences (DID) approach to evaluate the economic impact of these pilot zones on urban development. Complemented by qualitative policy analysis, the research further explores the underlying mechanisms driving these effects. The findings reveal that the pilot zones significantly enhance urban sustainability and innovation, with heterogeneous effects based on geographic location, industrial structure, city size, and cluster dynamics. Three key mechanisms are identified: digital infrastructure development, productive service agglomeration, and business environment optimization. These insights provide robust empirical support for refining cross-border e-commerce policies to maximize their economic benefits.
Keywords: Cross-border e-commerce; Sustainable development; Innovative development; Qualitative analysis

1 INTRODUCTION

The Chinese government's 2017 introduction of the high-quality economic development concept marked a strategic shift from growth quantity to development quality, emphasizing innovation, sustainability, and inclusiveness. In this context, digital trade - particularly cross-border e-commerce (CBEC) - has emerged as a transformative force in economic restructuring. Recognizing its potential, China has implemented comprehensive CBEC policies since 2015, beginning with pilot zones in Hangzhou and expanding nationwide, featuring innovative customs, tax, and financial support mechanisms. These policy experiments present a valuable opportunity to examine how digital trade policies influence urban economic transformation.

Existing literature reveals three significant research gaps. First, while numerous studies have documented digital trade's impact on economic growth, few have systematically examined its effects on development quality dimensions like sustainability and innovation. Second, most empirical analyses operate at national or provincial levels, leaving city-specific impacts underexplored. Third, current research tends to focus on quantitative assessments while neglecting qualitative policy analysis that could reveal underlying mechanisms. These limitations motivate our investigation into three core questions: how CBEC pilot zones affect high-quality urban development, through what mechanisms these effects operate, and whether impacts vary across cities with different characteristics.

This study makes several important contributions to the literature. By combining text analysis of policy documents with a multi-period difference-in-differences approach using panel data from 280 Chinese cities (2010-2021), we provide robust empirical evidence that CBEC pilot zones significantly enhance urban economic quality, with particularly strong effects in coastal cities, service-oriented economies, and large metropolitan areas. Our mechanism analysis reveals that this improvement operates through three key channels: the development of digital infrastructure, agglomeration of productive services, and optimization of local business environments. These findings not only extend digital trade research into the specific context of CBEC policy evaluation but also demonstrate the value of integrating qualitative and quantitative methods in policy impact assessment. Furthermore, our city-level analysis enriches understanding of how digital trade policies differentially affect urban economic trajectories, offering practical insights for regional development strategies.

2 QUALITATIVE ANALYSIS AND RESEARCH HYPOTHESIS

2.1 Frequency Analysis of Keywords

To gain a deeper understanding of the connotations of CBEC Pilot Areas policies and how these policies influence high-quality urban economic development, This study applies text mining and thematic analysis to policy documents from central and local governments in China, to identify key policy focuses and mechanisms. The results, as shown in Table 1 and 2, indicate that the policy focus is on digital infrastructure, the agglomeration of services, and the optimization of the business environment. These three themes occupy significant positions within the policy framework, with weighted proportions of 3.55%, 4.85%, and 2.57%, respectively. These themes reflect the government's strategic

priorities and the key paths for promoting cross-border e-commerce, providing theoretical support for the research hypotheses discussed later.

Table 1 Policy Documents Related to Cross-Border E-Commerce

Serial no.	Year	Title of document	Issuing organization
1	2015	Official Reply of the State Council on Approving the Establishment of the China (Hangzhou) Cross-Border E-Commerce Comprehensive Pilot Zone	State Council
2	2016	Notice of the Ministry of Finance, the General Administration of Customs and the State Administration of Taxation on the Tax Policies on Cross-Border E-Commerce Retail Imports	Ministry of Finance General Administration of Customs State Taxation Administration
3	2018	Announcement No. 194 [2018] of the General Administration of Customs—Announcement on Matters concerning the Supervision of Retail Imports and Exports in Cross-Border E-commerce	General Administration of Customs
……	……	……	……
64	2024	Opinions of the Ministry of Commerce and Other Eight Ministries and Commissions on Expanding Cross-Border E-commerce Exports and Promoting the Construction of Overseas Warehouses	Ministry of Commerce National Development & Reform Commission Ministry of Finance Ministry of Transport People's Bank of China General Administration of Customs

Table 2 Policy High Frequency Word Statistics

Thematic	Related Keywords.	Thematic frequency
Digital infrastructure construction	Electronics, Payment, Information, Platform, Data, Network, Technology, System, Digitization, Cloud Computing, Logistics Informatization, Blockchain, API Integration, Smart Terminal, Network Security	3.55%
Service industry agglomeration	Service, Business, Enterprise, Organization, Business, Commodity, Collaboration, Cluster, Warehousing, Logistics, Supply Chain, Finance, Marketing, Consulting, Training, Innovation, Cooperation, Brand, Cross-border Service Ecosystem	4.85%
Business Environment	Customs, supervision, regulation, pilot, declaration, policy, tax, compliance, intellectual property, risk prevention and control, administrative licensing, standardization, trade facilitation, dispute settlement, local policy support	2.57%

2.2 Thematic Analysis and Research Hypotheses

2.2.1 Digital infrastructure construction

Policy documents emphasize digital infrastructure as a critical enabler of high-quality development in CBEC Pilot Areas, with frequent mentions of "network," "digitalization," and "cloud computing." Drawing on the Solow growth model, digital infrastructure enhances economic growth by improving information flows, optimizing resource allocation, and reducing transaction costs. Specifically, logistics informatization and cybersecurity upgrades contribute to more efficient cross-border trade operations.

2.2.2 Service industry agglomeration

CBEC policies promote service agglomeration through terms such as "clusters," "finance," and "cross-border service ecosystem." Industrial clustering enhances supply chain coordination, reduces information asymmetry, and fosters synergies among logistics, financial, and IT services. This integrated ecosystem improves trade efficiency and helps cultivate globally competitive e-commerce hubs, supporting sustainable economic development.

2.2.3 Business environment optimization

A key focus of CBEC policies is improving the business environment, as reflected in terms like "customs," "regulation," and "compliance." Streamlined administrative procedures, lower institutional costs, and stronger intellectual property protections contribute to a more transparent and stable trade environment. These reforms reduce transaction costs and enhance institutional efficiency, facilitating higher-quality economic growth.

2.3 Research Hypotheses

Building on policy text analysis and the extended Solow growth model, which is based on the original growth theory proposed by Solow [1]. This study proposes three mechanisms through which CBEC Pilot Areas drive high-quality development: (1) digital infrastructure (capital input), (2) service agglomeration (labor and resource allocation), and (3) business environment optimization (transaction costs). These mechanisms collectively enhance economic efficiency by improving technological progress, market coordination, and institutional quality.

2.3.1 Construction of production functions

According to the Solow growth model, total output Y is related to the level of technology A, capital input K, and labor input L. Therefore, The production function can be expressed as:

$$Y = AK^{\alpha}L^{1-\alpha} \tag{1}$$

where Y denotes total output, A is the level of technology, K is capital inputs, representing the construction of digital infrastructure, and L is labor inputs, representing the agglomeration of productive services. α is the output elasticity of capital, and $1-\alpha$ is the output elasticity of labor.

2.3.2 The dynamic process of capital and labor accumulation

Based on further exploration of the Solow growth model, it was found that capital accumulation is related to the rate of saving, i.e., the rate of capital investment and the rate of depreciation of capital. The capital accumulation equation is given by:

$$\dot{K} = sY - \delta K \tag{2}$$

where s is the savings rate and δ is the depreciation rate of capital. To reflect the dynamic process of capital and labor accumulation, the production function is substituted into the capital accumulation equation to obtain the dynamic growth equation of capital as as follows:

$$\dot{K} = sAK^{\alpha}L^{1-\alpha} - \delta K \tag{3}$$

This equation indicates that when the accumulation of capital reaches long-run equilibrium, i.e., the steady-state level, the growth rate of capital is 0, i.e., $\dot{K}$ = 0, and steady-state capital K^* can be derived as follows:

$$K^* = \left(\frac{sAL^{1-\alpha}}{\delta}\right)^{\frac{1}{1-\alpha}} \tag{4}$$

2.3.3 Construction of an improved production function

$$Y = AK^{\alpha}L^{1-\alpha}T^{\gamma} \tag{5}$$

where T denotes transaction costs and γ denotes the output elasticity of transaction costs. A reduction in transaction costs leads to an increase in market efficiency, which in turn leads to an increase in aggregate output Y.

2.3.4 A study of the dynamic process with the inclusion of transaction costs

The derivation process above is not repeated, and after adding the transaction cost element, the steady state capital K^* is as shown in Equation (6):

$$K^* = \left(\frac{sAL^{1-\alpha}T^{\gamma}}{\delta}\right)^{\frac{1}{1-\alpha}} \tag{6}$$

At this point, total output Y is given by:

$$Y^* = A\left(\frac{sAL^{1-\alpha}T^{\gamma}}{\delta}\right)^{\frac{\alpha}{1-\alpha}}L^{1-\alpha}T^{\gamma} \tag{7}$$

Steady-state growth for high-quality development arises from capital investment, labor input, and lower transaction costs.Accordingly, CBEC Pilot Areas promote high-quality economic development through the construction of digital infrastructure, the aggregation of productive services, and the improvement of the business environment. Therefore, this paper proposes the following two hypotheses:

H1: The establishment of CBEC Pilot Areas promotes urban high-quality economic development.

H2: The establishment of CBEC Pilot Areas promotes urban high-quality economic development through the construction of digital infrastructure, the aggregation of productive services, and the improvement of the business environment.

3 RESEARCH DESIGN

3.1 Econometric Modeling

Between 2010 and 2021, 12 provinces were designated as CBEC Pilot Areas, covering 280 prefecture-level cities. Therefore, we employ a multi-period difference-in-differences (DID) model to explore the impact of CBEC Pilot Area establishment on urban high-quality economic development. By comparing the differences between the pilot cities, which serve as the treatment group, and the non-pilot cities, which serve as the control group, the study further analyze the impact of CBEC Pilot Areas on urban high-quality economic development. The model is specified in Equation (8):

$$HQD_{it} = \alpha_0 + \alpha_1 CBEC_{it} + \alpha_2 Contral + \mu_i + \nu_t + \varepsilon_{it} \tag{8}$$

Where i represents the city and t represents the year. The dependent variable is HQD, representing the level of high-quality economic development in the city. $CBEC_{it}$ is the core explanatory variable, indicating whether city i is recognized as a CBEC Pilot Area in year t. If city i is confirmed as a CBEC Pilot Area in year t or thereafter, the

value of CBEC in year t and beyond is 1; otherwise, it is 0. $Contral$ represents a set of control variables, ε_{it} denotes the random disturbance term, μ_i denotes city fixed effects, v_t denotes year fixed effects, and α_0 is the constant term. α_1 represents the direct effect of the establishment of CBEC Pilot Areas on the high-quality economic development of cities, which is the focus of this study.

3.2. Variable Selection

3.2.1 Dependent variable

The dependent variable in this study is the high-quality development (HQD) of urban economies. It is difficult to adequately measure its level using a single indicator because the HQD has multidimensional characteristics. Wei and Li indicated the development of a measurement system for the comprehensive evaluation of high-quality economic development has addressed this limitation [2]. Nie and Jian developed a high-quality development index system incorporating quality, benefits, and stability [3]. They found that the high-quality development index of China's provinces exhibits a spatial positive agglomeration pattern. This paper, drawing on the work of Liu et al. [4], constructs a comprehensive evaluation index system for high-quality economic development based on the five development concepts of "innovation, coordination, green, openness, and sharing," and employs the entropy method to measure the high-quality economic development index of Chinese cities.

3.2.2 Core explanatory variable

The core explanatory variable in this study is the interaction term of the CBEC Pilot Areas ($CBEC$). This variable is obtained by multiplying the spatial dummy variable $Treat$ with the time dummy variable $Ryear$. $Treat$ is used to identify cities involved in the establishment of CBEC Pilot Areas, and it is constructed based on whether a prefecture-level city has established a CBEC Pilot Area. If a city has established a CBEC Pilot Area, $Treat$ is assigned a value of 1; otherwise, it is assigned a value of 0. The time dummy variable $Ryear$ is used to identify the timing of the CBEC Pilot Areas initiative, set according to a multi-period difference-in-differences method. If city i is a CBEC Pilot Area from year t onward, $Ryear$ is assigned a value of 1; otherwise, it is assigned a value of 0.

3.2.3 Control variables

We have reviewed government policy documents related to the establishment of CBEC Pilot Areas and identifies characteristic variables that may influence their establishment. Building on the research of Qi et al. and Jiang et al. [5-6], this study identifies the factors influencing the establishment of CBEC Pilot Areas. These include population size (Popu), human capital (Capi), economic development (Ingdp), infrastructure development (Infra), government intervention (Inter), urbanization (Urban), household consumption (Incoms), and internet usage (Ininter).

3.3 Data Sources

This study investigates the impact of CBEC Pilot Areas on urban high-quality development using panel data from 280 cities between 2010 and 2021. Policy data were sourced from the China Government Website and State Council documents. Patent data come from the National Intellectual Property Administration. Data on economic development level, infrastructure construction level, government intervention level, household consumption level, and internet user level are from the China City Statistical Yearbook, various city statistical yearbooks and statistical bulletins, and the China Marine Statistical Yearbook. Missing values were interpolated to construct a balanced panel data for 280 cities nationwide from 2010 to 2021.

3.3.1 Descriptive statistics

Descriptive statistics for the core explanatory variable, control variables, and other variables are presented in Table 3.

Table 3 Descriptive Statistics

Variables	Obs	Mean	Std.Dev.	Min	Median	Max
CBEC	3360	0.0929	0.2903	0	0	1
lnpop	3360	5.9148	0.6638	3.4002	5.9463	8.1362
lnaca	3351	7.6926	1.3123	2.4849	7.6104	11.2343
lngdp	3360	16.6105	0.9256	14.1773	16.5039	19.8843
lngov	3360	14.8929	0.7595	12.9718	14.8323	18.24999
lninter	3360	13.4386	0.9627	9.2103	13.39999	17.7617
urban	3346	0.5487	0.1553	0	0.5333	1
lncons	3360	15.6009	1.0490	5.4723	15.5573	19.0129

4 EMPIRICAL ANALYSIS

4.1 Baseline Regression

The regression results in columns (1) and (2) of Table 4 show that the interaction term for CBEC Pilot Area development is significantly positive at the 1% level, indicating its role in promoting urban high-quality economic development. This supports the theoretical framework and confirms that the positive impact of CBEC Pilot Areas on economic growth dominates. Excluding centrally governed municipalities in column (3) yields similar positive results, further validating the robustness of the baseline regression. Thus, Hypothesis H1 is supported.

Table 4 Results of the Baseline Regression

Variables	HQD (1)	HQD (2)	HQD (3)
CBEC	0.0113***	0.0107***	0.0101***
	(6.13)	(3.60)	(3.37)
Control variable	No	Yes	Yes
Urban fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
N	3336	3327	3279
R-squared	0.5989	0.6045	0.6004

Note:***,**,and*indicate significant at the 0.1%, 1%, and 5% levels, respectively, with standard errors in parentheses.

4.2 Parallst

We test the parallel trends assumption using a 10-year window. Figure 1 shows that pre-treatment coefficients are insignificant, indicating no systematic differences between treatment and control groups. Post-policy, coefficients become significantly positive, confirming that CBEC Pilot Areas significantly improve high-quality urban economic development.

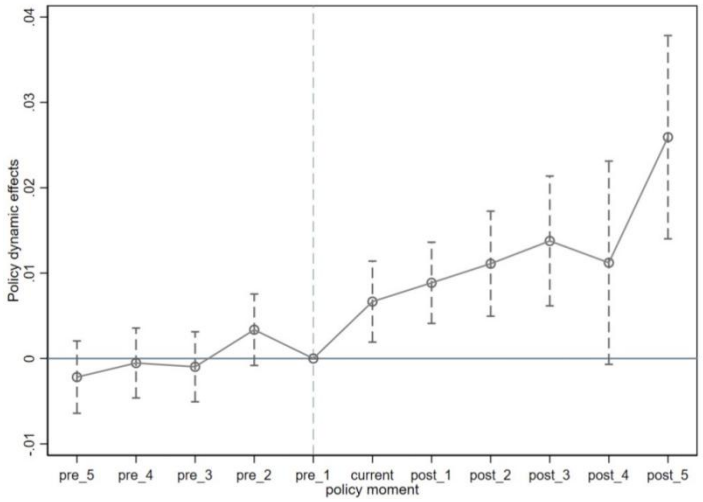


Figure 1 Results of the Parallel TrendTest

4.3 Robustness Tests

4.3.1 PSM-DID test

This section draws on the study by Jia [7], where the disposal and control group samples were first matched to ensure that the matched samples were better able to comply with the balance and co-support conditions. Subsequently, the causal treatment effect of digital trade policy on high-quality urban economic development and its mechanism are identified. Finally, robustness analysis is conducted.

The PSM-DID test conducted in this study includes sample matching, balance and common support tests, and causal treatment effects. First, a probit model is used to estimate the propensity score for each sample city to establish a CBEC Pilot Area.The model is specified as follows:

$$probit(treat_i = 1) = \alpha + \beta X_i + \varepsilon_i \tag{9}$$

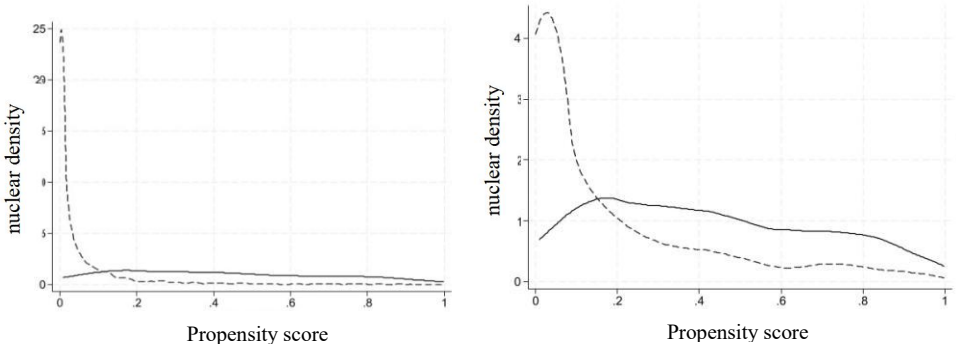
Here, $treat_i$ is a dummy variable for the establishment of CBEC Pilot Areas: it is assigned a value of 1 if the sample city established a CBEC Pilot Area, and 0 otherwise. X_i represents the matching variables, as previously mentioned, including the natural logarithms of the urban resident population, real per capita GDP, number of teachers, infrastructure construction, government expenditure, urbanization rate, total retail sales of consumer goods, and internet user data.

To address selection bias from the non-random assignment of CBEC Pilot Areas, this study applies kernel-based propensity score matching (Epanechnikov kernel, bandwidth 0.20). Balance tests confirm no systematic differences post-matching (Table 5), and the probit model yields high R^2, indicating strong explanatory power. The common

support condition is also satisfied, ensuring comparability and validity. As shown in Figure 2, propensity score overlap between treatment and control groups is limited before matching but substantially improves afterward, enhancing the accuracy of the average treatment effect. Based on the Heckman et al. and Lechner [8-9], we also test the common support condition, which is essential for comparability and estimation validity. A limited common support region only identifies subset effects. Figure 2 shows that before matching, propensity score overlap is small; after matching, overlap improves substantially, ensuring reliable estimation of the average treatment effect.

Table 5 Results of the Balance Test

Variable	Sample	Mean Difference Test			Standardized Difference	
		Treatment Group	Control Group	t-test (p-value)	Standardized Bias	Reduction (%)
Inpop	Before Matching	6.3295	5.8810	11.83 (0.000)	70.4	72.3
	After Matching	6.3263	6.202	2.25 (0.025)	19.5	
Inaca	Before Matching	9.2122	7.5432	23.02 (0.000)	137.5	81.1
	After Matching	9.2071	8.8922	2.87 (0.004)	25.9	
Ingdp	Before Matching	17.897	16.482	28.59 (0.000)	164.2	79.1
	After Matching	17.891	17.596	3.72 (0.000)	34.2	
Ingov	Before Matching	15.996	14.785	30.27 (0.000)	163.5	79.3
	After Matching	15.989	15.737	3.47 (0.001)	33.9	
urban	Before Matching	0.7083	0.5325	20.10 (0.000)	116.3	86.8
	After Matching	0.7106	0.6877	1.70 (0.090)	15.3	
Incons	Before Matching	16.987	15.469	26.97 (0.000)	162.3	79.3
	After Matching	16.98	16.665	3.81 (0.000)	33.6	
Ininter	Before Matching	14.772	13.307	28.55 (0.000)	187.7	81.6
	After Matching	14.768	14.499	4.00 (0.000)	34.5	
R^2		Before Matching			0.432	
		After Matching			0.024	



(a) Before Matching (b) After Matching

Figure 2 Kernel Density Results of the Propensity Scores before and after Sample Matching

After confirming that matched samples meet the conditional independence and common support assumptions, we estimate the average treatment effect of CBEC Pilot Areas on real per capita GDP growth. Results (Table 6) show consistent positive effects, confirming the robustness of baseline estimates and the policy's role in promoting high-quality economic development.

Table 6 Average Treatment Effects of the establishment of CBEC Pilot Areas

	Kernel Matching

	HQD
ATT	0.0303***
	(0.0095)
Treated	311
Untreated	3003
Total	3314

Note: ***,**,and*indicate significant at the 0.1%, 1%, and 5% levels, respectively, with standard errors in parentheses.

4.4 Heterogeneity Analysis

China's vast territory entails considerable regional disparities in economic, political, and natural conditions.Therefore, the establishment of CBEC Pilot Areas in regions with differing factor endowments may exert heterogeneous effects on high-quality economic development.This study will analyze such heterogeneity from four perspectives: location heterogeneity, industrial structure heterogeneity, urban size heterogeneity, and urban cluster heterogeneity.

4.4.1 Locational heterogeneity

The impact of CBEC Pilot Areas on high-quality urban economic development exhibits regional heterogeneity. Based on national policies, 280 prefecture-level cities are divided into 51 coastal and 229 inland cities. Regression results are shown in columns (1)–(4) of Table 7. The results show that the policy significantly promotes high-quality development in coastal cities, but its effect in inland cities is positive yet insignificant. This likely reflects the advantages of coastal cities in location, industrial agglomeration, trade openness, infrastructure, human capital, and institutional support, which facilitate faster policy transmission. Inland cities, by contrast, face constraints due to geographic remoteness, weaker infrastructure, and slower institutional adaptation.

The impact of CBEC Pilot Area establishment on high-quality economic development varies by region. This section divides the sample cities into six eastern, six central, ten western, and three northeastern regions based on the Several Opinions on Promoting the Rise of the Central Region and data from the National Bureau of Statistics. Regression results are presented in columns (5)–(7) of Table 7. The results show significant positive effects in the east and northeast, but insignificant or negative effects in central and western regions. Eastern cities benefit from early digital trade adoption, geographic advantages, mature infrastructure, and innovation. The northeast leverages its border and port access, facilitates cross-border flows via digital technologies. The central region lags due to weak infrastructure, limited external connectivity, and fewer trade channels, though recent industrial upgrades have improved its potential. In the west, poor transport and digital capacity, coupled with the policy's recent rollout, delay measurable effects.

Table 7 Results of the Test for Locational Heterogeneity.

	Coastal cities (1)	Inland cities (2)	Eastern region (3)	Central region (4)	Western region (5)	Northeast region (6)
Coast×CBEC	0.0168***					
	(4.07)					
Inland×CBEC		0.0039				
		(1.03)				
East×CBEC			0.0182***			
			(5.16)			
Mid×CBEC				-0.0033		
				(-0.94)		
West×CBEC					-0.0103	
					(-1.45)	
Northeast×CBEC						0.0256**
						(2.78)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
N	3327	3327	3327	3327	3327	3327
R-squared	0.6872	0.6838	0.6893	0.6836	0.6843	0.6859

Note: ***,**,and*indicate significant at the 0.1%, 1% and 5% levels, respectively, with standard errors in parentheses.

4.4.2 Industrial structure heterogeneity

The impact of CBEC Pilot Area establishment on high-quality economic development varies significantly across cities with different dominant industrial structures. Cities are classified by the ratio of tertiary to secondary industry output: a ratio above one defines tertiary-led cities, otherwise secondary-led. The specific results of the regression analysis are shown in Table 8. The findings show that CBEC Pilot Areas significantly promote high-quality development in tertiary-led cities but have no effect in secondary-led ones. Based on the study by Zhang et al. [10], tertiary cities benefit from IT density, policy support, and service agglomeration, which attract capital and foster innovation. In contrast, secondary-led cities rely on low-end manufacturing, lack tech capacity, and face weak innovation. The

establishment of CBEC Pilot Areas may further shift resources toward services, exacerbating these weaknesses and limiting their contribution to high-quality economic development.

Table 8 Results of the Test for Industrial Structure Heterogeneity

	Second (1)	Third (2)
Second × CBEC	0.0056 (1.58)	
Third × CBEC		0.0099*** (2.84)
Control variable	Yes	Yes
City fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
N	3327	3327
R-squared	0.6838	0.6859

Note: ***,**,and*indicate significant at the 0.1%, 1% and 5% levels, respectively, with standard errors in parentheses.

4.4.3 Heterogeneity analysis of different city sizes

The construction of CBEC Pilot Areas has had a significant heterogeneous impact on the high-quality economic development of cities of different sizes. According to the Notice on Adjusting the Standards for Dividing Urban Sizes issued by the State Council, cities with 5-10 million residents megacities, those with 1-5 million are large cities, and those with less than 1 million are small and medium-sized cities. Among 280 sample cities, 91 are megacities and 181 are large or medium-sized. The regression results are shown in Table 9. The results show that CBEC Pilot Areas significantly enhance high-quality development in megacities but have limited impact on large and medium-sized cities. According to Ming et al. [11], strong agglomeration effects in megacities attract capital, talent, and technology, amplified by CBEC incentives and efficient logistics. In contrast, weaker industrial bases and limited market capacity hinder smaller cities. The siphon effect redirects key factors to megacities, constraining the effect of CBEC Pilot Areas.

Table 9 Results of City Size Heterogeneity Test

	Mega city (1)	Large or medium-sized city (2)
Large × CBEC	0.0133*** (3.68)	
Medium × CBEC		0.0025 (0.56)
Control variable	Yes	Yes
City fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
N	3327	3327
R-squared	0.6871	0.6836

Note:***,**,and*indicate significant at the 0.1%, 1% and 5% levels, respectively, with standard errors in parentheses.

4.4.4 Heterogeneity of urban agglomerations

The establishment of the CBEC pilot area has a significantly heterogeneous impact on the ecological resilience of different urban agglomerations. According to the Outline of the Beijing-Tianjin-Hebei Cooperative Development Plan, Yangtze River Delta Urban Agglomeration Development Plan, and Outline of the Plan for the Reform and Development of the Pearl River Delta Region, this section divides the sample of cities into the three major urban agglomerations: Beijing-Tianjin-Hebei (JJJ), Yangtze River Delta (YRD) , and Pearl River Delta (PRD) regions. The regression results are summarized in Table 10. The results show that CBEC Pilot Areas significantly promote high-quality economic development in the Pearl River Delta, followed by the Yangtze River Delta, while the effect in the Beijing-Tianjin-Hebei region is insignificant. The PRD's advantage stems from robust digital economic policies, strong IT infrastructure, and innovation clusters. The YRD benefits from digital development but lags in R&D investment and patent intensity, resulting in a smaller effect. The Beijing-Tianjin-Hebei region, despite advantages in transport and industry, suffers from imbalanced development and weak high-end manufacturing agglomeration, limiting CBEC policy impact.

Table 10 Results of the Heterogeneity Test for City Clusters

	JJJ (1)	YRD (2)	PRD (3)
JJJ × CBEC	0.0133 (0.78)		
YRD × CBEC		0.0114* (2.11)	

PRD × CBEC			0.0271***
			(3.39)
Control variable	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
N	3323	3323	3323
R-squared	0.6838	0.6844	0.6861

Note: ***,**,and*indicate significant at the 0.1%, 1% and 5% levels, respectively, with standard errors in parentheses.

5 MECHANISM TESTING

This section tests the mechanisms through which CBEC Pilot Areas affect high-quality urban economic development. Following the prior qualitative analysis, this study adopt the Sobel test to verify whether digital infrastructure, service agglomeration, and business environment act as transmission channels. Each variable is introduced as a mediator to assess its individual role and effect strength. The mediation model is specified as follows：

$$M_{it} = \beta_0 + \beta_1 cbec_{it} + \gamma X_{it} + \lambda_i + \mu_i + \varepsilon_{it} \tag{10}$$

$$\gamma_{it} = \beta_0 + \beta_1 cbec_{it} + \beta_2 M_{it} + \gamma X_{it} + \lambda_i + \mu_i + \varepsilon_{it} \tag{11}$$

In equations (10) and (11), M_{it} represents the mediator variable, which is substituted with the Digital Infrastructure Construction Index (diginf), Service Industry Agglomeration Index (spec), and the China Urban Business Credit Environment Index (envir), while other variables remain consistent with those previously discussed.

5.1 Digital Infrastructure Construction

Digital infrastructure captures both hardware investment and digital adoption. This section drawing on the work of Wang Qin et al. [12], constructing an index based on six input–output indicators. The data are sourced from the statistical yearbooks of each province and the China Urban Statistical Yearbook. A mediation model examines whether the construction of CBEC Pilot Areas promote high-quality urban economic development through the expansion of digital infrastructure. As shown in Table 11, both the regression coefficient and Sobel Z-statistic are significantly positive at the 1% level, indicating that digital infrastructure partially mediates the effect of CBEC Pilot Areas on economic growth.

Table 11 Mechanism Testing: Digital Infrastructure Development

	(1)
Variable	HQD
diginf	0.4116***
	(7.24)
CBEC	0.0760***
	(11.18)
Sobel Z	6.884***
Control variable	Yes
City fixed effect	Yes
Year fixed effect	Yes
N	3336

Note: ***,**,and*indicate significant at the 0.1%, 1% and 5% levels, respectively, with standard errors in parentheses.

5.2 Service Industry Agglomeration

This section employs a mediation model to assess whether CBEC Pilot Areas foster high-quality urban development by enhancing productive service agglomeration. Following Han and Yang [13], the overall specialized agglomeration index of the productive service industry is the sum of the agglomeration indices of all the subsectors, as shown in Equation (12):

$$spec_{it} = \frac{\sum_{j=1}^{J} S_{ijt} / \sum_{i=1}^{N} \sum_{j=1}^{J} S_{ijt}}{S_{it} / \sum_{i=1}^{N} S_{it}} \tag{12}$$

Where S_{it} denotes the total number of persons employed in each industry in year t for city i and N denotes the number of cities. Table 12 presents the regression results for the impact of CBEC Pilot Area development on service sector concentration, as well as the results of the Sobel test for the mediating effect. The regression coefficient for overall service sector concentration is significantly positive, as well as the results of the Sobel test for the mediating effect. Both low-end and high-end services show significant coefficients and Sobel Z-statistics at the 1% level, with a stronger effect for low-end services. These results suggest that CBEC Pilot Areas mainly promote service sector agglomeration by concentrating low-end services.

According to the latest Statistical Classification of Productive Services issued by the National Bureau of Statistics and the research of Gu [14-15], the productive services industry defined in this paper includes 6 industries: transportation, warehousing, and postal services; wholesale and retail trade; leasing and business services; information transmission, software, and information technology services; financial services; and scientific research and technology services. Following the Liu et al. [16], the first three industries belong to the low-end and middle-end productive service industries; the last three industries belong to the high-end productive service industries. The development of CBEC Pilot Areas has strengthened logistics networks, driving the rapid growth of low-end services to meet rising demand through improved efficiency and cost reduction. High-end services, however, require deeper innovation, longer investment cycles, and market readiness, leading to slower development under current conditions.

Table 12 Mechanism Test: Agglomeration of Services

Variable	HQD	HQD	HQD
spec	0.0338***		
	(7.24)		
Spec_low		0.0314***	
		(5.48)	
Spec_high			0.0166***
			(2.94)
CBEC	0.0855***	0.0851***	0.0928***
	(8.39)	(8.39)	(9.21)
Sobel Z	4.711***	5.651***	2.83***
Control variable	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
N	2780	2780	2780

Note: ***,**,and*indicate significant at the 0.1%, 1% and 5% levels, respectively, with standard errors in parentheses.

5.3 Improvement in the Business Environment

The business environment encompassing external factors such as public services, human resources, administrative environment, market environment, legal environment, and cultural environment. The construction of CBEC Pilot Areas encourage governments to lower operational costs and ease market access, fostering new entrants and improving transparency. Following Jia et al. [17], we use the Urban Commercial Credit Environment Index to measure business environment quality. As shown in Table 13, both the regression coefficient and Sobel Z-statistic are significantly positive, confirming Hypothesis H2.

Table 13 Mechanism Test: Improvements in the Business Environment

	(3)
Variable	HQD
envir	0.2154***
	(5.71)
CBEC	0.0808***
	(11.98)
Sobel Z	5.495***
Control variable	Yes
City fixed effect	Yes
Year fixed effect	Yes
N	3326

Note: ***,**,and*indicate significant at the 0.1%, 1% and 5% levels, respectively, with standard errors in parentheses.

6 CONCLUSION AND DISCUSSION

Cross-border e-commerce has emerged as a key driver of global trade. This study uses panel data from 280 cities from 2010 to 2021 and a multi-period DID model to evaluate the impact CBEC Pilot Areas on urban high-quality economic development. Results show robust positive effects, especially in border regions, tertiary-led cities, and megacities. At the cluster level, effects are strongest in the PRD, followed by the YRD. Mechanism tests confirm that CBEC Pilot Areas promote urban high-quality economic development through digital infrastructure, service agglomeration, and business environment improvements.

Based on the above research, this paper proposes the following policy recommendations:

First, the government should promote best practices of CBEC Pilot Areas, tailor implementation to local conditions, and prioritize support for smaller cities. Enhancing openness in these regions fosters coordinated cross-border e-commerce development and balanced growth, contributing to a more integrated national economic structure.

Second, improve infrastructure construction. The government should offer fiscal incentives such as subsidies and low-interest loans to support digital infrastructure, focusing on cloud platforms, 5G, and western coverage to enhance efficiency and innovation.

Third, increase support for productive services. The government should provide targeted subsidies to foster productive services, encouraging technological and managerial upgrading to support CBEC ecosystems and scalable service innovation.

Fourth, improve the business environment. The government should improve the business environment by streamlining approvals, lowering market entry barriers, and enhancing administrative efficiency. Facilitate flexible financing for CBEC firms, and establish dynamic policy evaluation mechanisms to ensure responsiveness to evolving market conditions.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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