World Journal of Management Science
ISSN: 2959-9636
DOI: https://doi.org/10.61784/wms3067

HOW DIGITAL TRADE POLICIES INFLUENCE THE DEVELOPMENT OF URBAN DIGITAL ECONOMIES

YuMei Li[1], HaiHui Wang[2,3*]
[1]*School of Applied Technology, Wuxi University, Wuxi 214105, Jiangsu, China.*
[2]*School of Digital Economics and Management, Wuxi University, Wuxi 214105, Jiangsu, China.*
[3]*Institute of China (Wuxi) Cross-Border Electronic Commerce Comprehensive Pilot Zone, Wuxi University, Wuxi 214105, Jiangsu, China.*
Corresponding Author: HaiHui Wang, Email: wanghh@cwxu.edu.cn

Abstract: Digital trade plays a crucial role in global economic development, and the impact of related policies on urban digital economies has become a prominent research area. This study conducts qualitative analysis of digital trade policy documents in China, identifying core mechanisms driving urban digital economy growth. Using panel data from 280 Chinese cities (2010-2021), we apply the Difference-in-Differences method, treating Cross-border E-commerce comprehensive pilot areas as a quasi-natural experiment to evaluate digital trade policy impacts on urban digital economic development. Findings reveal that pilot areas significantly boost urban digital economy development. Heterogeneity analysis shows this effect is particularly pronounced in eastern coastal regions, megacities, and the Yangtze River Delta. Mechanism analysis suggests digital trade policies foster urban digital economic development by advancing digital infrastructure, promoting service industry agglomeration, and improving business environments.
Keywords: Digital trade policy; Digital economy; Cross-border e-commerce

1 INTRODUCTION

With the advancement of global economic integration and information technology, digital trade has become a crucial driver of digital economic growth. The Chinese government has prioritized the digital economy, as evidenced by the Three-Year Action Plan for Digital Commerce (2024-2026), which promotes cross-border e-commerce and digital trade through innovation, data-driven strategies, and institutional reform.

The cross-border e-commerce (CBEC) comprehensive pilot areas are a central instrument in advancing China's digital trade and urban digital economy. Serving as both platforms and policy laboratories, these pilots have expanded from the first one launched in Hangzhou in 2015 to 165 across all 31 provinces. These pilots have facilitated the development of a regulatory framework for global cross-border e-commerce, promoting industrial digitalization and sustainable trade. As their scope broadens, critical questions arise: What impact do digital trade policies have on urban digital economies? Through which mechanisms? Are these effects heterogeneous? These questions warrant empirical investigation to assess policy effectiveness and guide future improvements.

Digital trade has received extensive academic attention. The OECD-WTO-IMF Handbook (2020) defines it as trade conducted via digital ordering or delivery, comprising digital goods, digital services, and platform-enabled transactions. Li and Fu align these categories with the digitalization of goods [1], services, and cross-border e-commerce, respectively. Within this framework, countries have adopted distinct digital trade strategies. The United States focuses on liberalization by reducing digital trade barriers Meltzer [2]; the European Union aims to build a digital single market, placing emphasis on data protection and cybersecurity [3]; Japan prioritizes technological innovation and infrastructure, often advancing digital trade through trade agreements [4]. In China, Chen and Luo identify digital trade—particularly cross-border e-commerce—as a key driver of foreign trade growth [5].

The concept of the digital economy was introduced by Don Tapscott [6], who defined it as the integration of digital technologies and intelligent systems. The U.S. Department of Commerce highlighted its role in economic development. Mesenbourg expanded its scope to include digital infrastructure [7], business networks, and e-commerce transactions. Scholars have since developed various measurement frameworks. Bukht and Heeks proposed a layered model based on infrastructure and technology adoption [8]. Zhang and Shen employed factor analysis to construct a digital economy index [9], while Liu et al. (2020) applied the NBI weighting method to assign indicator weights [10].

Digital trade, the digital economy, and cross-border e-commerce form a dynamic and interdependent system. López González and Ferencz argue that digital trade is a core element of the digital economy [11], driving global competitiveness. Zhang and Xia highlight their shared reliance on internet technologies [12], with digital trade fostering innovation and accelerating traditional industry digitalization, thus propelling overall digital economy growth. Cross-border e-commerce plays a key role in enhancing digital trade efficiency and transforming industries [13]. China's CBEC policies, which have evolved from taxation to logistics and regulation [14], reduce transaction costs and promote stable trade [15]. CBEC pilot areas, part of China's national strategy since 2015, have boosted trade competitiveness and supported digital economic growth [16]. Digital trade enhances the digital economy through mechanisms such as optimizing global resource allocation [17], matching cross-border supply and demand [18], and reshaping industrial supply chains [19]. Li and Zhang emphasize the importance of institutional innovation [20], infrastructure development, and cross-border data flows in driving digital economic transformation.

Existing literature reveals several areas for further exploration. While most research centers on national-level digital trade policies, fewer studies examine urban-level impacts, particularly the role of local governments and CBEC policies on city-level digital economies. Moreover, although the link between digital trade and digital economy development has been acknowledged, existing studies are largely descriptive. More empirical research is needed to provide deeper insight into these dynamics.

Building on the Solow growth model, this study proposes that CBEC pilot areas promote urban digital economy development through three key mechanisms: digital infrastructure, service industry agglomeration, and business environment optimization. Infrastructure investment enhances production capacity, agglomeration reflects labor and talent input, while business environment optimization reduces transaction costs. These mechanisms work synergistically to drive digital growth.

This study examines digital trade policy impacts using both qualitative and quantitative methods. Policy text analysis of 64 national documents identifies three key themes: digital infrastructure, service industry agglomeration, and business environment optimization, which align with our theoretical framework. Using panel data from 280 cities (2010-2021) and treating CBEC pilot areas as a quasi-natural experiment, we employ a difference-in-differences approach. Results show CBEC pilot areas significantly boost urban digital economies, particularly in eastern coastal regions, megacities, and the Yangtze River Delta. This study contributes city-level evidence and a Solow-based framework linking policy tools to capital, labor, and cost efficiency.

2 THEORETICAL MODEL AND RESEARCH HYPOTHESES

2.1 Qualitative Analysis

Policy text analysis is a key method for examining how digital trade policies affect urban digital economy development. This study systematically analyzes 64 policy documents issued between 2014 and 2024 by the State Council, Ministry of Finance, and General Administration of Customs (see Table 1). Three core policy themes emerge: digital infrastructure, service industry agglomeration, and business environment optimization. As shown in Table 2, these themes reflect the main mechanisms through which digital trade policies promote urban digital growth.

Table 1 Summary of Cross-Border E-Commerce-Related Policy Documents from 2014 to 2024

NO.	Year	Document Title	Issuing Institution
1	2015	Approval for the Establishment of the China (Hangzhou) Cross-Border E-Commerce Comprehensive Pilot Areas	State Council
2	2015	Opinions on Vigorously Developing E-Commerce and Accelerating the Cultivation of New Economic Drivers	State Council
3	2018	Notice on Issuing the Work Plan for Optimizing Port Business Environment and Promoting Cross-Border Trade Facilitation	State Council
4	2023	Notice on Improving the Supervision of Cross-Border E-Commerce Retail Imports	Ministry of Finance, General Administration of Customs, State Taxation Administration
...	...	...	...
64	2024	Opinions on Expanding Cross-Border E-Commerce Exports and Promoting Overseas Warehouse Construction	Ministry of Finance and 9 Other Departments

Policy text analysis reveals three core themes with varying frequencies but complementary impacts. Service industry agglomeration is the most prominent theme (4.85%), with high-frequency terms such as "service," "cluster," and "synergy" indicating policy support for industry concentration in logistics and finance, promoting knowledge spillovers and resource sharing that reflect a focus on human capital and industrial synergy. Digital infrastructure appears in 3.55% of documents, emphasizing core infrastructure—electronic payments, data platforms, and network technologies—that generate network effects and economies of scale, reducing barriers to digital transformation. Although business environment optimization accounts for only 2.57% of policy documents, its institutional impact is notable through customs reform, regulatory harmonization, and tax incentives that reduce transaction costs, mitigate information asymmetry, and create a stable, predictable environment.

Together, these three themes form an integrated policy framework: infrastructure offers technological support, clustering improves factor allocation, and business environment reforms reduce frictions. Collectively, they correspond to capital accumulation, labor input, and transaction efficiency—core elements of economic growth theory and a basis for the study's model.

Table 2 Frequency Analysis of Key Policy Terms

Theme	Related Keywords (Sorted by Frequency and Relevance)	Theme Frequency
Digital Infrastructure	Electronics, Payment, Information, Platform, Data, Network, Technology, System, Digitization, Cloud Computing, Logistics Information, Blockchain, API Integration, Smart Devices, Cybersecurity	3.55%
Service Industry	Service, Business, Enterprise, Institution, Operations, Goods, Synergy, Cluster,	4.85%

agglomeration	Warehousing, Logistics, Supply Chain, Finance, Marketing, Consulting, Training, Innovation, Cooperation, Brand, Cross-Border Service Ecosystem	
Business Environment	Customs, Supervision, Regulations, Pilot, Declaration, Policy, Tax, Compliance, Intellectual Property, Risk Prevention, Administrative Licensing, Standardization, Trade Facilitation, Dispute Resolution, Local Policy Support	2.57%

Note: Word Frequency Analysis: High-Frequency Terms

2.2 Theoretical Model

Building on the policy analysis above, this study employs the Solow growth model to examine the impact pathways through which digital trade policies influence urban digital economic development [21]. The model highlights capital accumulation, labor input, and technological progress as key growth drivers, aligning with our three policy themes.

2.2.1 Construction of the production function

In the standard Solow model, total output Y is determined by capital K and labor L, with the production function defined as:

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

In this model, Y represents the total output of the digital economy, while A denotes the level of technology, capturing exogenous technological progress. K stands for capital input, and L represents labor input. The parameter α is the output elasticity of capital, with $1-\alpha$ representing the output elasticity of labor.

In the digital economy, capital K primarily refers to investments in digital infrastructure, such as 5G networks and data centers. Labor L represents the agglomeration of service industries and the input of high-skilled talent. Improvements in the business environment are captured by reduced transaction costs, denoted as T. As T decreases, economic efficiency rises, resulting in higher total output.

2.2.2 Dynamic accumulation of capital and labor

In the Solow model, capital accumulation is determined by the savings rate s and the capital depreciation rate δ. The capital accumulation equation is given by:

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

By substituting the production function into the capital accumulation equation, we obtain the dynamic capital accumulation equation as follows:

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

This equation indicates that the growth rate of capital depends on current output and capital depreciation. When capital accumulation reaches the steady-state level, capital no longer grows, i.e., $\dot{K}$ =0. At this point, the steady-state capital level, K^*, can be derived as follows:

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

2.2.3 The impact of transaction costs on economic growth

Transaction costs T are a critical determinant of economic growth. In the digital economy, optimizing the business environment—such as simplifying cross-border e-commerce procedures and lowering compliance costs—effectively reduces transaction costs. To reflect this in the model, we extend the production function by introducing transaction efficiency T, as follows:

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

Where T represents the improvement in transaction efficiency, and γ is the elasticity of output with respect to transaction efficiency.

Lower transaction costs imply higher T enhancing efficiency and boosting output Y. In the long run, business environment optimization promotes sustained digital economy growth.

2.2.4 Steady-state analysis

After incorporating the transaction cost factor, the expression for the steady-state capital K^* is as follows:

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

Under steady-state conditions, the total output Y^* is given by:

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

Simplifying, we obtain:

$$Y^* = A^{\frac{1}{1-\alpha}}\left(\frac{s}{\delta}\right)^{\frac{\alpha}{1-\alpha}} LT^{\gamma} \tag{8}$$

From the steady-state output function, The steady-state output of the digital economy depends on capital, labor, and transaction costs. Capital investment (e.g., digital infrastructure) and labor agglomeration (e.g., services) directly raise output, while reducing transaction costs through business environment optimization further boosts total output.

2.2.5 Mechanisms and hypotheses for promoting urban digital economy development

The above model derivation demonstrates that CBEC pilot areas promote urban digital economy development via three mechanisms. First, digital infrastructure construction increases capital investment, boosting output. Second, service industry agglomeration enhances labor input and efficiency. Third, business environment optimization lowers transaction costs, improving economic performance. These mechanisms are supported by policies such as tax incentives and financial subsidies that foster infrastructure investment and service agglomeration.

Based on this, we propose:

Hypothesis 1: Digital trade policies, represented by CBEC pilot areas, promote urban digital economy development.

Hypothesis 2: CBEC pilot areas promote such development through digital infrastructure construction, service industry agglomeration, and business environment optimization.

3 RESEARCH DESIGN

3.1 Model Design

Between 2010 and 2021, China designated 30 provinces and municipalities across five batches as CBEC pilot areas. The first batch was launched in 2015 and the last in 2021, aligning with the rapid growth of the digital economy and the refinement of CBEC policies. This period provides a suitable window to examine changes in urban digital economic development before and after policy implementation. Accordingly, this study employs a multi-period difference-in-differences (DID) model to assess the policy's impact. By comparing pilot cities (treatment group) with non-pilot cities (control group), we identify the causal effects of the CBEC policy. The model is specified as follows:

$$Dig_{it} = \alpha_0 + \alpha_1\ Cbec_{it} + \alpha_2\ Control + \mu_i + \nu_t + \varepsilon_t \tag{9}$$

Where i represents the city and t represents the year. Dig_{it} is the dependent variable, which denotes the level of urban digital economy development. $Cbec_{it}$ is the key explanatory variable. If city i is identified as a cross-border e-commerce pilot city in year t, then $Cbec_{it}$ will take the value of 1 in year t and thereafter; otherwise, it will be 0. Control represents a set of control variables. ε_t is the random error term, μ_i denotes city fixed effects, ν_t represents 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 development of the urban digital economy, which is the main focus of this study.

3.2 Variable Selection

3.2.1 Dependent variable

The dependent variable is urban digital economy development (Dig). Following Zhao et al. [22], we construct a composite index based on two dimensions: digital internet development and digital inclusive finance. For digital internet development, we adopt Huang et al.'s method using four indicators: broadband users per 100 people (internet penetration rate) [23], share of computer and software service employees (proportion of workforce in digital technology fields), per capita telecommunications business volume (digital service output level), and mobile phone users per 100 people (mobile communication coverage rate). For digital inclusive finance, we use the China Digital Inclusive Finance Index developed by Peking University and Ant Financial [24]. Principal component analysis (PCA) is applied to these five indicators to construct the final index.

3.2.2 Core explanatory variable

The core explanatory variable is the interaction term CBEC, constructed by multiplying a spatial dummy (Treat) and a time dummy (Ryear). Treat equals 1 if the city has been designated as a CBEC pilot area, and 0 otherwise. Ryear equals 1 from the year the city became a pilot, and 0 otherwise. This setting follows the multi-period DID framework to capture policy effects.

3.2.3 Control variables

The establishment of CBEC pilot areas may involve regional and temporal selection biases, potentially introducing endogeneity due to correlation with urban digital economy development. Although policy documents do not specify selection criteria, this study seeks to identify pre-existing factors influencing the designation of CBEC pilot cities. Key selection factors identified from policy reviews are incorporated as control variables in the analysis. Following Jiang et al. [25], we include the following pre-existing factors as control variables: population size (Inpop), human capital (Inaca), economic development level (Ingdp), government intervention (Ingov), urbanization level (Urban), consumer spending level (Incoms), and internet user level (Ininter). A binary panel Logit model is employed to estimate the probability of city selection as a CBEC pilot area. The dependent variable equals one if a city is selected and zero otherwise. Results indicate that selection is primarily driven by the seven factors listed above, validating their use as controls.

3.2.4 Data sources

This study uses panel data from 280 cities (2010-2021). CBEC data comes from Ministry of Commerce lists, patent data from the National Intellectual Property Administration, and socio-economic data from official yearbooks. Cities with major missing values were excluded, and minor gaps were interpolated. As shown in Table 3, the average digital economy index (Dig) is 0.332, with a maximum of 0.801, minimum of 0.065, and a standard deviation of 0.11.

Table 3 Descriptive Statistics of Variables.

Variable	Observations	Mean	Std. Dev	Minimum	Median	Maximum
Dig	3 360	0.332 3	0.110 8	0.065 1	0.352 2	0.801 9
CBEC	3 360	0.092 9	0.290 3	0.000 0	0.000 0	1.000 0
lnpop	3 360	5.914 8	0.663 8	3.400 2	5.946 3	8.136 2
lnaca	3 351	7.692 8	1.312 3	2.484 9	7.610 4	11.234 3
lngdp	3 360	16.610 5	0.925 6	14.177 3	16.503 9	19.884 3
lngov	3 360	14.892 9	0.759 5	12.971 8	14.832 3	18.250 0
lninter	3 360	13.438 6	0.962 7	9.210 3	13.400 0	17.761 7
urban	3 325	0.552 2	0.149 5	0.180 6	0.534 7	1.000 0
lncons	3 360	15.600 9	1.049 0	5.472 3	15.557 2	19.012 9

4 EMPIRICAL ANALYSIS

4.1 Baseline Regression

Table 4 presents baseline regression results. Column (1) shows a significantly positive CBEC coefficient at the 0.1% level without control variables, indicating that CBEC pilot areas promote urban digital economy development. The positive effect remains significant after adding control variables in columns (2) and (3). Column (3) excludes centrally administered municipalities to account for their unique characteristics in pilot designation and digital development, with results still showing significant effects. All models include city and year fixed effects. These findings support Hypothesis H1, confirming the robust positive impact of CBEC pilot policy on urban digital economic development.

Table 4 Baseline Regression Results

	Dig (1)	Dig (2)	Dig (3)
CBEC	0.007 5*** (4.08)	0.006 5*** (3.41)	0.006 3* (2.12)
Controls	No	Yes	Yes
City	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	3 360	3 316	3 269
R-squared	0.686 9	0.690 7	0.687 9

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

4.2 Parallel Trends Test

To validate the DID model, a parallel trend test is conducted within a 10-year window. As shown in Figure 1, before the policy, digital economy trends in the treatment and control groups are aligned, with no significant deviation in estimated coefficients. After implementation, the treatment group shows a significant positive shift, confirming the parallel trends assumption. These results demonstrate the policy's positive effect on urban digital economy development and suggest a potential demonstration effect of digital trade policy.

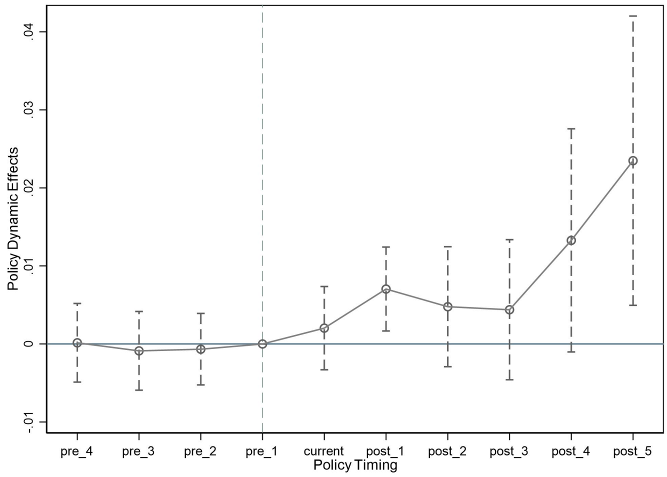


Figure 1 Parallel Trend Test Results

4.3 Robustness Check

4.3.1 Placebo test

Although the DID method addresses endogeneity and passes the parallel trend test, unobserved factors may still bias results. To test robustness, we conduct a placebo test by randomly assigning CBEC pilot locations and repeating the regression 500 times. As shown in Figure 2, the estimated coefficients are normally distributed around zero, indicating no significant influence from unobserved factors. This confirms that the observed positive effect on urban digital economy development is indeed driven by the actual CBEC pilot policy.

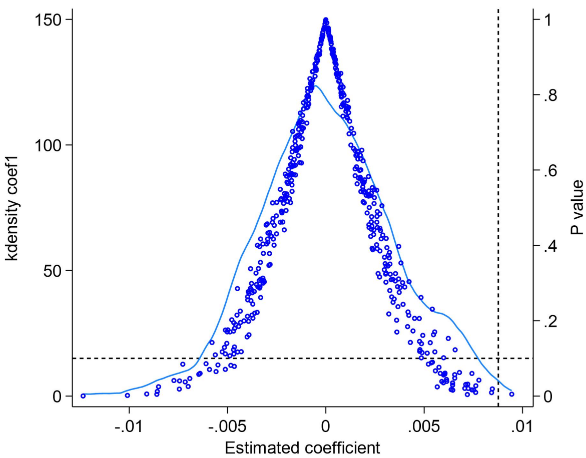


Figure 2 Placebo Test

4.3.2 PSM-DID analysis

This study uses the following probit model to estimate the predicted probability of each sample urban establishing a CBEC pilot area, i.e., the propensity score:

$$probit\left(treat_i = 1\right) = \alpha + \beta X_i + \varepsilon_i \tag{10}$$

$treat_i$ is a dummy variable for the establishment of a CBEC pilot area: if a sample cities established a CBEC pilot area between 2010 and 2021, it is assigned a value of 1; otherwise, 0. X_i represents the matching variables, which include the natural logarithms of regional GDP, general government fiscal expenditure, urbanization rate, total retail sales of consumer goods, and internet user data.

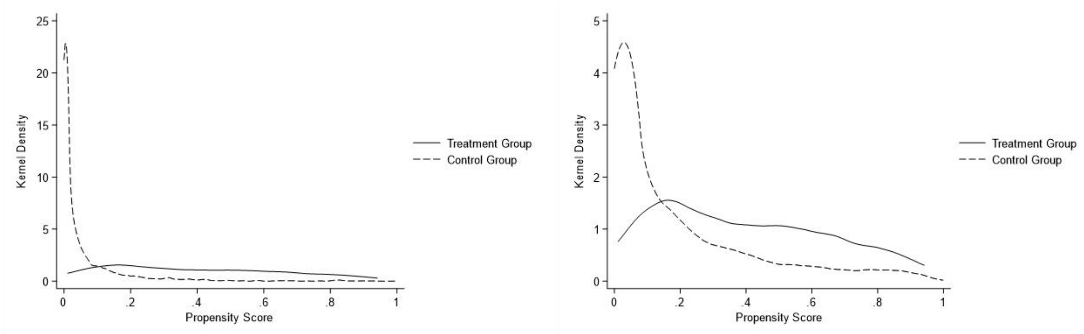
We apply kernel matching with an Epanechnikov kernel and 0.20 bandwidth following Rosenbaum and Rubin to improve robustness [26]. Balance tests confirm the conditional independence assumption: post-matching t-tests (Table 5) show no significant mean differences between groups, with standardized differences greatly reduced. The low R^2 from the Probit model suggests limited predictive power of matching variables, indicating policy assignment can be treated as conditionally random.

A common support test ensures comparability. Lechner highlights that limited overlap reduces estimate reliability [27].

Figure 3 shows that before matching, propensity score distributions show little overlap; after matching, they align closely and the support region expands. Observations outside this region are excluded, ensuring credible estimates of the average treatment effect.

Table 5 Balance Test Results

Variable	Sample	Mean Difference Test			Standardized Difference Test	
		Treatment Group	Control Group	t-test (p-value)	Standardized Bias	Reduction (%)
Regional GDP (logged)	Unmatched	17.909	16.485	28.63(0.000)	167.2	77.8
	Matched	17.909	17.593	4.04(0.000)	37.1	
Government General Fiscal Expenditure (logged)	Unmatched	16.005	14.786	30.30(0.000)	66.6	76.9
	Matched	16.005	15.723	3.89(0.000)	38.4	
Urbanization Rate (%)	Unmatched	0.722	0.535	22.35(0.000)	142.1	85.9
	Matched	0.722	0.696	2.17(0.030)	20.1	
Total Retail Sales of Consumer Goods(logged)	Unmatched	17.005	15.472	27.13(0.000)	166.9	78.1
	Matched	17.005	16.669	4.12(0.000)	36.6	
Internet User Data(logged)	Unmatched	14.785	13.307	28.55(0.000)	190.9	78.6
	Matched	14.785	14.468	4.65(0.000)	40.9	
Pseudo R^2		Unmatched			0.405	
		Matched			0.026	



(a) Before Matching (b) After Matching

Figure 3 Results of the Co-Support Test

As shown in Table 6, the policy exerts a positive and statistically significant impact. The average treatment effect estimated by kernel matching is 0.0304, suggesting that during the sample period, the establishment of CBEC pilot areas promoted digital economic growth in the treated cities. This result aligns with the baseline regression, further reinforcing its robustness.

Table 6 Average Treatment Effects of Digital Trade Policy

	Kernel Matching
	urban digital economic development
Average Treatment Effect	0.030 4*** (0.009 6)
Treatment Group Sample	305
Control Group Sample	3 011
Total Sample	3 316

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

5 FURTHER ANALYSIS

5.1 Mechanism Test

Building on prior qualitative analysis, this section empirically examines how digital infrastructure, service industry agglomeration, and business environment optimization mediate the effects of CBEC policies. We employ Sobel tests to identify the significance and strength of these transmission mechanisms, as specified in the following model.

$$M_{it} = \beta_0 + \beta_3 cbec_{it} + \gamma X_{it} + \lambda_i + \mu_i + \varepsilon_{it} \tag{11}$$

$$\gamma_{it} = \beta_0 + \beta_1 cbec_{it} + \beta_4 M_{it} + \gamma X_{it} + \lambda_i + \mu_i + \varepsilon_{it} \tag{12}$$

In (11) and (12) M_{it} represents the mediator variable, which is replaced by the Digital Infrastructure Index (Diginf), the Service Industry Agglomeration Index (Spec), and the Chinese Urban Business Credit Environment Index (Envir), while other variables remain consistent with those used earlier.

5.1.1 Digital infrastructure construction

Digital infrastructure is crucial for China's growth, public services, regional equity, and security. Following Wang et al. [28], we construct a two-dimensional Digital Infrastructure Index (Diginf) using six indicators. Table 7 shows that CBEC pilot areas significantly enhance digital infrastructure. The interaction term is positively significant, and the Sobel test confirms a strong mediating effect at the 1% level. CBEC policies thus promote both physical infrastructure and digital ecosystems such as cloud computing, big data, and cybersecurity.

Table 7 Mechanism Test: Digital Infrastructure Construction

	(1)
Variable	Dig
Diginf	0.393 6*** (6.93)
CBEC	0.074 6*** (10.95)
Sobel Z	6.62***
Controls	Yes
City	Yes
Year	Yes
N	3 360
R-squared	0.0708

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

5.1.2 Service industry agglomeration

Productive services are central to global industrial competition and crucial for manufacturing-driven growth. Based on the 2019 classification by China's National Bureau of Statistics and Gu [29], this study includes six sectors: ① Transportation, storage, and postal services; ② Wholesale and retail; ③ Leasing and business services; ④ Information transmission, software, and IT services; ⑤ Finance; ⑥ Scientific research and technical services. The first three are low-to-mid-end services, and the latter three are high-end. The service industry agglomeration index (Spec) is calculated following Han and Yang as the sum of sub-industry agglomeration indices [30], with the calculation formula as follows:

$$Spec_{it} = \frac{\sum_{j=1}^{J} S_{ijt} / \sum_{i=1}^{N} \sum_{j=1}^{J} S_{ijt}}{S_{it} / \sum_{i=1}^{N} S_{it}} \tag{13}$$

S_{ijt} represents the number of employees in industry j of city i in year t, S_{it} represents the total number of employees across all industries in city i in year t, and N represents the number of cities.

The impact of CBEC pilot areas on service industry agglomeration is significant (0.1% level), with the Sobel test confirming mediation is presented in Table 8. Both high-end and low-/mid-end services respond positively, though the latter are more affected due to strong demand, low entry barriers, and cost-reducing incentives in sectors like logistics and warehousing. In contrast, high-end services such as finance and R&D require more capital and talent, leading to slower, less policy-sensitive agglomeration.

Table 8 Mechanism Test: Service Industry Agglomeration

	(2)
Variable	Dig
Spec	0.032 5*** (4.81)
CBEC	0.085 8*** (8.40)
Sobel Z	4.548***

Controls	Yes
City	Yes
Year	Yes
N	2 800
R-squared	0.0419

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

Table 9 Mechanism Test: Service Industry Agglomeration

	(2)
Variable	Dig
Spec_low	0.030 7*** (5.35)
CBEC	0.085 2*** (8.38)
Sobel Z	4.957***
Controls	Yes
City	Yes
Year	Yes
N	2 800
R-squared	0.0437

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

Table 10 Mechanism Test: Service Industry Agglomeration

	(2)
Variable	Dig
Spec_high	0.015 4** (2.73)
CBEC	0.093 0*** (9.22)
Sobel Z	2.641***
Controls	Yes
City	Yes
Year	Yes
N	2 800
R-squared	0.0365

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

5.1.3 Business environment optimization

The business environment spans economic, legal, and social dimensions and plays a critical role in industrial upgrading and digital transformation. Using the China Urban Business Credit Environment Index [31]. this study finds that CBEC pilot areas significantly enhance urban business conditions (Table 11), with results robust at the 0.1% level. The Sobel test confirms a significant mediating effect. Improvements stem from streamlined e-commerce processes, simplified customs and tariffs, and enhanced regulatory transparency, jointly fostering a stable, efficient, and predictable environment for digital economy growth.

Table 11 Mechanism Test: Business Environment Optimization

	(3)
Variable	Dig
Envir	0.200 5*** (5.33)
CBEC	0.079 4*** (11.77)
Sobel Z	5.159***
Controls	Yes
City	Yes
Year	Yes
N	3 350
R-squared	0.065 4

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

In conclusion, the three mediating variables—digital infrastructure development, service industry agglomeration, and business environment optimization—mediate the relationship between digital trade policies and urban digital economic development. Therefore, Hypothesis 2 is validated.

5.2 Heterogeneity Analysis

5.2.1 Regional heterogeneity

Given China's regional disparities, the impact of CBEC pilot areas on digital economy development is likely heterogeneous.

This study examines this from three dimensions: geographic location, city size, and urban agglomeration. Based on national classifications, 280 cities are categorized into 51 coastal and 229 inland cities. As shown in Table 12 (columns 1-2), CBEC pilot areas significantly promote digital economic growth in coastal cities (significant at the 0.1% level), while effects in inland cities are insignificant. Coastal regions benefit from advanced infrastructure, greater openness, maritime advantages, and early policy adoption, enhancing implementation outcomes. In contrast, inland areas face logistical and institutional constraints that reduce policy effectiveness.

Further, based on data from the National Bureau of Statistics, this study divides cities into four regions: Eastern, Central, Western, and Northeastern. Table 12(columns 3-6) indicates that significant policy effects are observed in the Eastern region. Effects in the Central and Western regions are statistically insignificant, while those in the Northeast are limited. This heterogeneity reflects the East's advantages in economic concentration, infrastructure, and policy readiness. In contrast, weaker foundations and sparse pilot coverage in other regions—especially the Northeast, with only 14 pilots by 2022—may delay or dilute policy impacts, highlighting spatial and temporal disparities in implementation.

Table 12 Regional Heterogeneity

	Coastal cities (1)	Inland cities (2)	Eastern region (3)	Central region (4)	Western region (5)	Northeastern region (6)
Coast×CBEC	0.013 6*** (3.40)					
Inland×CBEC		0.000 5 (0.15)				
East×CBEC			0.014 6*** (4.61)			
Mid×CBEC				-0.006 4 (-1.48)		
West×CBEC					-0.011 0* (2.15)	
Northeast×CBEC						0.020 2 (1.85)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	3 316	3 316	3 316	3 316	3 316	3 316
R-squared	0.691 8	0.689 5	0.693 1	0.689 8	0.690 4	0.690 8

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

5.2.2 City scale heterogeneity

To examine policy effects across city sizes, this study divides cities into megacities and medium-to-large cities based on population size. Table 13 shows that CBEC pilot areas significantly promote digital economy development in megacities (0.1% level), while effects in medium-to-large cities are insignificant or negative. This heterogeneity stems from infrastructure gaps, weaker industrial ecosystems, and lower policy absorption in smaller cities. Megacities, with mature digital infrastructure and stronger markets, attract cross-border e-commerce firms and amplify policy effects. Conversely, smaller cities face limited market capacity and the "siphon effect" of megacities, reducing their ability to benefit from CBEC policies and possibly weakening local industries.

Table 13 City Scale Heterogeneity

	Megacities (Population > 5 million) (1)	Large Cities (Population 1–5 million) (2)
Large×Cbec	0.009 5** (2.65)	
Medium×Cbec		-0.000 6 (-0.17)
Controls	Yes	Yes
City	Yes	Yes
Year	Yes	Yes
N	3 316	3 316
R-squared	0.691 3	0.689 5

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

5.2.3 Urban agglomeration heterogeneity

Based on the Beijing-Tianjin-Hebei Coordinated Development Plan and other national development plans, we divide cities into three major urban agglomerations: Beijing-Tianjin-Hebei (JJJ), Yangtze River Delta (YRD), and Pearl River Delta (PRD). Table 14 shows CBEC pilot areas significantly promote digital economy development in YRD and PRD, with stronger effects in YRD. YRD benefits from mature industrial base, advanced infrastructure, and high openness, while PRD leverages strong export networks and digital services. In contrast, JJJ shows no significant policy effect, possibly due to structural imbalances, slow industrial transformation, and weak innovation-to-application conversion that hinder full utilization of CBEC policy advantages.

Table 14 Urban Agglomeration Heterogeneity

	JJJ (1)	YRD (2)	PRD (3)
JJJ×CBEC	0.011 2 (0.76)		
Yangtz×CBEC		0.011 1** (2.74)	
Pearl×CBEC			0.018 2* (1.99)
Controls	Yes	Yes	Yes
City	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	3 316	3 316	3 316
R-squared	0.689 7	0.690 4	0.690 6

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

6 CONCLUSION AND DISCUSSION

This study investigates how digital trade policies influence the development of urban digital economies. Existing literature suggests such policies reduce transaction costs, foster technology spillovers, and improve resource allocation efficiency [32]. Qi et al. find that cross-border e-commerce policies enhance regional digital services through infrastructure investment [33]. Chou et al. highlight digital technology diffusion's role in boosting productivity [34], while Casalini and González emphasize that liberalized cross-border data flows facilitate industrial clustering [35]. However, most studies focus on national-level mechanisms and lack empirical assessment of regional heterogeneity and transmission pathways.

Drawing on policy text analysis and a difference-in-differences (DID) model, this study finds that CBEC pilot areas significantly promote urban digital economy development through three key mechanisms: digital infrastructure, service industry agglomeration, and business environment optimization. These results align with Ruan et al. [36], who show stronger policy impacts in coastal and megacities with robust digital and institutional capacities. The findings also support Zhou [37], emphasizing the importance of policy coordination. A limitation is the focus on short-term effects; further research is needed to explore long-term institutional dynamics and sustainability.

Based on these conclusions, China's experience offers valuable policy lessons for other countries:

(1) Investment in Digital Infrastructure

Governments should prioritize upgrading broadband, 5G, data centers, and cloud platforms to bridge the digital divide. Strengthening digital governance and cybersecurity can enhance transaction reliability and create a more inclusive environment for SMEs.

(2) Talent and Technological Innovation

Developing human capital in AI, big data, and blockchain is essential for sustainable growth. Supporting research collaboration and offering innovation incentives—such as funding or tax relief—can boost the CBEC sector's global competitiveness.

(3) Improving the Business Environment

Policymakers should streamline regulations, enhance transparency, and reduce compliance costs. Local authorities should tailor measures to local conditions—for instance, promoting innovation in advanced cities and improving infrastructure in underdeveloped regions—to support balanced digital economic development.

COMPETING INTERESTS

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

REFERENCES

[1] Li J, Fu X. Digital trade promotes the development of digital economy: Mechanism, facts, and suggestions. International Trade, 2024(07): 45–46. DOI: 10.14114/j.cnki.itrade.2024.07.007.

[2] Meltzer J P. Governing digital trade. World Trade Review, 2019, 18(S1): S23–S48.

[3] Shi D, Nie X, Qi F. Globalization of digital economy: technological competition, rule game and China's choice. Journal of Management World, 2023, 39(9): 1-15.

[4] Wang T, Li J, Zhang W. Experience of Digital Trade Development in the United States and Europe and Its Policy Enlightenment to China. International Trade, 2023(02): 57-63+86.

[5] Chen K, Luo S. Cross-border e-commerce development and enterprise digital technology innovation—Empirical evidence from listed companies in China. Heliyon, 2024, 10(15).

[6] Tapscott D. The digital economy: Promise and peril in the age of networked intelligence. Educom Review, 1996, 31: 52–54.

[7] González J L, Ferencz J. Digital trade and market openness. OECD, 2018.

[8] Bukht R, Heeks R. Defining, conceptualising and measuring the digital economy. Development Informatics Working Paper, 2017(68).

[9] Zhang B C, Shen K Y. Quantitative evaluation and characteristics of the development readiness in digital economy for "Belt and Road" countries. Shanghai Journal of Economics, 2018(1): 94–103.

[10] Liu J, Yang Y, Zhang S. Research on the measurement and driving factors of China's digital economy. Shanghai Journal of Economics, 2020, 6: 81–96. DOI: 10.19626/j.cnki.cn31-1163/f.2020.06.008.

[11] López González J, Jouanjean M. Digital trade: Developing a framework for analysis. OECD Trade Policy Papers, No. 205. OECD Publishing, 2017.

[12] Zhang X, Li D. Research on the coupling development of the digital economy, cross-border e-commerce, and digital trade: Application prospect of blockchain technology among them. Theoretical Exploration, 2020(1): 115–121.

[13] Wu J, Luo Z, Wood J. How do digital trade rules affect global value chain trade in services?—Analysis of preferential trade agreements. The World Economy, 2013, 46(10): 3026-3047.

[14] Xiong L, Ye K. Research on the relevance of cross-border e-commerce ecological development and policy combination dimensions. Soft Science, 2020, 34(2): 129–136. DOI: 10.13956/j.ss.1001-8409.2020.02.21.

[15] Huang S. The origin and present situation of institutional economics. Reform, 2017(1): 132–144.

[16] Wei D, Zhang J. Achievements and prospects on the construction of China's cross-border e-commerce comprehensive pilot area. International Trade, 2019(7): 18–24.

[17] Zhu Z, Jiang F. Does China's export of digital services promote the upgrading of global industrial structure?—Based on the perspective of resource mismatch. International Business (Journal of the University of International Business and Economics), 2022.

[18] Miao Y, Du R, Li J, et al. A two-sided matching model in the context of B2B export cross-border e-commerce. Electronic Commerce Research, 2019, 19: 841–861.

[19] Li Q, Zhao S. The impact of digital economy development on industrial restructuring: Evidence from China. Sustainability, 2023, 15(14): 10847.

[20] Li B, Zhang S. Research on the development path of China's digital trade under the background of the digital economy. Journal of Internet and Digital Economics, 2020, 2: 1–14.

[21] Solow R M. A contribution to the theory of economic growth. The quarterly journal of economics, 1956, 70(1): 65-94. DOI: 10.2307/1884513.

[22] Zhao T, Zhang Z, Liang S K. Digital economy, entrepreneurship, and high-quality economic development: Empirical evidence from urban China. Management World, 2020(10): 65–76.

[23] Huang Q, Yu Y, Zhang S. Internet development and productivity growth in manufacturing industry: Internal mechanism and China experiences. China Ind. Econ, 2019, 8: 5-23.

[24] Guo F, Wang J, Wang F, et al. Measuring China's digital financial inclusion: Index compilation and spatial characteristics. China Economic Quarterly, 2020, 19(4): 1401-1418.

[25] Jiang L D, Lu Y, Zhang G F. The construction of the pilot free trade zone and Chinese exports. China Industrial Economics, 2021, 8: 75-93.

[26] Rosenbaum P R, Rubin D B. The central role of the propensity score in observational studies for causal effects. Biometrika, 1985, 70(1): 41-55.

[27] Lechner M. Identification and estimation of causal effects of multiple treatments under the conditional independence assumption. Physica-Verlag HD, 2001: 43-58.

[28] Wang Q, Li J, Ding K, et al. Digital infrastructure, factor allocation efficiency, and urban-rural income gap. Statistics and Decision, 2023(09): 29–34.

[29] Wang X, Xie J, Fan Z P. B2C cross-border e-commerce logistics mode selection considering product returns. International Journal of Production Research, 2021, 59(13): 3841–3860.

[30] Han F, Yang L. How does the agglomeration of producer services promote the upgrading of manufacturing structure?: an integrated framework of agglomeration economies and schumpeter's endogenous growth theory. Management world, 2020, 36(2): 72-94. DOI: 10.19744/j.cnki.11-1235/f.2020.0022.

[31] Zhang Y, Cai D, Jia F, et al. The bounded incentive effect of informal institutions: An empirical study of executive compensation incentives based on the regional trust environment. Nankai Business Review International, 2019, 10(2): 207-232.

[32] Herman P R, Oliver S. Trade, policy, and economic development in the digital economy. Journal of Development Economics, 2023, 164: 103135.

[33] Qi X, Qin W, Lin B. Case study on synergistic development strategy of cross-border e-commerce and logistics: An empirically model estimation. Plos one, 2024, 19(6): e0304393.

[34] Ma S, Guo J, Zhang H. Policy analysis and development evaluation of digital trade: An international comparison. China & World Economy, 2019, 27(3): 49-75.
[35] Casalini F, González J L. Trade and cross-border data flows. 2019.
[36] Ruan J, Zou L, Liu R, et al. The Impact of Digital Economy Development on Regional Income Gaps: A Perspective on Multidimensional Inequality Decomposition and Threshold Effects. Mathematics, 2024, 12(24): 4024.
[37] Zhou A. Digital infrastructure and economic growth—Evidence for China. Journal of Infrastructure, Policy and Development, 2022, 6(1): 1397.