CROSS-BORDER E-COMMERCE, DIGITAL FINANCE AND ECONOMIC RESILIENCE

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Abstract: *This paper uses panel data of 259 prefecture-level cities in China from 2011 to 2022, and applies the double-difference method to explore the specific role and influence path of cross-border e-commerce on the economic resilience of cities. The results show that cross-border e-commerce can enhance urban economic resilience. The mechanism effect shows that cross-border e-commerce enhances the economic resilience of cities by promoting the level of digital financial development, including the breadth of digital financial coverage, depth of use and activity. The heterogeneity study finds that cross-border e-commerce can enhance the economic resilience of cities with higher administrative rank, larger population size and outflow, non-resource-based, non-growth-based and non-mature cities. The findings provide a basis for cross-border e-commerce to promote stable economic development.*

Keywords: *cross-border e-commerce; digital finance; economic resilience; double difference*
JEL*: F01; F02; F42*

1. Introduction

The global economy is undergoing a significant shift unseen for a century. External factors, like new trade protectionism and "anti-globalization" sentiments, have amplified macroeconomic volatility. Consequently, fostering economic resilience is important to ensuring the steady advancement and quality growth of China's economy. In this context,

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boosting economic resilience is pivotal for China's economy's steady and superior development. China's cross-border e-commerce has flourished recently. The General Administration of Customs declared that China's total cross-border e-commerce imported and exported volume surged to RMB 2.37 trillion in 2023, reflecting an impressive year-on-year advance of 15.3%. Concurrently, cross-border e-commerce provides opportunities to enhance economic resilience by proactively responding to international risk changes with an open trade model. Understanding the role of cross-border e-commerce in promoting economic resilience can unlock its potential.

Existing studies have only demonstrated the role of cross-border e-commerce in enhancing economic resilience, but have not investigated the mechanism between the two. For example, Wang & Wang (2024) found that cross-border e-commerce enhances the economic resilience of cities by utilizing its trade advantages such as facilitation, low cost, and high efficiency with spatial spillover effects. In the digital era, digital finance plays an important role in cross-border e-commerce trade (Goldberg et al., 2010) and is also an important influence on economic resilience (Decai et al., 2024). Previous literature lacks an in-depth discussion of the relationship between cross-border e-commerce, digital finance and economic resilience.

This article employs China's comprehensive pilot zone for cross-border e-commerce as a natural experiment, leveraging panel data from 2011-2022 across 259 Chinese prefecture-level cities to substantiate the enhancing effect of cross-border e-commerce on economic resilience via digital finance. Furthermore, it examines the differentiated effect of cross-border e-commerce on the economic resilience of various city types. The marginal contributions of this paper are: (1) From the research perspective, this paper proves that cross-border e-commerce can enhance the economic resilience of cities by promoting the development of digital finance, which expands the research scope of economic resilience to a certain extent. (2) In terms of research content, this paper analyzes the direct effect of cross-border e-commerce on the economic resilience of cities, and carries out a detailed heterogeneity analysis based on the administrative level of cities, demographic characteristics, and types of resources, so as to provide detailed empirical evidence for the implementation of China's cross-border e-commerce comprehensive pilot zones policies in different types of cities.

The rest of the paper is structured as follows: Part II reviews the previous literature and summarizes the academic contributions of this paper. The third part provides a mechanism analysis. The fourth part introduces the econometric model and data description; the fifth part presents the empirical results and analysis. The sixth part is the results of mechanism test; the seventh part is the results of heterogeneity analysis. The eighth part is the conclusion and recommendation of this paper.

2. Literature review

2.1. Economic resilience

The current literature on economic resilience focuses on three aspects: concept, measurement and influencing factors. The first is the concept of economic resilience. The concept of economic resilience was first proposed by Reggiani (2002), which refers to the ability of an economic system to resist and recover from shocks. Martin (2012) explains economic resilience in terms of disaster and post-disaster, i.e., the ability to integrate internally and adapt to external environments as well as resisting shocks when subjected to shocks. The Second is a measure of economic resilience. Briguglio (2009) and others proposed a multidimensional economic resilience composite index to empirically analyze macroeconomic stability, social development, microeconomic market efficiency and economic governance. Single-indicator measures are mainly measured by employment, unemployment and real GDP changes. For example, Martin (2015) uses the employment indicator to measure economic resilience, and he argues that the percentage decline in employment is greater than the percentage decline in output during a recession. Davies (2011), Brakman et al. (2015) measure economic resilience by combining two types of data: the number of unemployed and GDP. Thirdly, the influencing factors of economic resilience. Brown & Greenbaum (2017) use the data of Ohio counties in the U.S., and the study points out that the diversification of industrial structure can enhance the economic resilience; Bristow & Healy (2018) use the data of 28 countries in the European Union, and point out that the ability to innovate can withstand the shocks caused by the economic crisis; Boschma (2015) pointed out that innovation not only enhances the buffer capacity of industries to cope with shocks, but also strengthens the restructuring and renewal capacity of the economy during the recovery period. The studies of Christopherson et al. (2012) and Di Caro (2017) showed that factors such as market size and human capital also have an impact on economic resilience. In recent years, with the advent of the digital era, digital finance has also emerged as a key factor influencing economic resilience.

2.2. Cross-border e-commerce

Contemporary research on cross-border e-commerce predominantly examines its impact on global trade. This technology offers a real-time information management system for both transactional parties, facilitating seamless business interactions (Malone et al., 1987). Costs are primarily attributed to market information acquisition in the exporting nation, and the convenience of cross-border e-commerce decreases search time (Broocks & Biesebroeck, 2017), thereby reducing trade expenses and boosting trade volumes. Unlike traditional trade, cross-border e-commerce overcomes geographical constraints (Lendle et al., 2016), leading

to the "long-tail effect" of customization and expanding product variety. It also enhances export product quality by augmenting enterprise productivity, R&D investment, imported product categories, service inputs, and promoting service trade and product market demand (Munch & Schaur, 2018), thereby stimulating national economic growth (Guo et al., 2018).

2.3. Cross-border e-commerce and economic resilience

The significance of cross-border e-commerce in propelling economic resilience is undeniable. Comprehensive cross-border e-commerce pilot zones implement various innovations in institutions, management, and services, enhancing city innovation capability and resilience against external disturbances (Bristow & Healy 2018). Facilitated cross-border e-commerce overcomes the limitations of trade subject locations and spaces (Kim et al., 2017), expanding market capacity and realizing scale effects, thereby bolstering the resilience of the trade sector and the city economy as a whole, ultimating in the enhancement of economic resilience (Christopherson et al., 2012).

2.4. Digital finance and economic resilience

Digital finance contributes significantly to economic resilience in the digital era. Yang et al. (2024) underscore that digital finance boosts the economy's resilience, adaptability and adjustments. Sara (2011) discovered that digital finance enhances financial inclusion via credit and digital payment products, thereby bolstering the economic system's risk resistance. Hou et al. (2023) suggest that digital finance impacts economic resilience by enhancing capital allocation efficiency, strengthening innovation capacity, and stimulating residents' consumption. Wu (2023) found that digital finance and green innovation synergistically enhance the city's economic resilience. Decai et al. (2024) further confirm a significant positive correlation between digital finance and economic resilience.

3. Mechanism Analysis

Cross-border e-commerce amplifies market size and participant base through digital tech and network platforms, incentivizes enterprise innovation, elevates trade efficiency and convenience, thereby fortifying urban economy resilience, adaptability, and recovery. Firstly, it enables enterprises and products to circumvent geographical boundaries via global marketplace linkage, mitigating single market risks and augmenting economic stability against external adversities. When regional or market economic fluctuations arise, cross-border e-commerce firms can swiftly alter their market strategies and pivot to alternative markets, ensuring steady economic progression. Secondly, these firms necessitate continuous R&D investment to sustain global market competitiveness, adopt innovative technologies and tools to enhance operational efficiency and service quality, thereby

bolstering the enterprises' adaptability in international trade, thereby enhancing the city's overall adaptability. Lastly, the flexibility and innovation of cross-border e-commerce enable enterprises to rebound swiftly from economic hardships, invigorate market vitality and stimulate economic growth through the introduction of novel products, technologies, and models.

Hypothesis 1: Cross-border e-commerce can enhance urban economic resilience.

Cross-border e-commerce affects the breadth of digital financial coverage by expanding market size, thereby enhancing urban economic resilience. First, cross-border e-commerce expands the market scale of digital finance by providing convenient online payment and settlement services, enabling digital financial services to reach a wider range of regions and users, and increasing the breadth of digital financial coverage. Second, cross-border e-commerce promotes the construction of digital financial infrastructure to serve a wide range of enterprises, thus expanding the participating subjects, which directly affects the coverage of digital financial services. The breadth of digital financial coverage affects the overall operational stability of the economy, thereby enhancing the resilience of the city's economy. Finally, cross-border e-commerce itself has a significant entrepreneurial effect, which can effectively promote enterprise entry through channels such as reducing financing constraints and administrative burdens, expanding overseas cooperation (Alder et al., 2016; Tian & Xu 2021), effectively reducing the cost of services to the main body of the financing, thus meeting the long-term demand for financial services of urban SMEs and other long-tail customer groups, and providing the urban economy to cope with risky shocks to provide a wider range of financial support and enhance the resilience of the urban economy.

Hypothesis 2: Cross-border e-commerce enhances urban economic resilience by promoting the breadth of coverage of digital finance.

Cross-border e-commerce amplifies digital financial utilization through cultivating dynamic firm innovations, thereby enhancing city economic resilience. With rapid cross-border e-commerce expansion, service product transaction scales expand, and financial services budge into the cross-border e-commerce service sector. To gain economic leverage, companies employ digital technology to thoroughly comprehend buyers' shopping inclinations, preferred choices, and specific needs, thereby innovating personalized and diverse marketing tactics and intensifying digital financial services. This has also propelled the depth of digital finance usage, thereby bolstering the city's economic resilience. Financial institutions have also expedited trade finance and product innovation to offer credit services tailored for cross-border e-commerce requirements, thereby stimulating the depth of their digital finance usage. This not only boosts the competitiveness of firms and financial

institutions, but also augments the resilience and innovation of the city as a whole. For instance, the digital RMB streamlines the payment process, making it more cost-effective and secure. This innovative payment method escalates the depth of digital finance usage and fortifies the city's economic resilience.

Hypothesis 3: Cross-border e-commerce can enhance urban economic resilience by affecting the depth of digital finance.

Cross-border e-commerce affects digital financial activity by improving trade efficiency, thereby enhancing urban economic resilience. On the offline side, cross-border e-commerce accelerates the agglomeration of cross-border e-commerce industry chain and supply chain by providing enterprises with offline parks, forming a more complete supply chain and ecosystem covering manufacturing, trading, payment, logistics, warehousing, and technology, which improves transaction efficiency. The improved transaction efficiency makes enterprises more active in the field of digital finance. Cross-border e-commerce improves the operational efficiency of trade logistics, enhances the response and matching acumen of production factors, realizes the interconnection and efficient sharing of regional factor resources, and thus enhances the activity of digital finance. On the online side, the construction of cross-border e-commerce platforms can avoid the risks brought about by false trade financing, and also improve the diversification of financing channels, helping SMEs to solve financing problems (Tadelis, 2016). When the financing problem is effectively solved, enterprises are more willing to utilize cross-border e-commerce for trade, which effectively promotes the overall digital financial activity of the city. The enhancement of digital financial activity enables financial institutions to respond quickly to market financial demands and provide high-quality financial services to market players when the city faces risky shocks, enhancing the city's economic resilience.

Hypothesis 4: cross-border e-commerce enhances the city's economic resilience by affecting digital financial activity.

4. Research design

4.1. Benchmark regression model

In order to examine the impact of cross-border e-commerce on the economic resilience of Chinese cities, this paper sets up the following regression model:

$$Resilience_{it} = \alpha_0 + \beta did_{it} + \sum \gamma X_{it} + \delta_i + \sigma_t + \mu_{it}$$

where $Resilience_{it}$ is the economic resilience of city i in year t; did_{it} is a dummy variable for the comprehensive cross-border e-commerce pilot zone (cross-border e-commerce

belongs to the proxy variable of this policy), where $did_{it} = 1$ indicates that the city belongs to the comprehensive cross-border e-commerce pilot zone city, or else 0; X_{it} denotes the control variable; and α_0 is a constant term; and β is the average effect of cross-border e-commerce on the economic resilience of the city, which is also the the main research variable of this paper; γ denotes the coefficient of the control variable; δ_i and σ_t is the individual fixed effect and time fixed effect; μ_{it} is the random perturbation term.

4.2. Mediation effect model

Based on the above analysis, this paper considers that cross-border e-commerce may enhance the city's economic resilience by promoting the city's digital financial development level. Therefore, the mediation effect test model is constructed as follows:

$$Intermediary_{it} = \alpha_1 + \beta_1 did_{it} + \sum \gamma X_{it} + \delta_i + \sigma_t + \mu_{it}$$

$$Resilience_{it} = \alpha_2 + \beta_2 Intermediary_{it} + \sum \gamma X_{it} + \delta_i + \sigma_t + \mu_{it}$$

where $Intermediary_{it}$ denotes the mediating mechanism variable in this paper, β_1 denotes the average impact effect of cross-border e-commerce on the mediating mechanism variable, β_2 denotes the average impact effect of the mediating mechanism variable on the economic resilience of the city. If β_1 and β_2 are both significantly positive, the mediating mechanism effect exists.

4.3. Heterogeneity model

Recognizing that the role of cross-border e-commerce in enhancing the economic resilience level of cities might be affected by factors such as city class, demographics, resource availability, etc., we kindly introduce a cross-multiplier term of differentiation factors and did into our model, constructed based on the benchmark regression:

$$Resilience_{it} = \alpha_3 + \beta_3 did_{it} * Diff_{it} + \sum \gamma X_{it} + \delta_i + \sigma_t + \mu_{it}$$

$Diff_{it}$ indicates the differential factors such as whether it is a provincial capital city, a central city, a large or medium-sized city, etc., and β_3 indicates the average impact effect of cross-border e-commerce on the improvement of the level of economic resilience of the city under different conditions. The names of the remaining variables are consistent with the benchmark regression model.

4.4. Variable selection and measurement

The explanatory variable is economic resilience. For the measurement of economic resilience, drawing on Martin et al. (2015) and others, the financial crisis of 2008 is regarded as an exogenous shock, and by comparing the real GDP of the city after the shock from the national

real GDP to measure the level of economic resilience of the city is calculated using the following formula:

$$RE_{it} = \frac{City\ GDP_{it} - City\ GDP_{2008}}{City\ GDP_{2008}}$$

$$GR_t = \frac{Nation\ GDP_t - Nation\ GDP_{2008}}{Nation\ GDP_{2008}}$$

$$Resilience_{it} = \frac{RE_{it} - GR_t}{GR_t}$$

The core explanatory variable is cross-border e-commerce (did). Construct the cross-border e-commerce integrated zone policy variable, which is 1 if the city implements the policy in that year and thereafter, and 0 otherwise. Considering the potential impacts brought by other factors on the robustness of the empirical results, a series of control variables are selected in this paper. These include fiscal self-sufficiency (fiscal revenue/fiscal expenditure), consumption dynamism (total retail sales of consumer goods/GDP), market size (total merchandise sales of wholesale and retail trade above the quota/GDP), financial activeness (end-of-year financial institutions' loan and deposit balances/GDP), industrial structure (tertiary industry value added/secondary industry value added), educational environment (education and technology expenditures/fiscal expenditures), Science and Technology Emphasis (Science and Technology Expenditure/Fiscal Expenditure).

The mediator variable employs the comprehensive digital finance index provided by the esteemed Digital Finance Research Center at Peking University, China, to encapsulate the general level of digital finance. This index considers three facets: digital finance's scope, usage, and vibrancy. The scope indicates digital finance's reach; the usage captures how it's currently employed by users; while the vibrancy symbolizes its degree of digitization.

4.5. Data sources and descriptive statistics

This study utilizes 259 Chinese provincial capitals from 2011 to 2022, excluded those with excessive missing values. All individual missing data were reassigned via linear interpolation. The primary data is sourced from China's Digital Finance Research Center at Peking University, China Urban Statistical Yearbook, China Urban Construction Statistical Yearbook, China Science and Technology Statistical Yearbook, and respective city government's official data and statistical bulletins. Table 1 presents the descriptive statistics of key variables.

Table 1 Descriptive statistics

		(1)	(2)	(3)	(4)	(5)
	Variables	N	mean	sd	min	max
Core explanatory variables	Cross-border e-commerce	3108	0.136	0.343	0	1
Explanatory variable	Resilience	3108	24.200	24.800	-11.450	161.400
Control variable	Govern	3108	0.467	0.214	0.072	1.541
	Consume	3108	0.388	0.107	0	1.013
	Market	3108	0.462	0.441	0.004	4.697
	Finance	3108	0.703	0.226	0.060	5.613
	Structure	3108	1.063	0.586	0.175	5.650
	Education	3108	0.176	0.039	0.044	0.356
	Science	3108	0.018	0.018	0.001	0.207
Intermediary variable	Breadth of digital financial coverage	3108	195.100	76.100	21.260	361.100
	Depth of use of digital finance	3108	189.400	80.400	4.490	392.800
	Digital Financialization Activity	3108	226.500	83.760	2.700	437.900

5. Empirical results and analysis

5.1. Benchmark regression

Table 2 presents the outcomes of benchmark regressions. Columns (1) and (2) illustrate the outcomes of random effects models without and with control variables, revealing that both Cross-border e-commerce's impact on economic resilience is significantly positive. Columns (3) and (4) incorporate individual and time double fixed effects into models (1) and (2), respectively, and despite a decrease in Cross-border e-commerce's estimated coefficient, it remains significantly positive. These results confirm that cross-border e-commerce significantly supports urban economic resilience, regardless of the model employed or inclusion of control variables. Hypothesis 1 is validated, demonstrating that cross-border e-commerce bolsters urban economic resilience.

Table 2 Benchmark regression results

	(1)	(2)	(3)	(4)
Variables	Resilience	Resilience	Resilience	Resilience
Cross-border e-commerce	32.010***	22.500***	4.967***	3.710**
	(1.222)	(1.281)	(1.819)	(1.559)
Constant	19.830***	21.210***	3.978***	-25.130***
	(0.600)	(3.385)	(0.546)	(5.824)

Control	NO	YES	NO	YES
Individual fixed effect	NO	NO	YES	YES
Time fixed effect	NO	NO	YES	YES
Observations	3,108	3,108	3,108	3,108
R-squared	0.786	0.820	0.786	0.820
Number of id	259	259	259	259

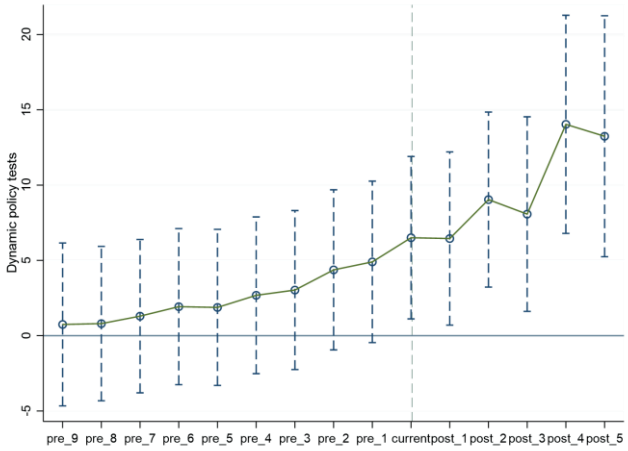
*Note: *, **, and *** denote significant at the 10%, 5%, and 1% levels, respectively; clustered robust standard errors are in parentheses, as in the table below.*

5.2. Robustness test

5.2.1.Parallel trend test

We carefully craft the interaction term linking the city to the dummy variable across each year in the parallel trend test, evaluating the parallel trend test's acceptance based on the apparent significance of the regression coefficients each year. Figure 1 elegantly illustrates the parallel trend test concerning the influence of cross-border e-commerce on urban economic resiliency, with the dashed line demarcating the year of the implementation of the comprehensive pilot zone policy for cross-border e-commerce. Results illustrate that the regression coefficients prior to this policy implementation were insignificant, suggesting no notable difference in the influence bore by city groups under the comprehensive pilot zone versus non-comprehensive pilot zone on city economic resiliency. However, following this policy shift, we observe markedly higher economic resilience among comprehensive pilot zone cities compared to their counterparts. This effect persists and exhibits lasting impacts even over many years of implementation. Hence, our research sample successfully meets the parallel trend test criteria. These results suggest that cross-border e-commerce can indeed bolster city economic resiliency.

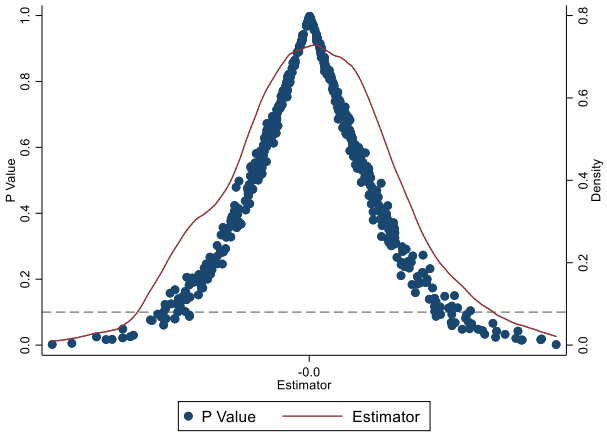
Figure 1 Parallel trend test



5.2.2.Placebo test

To ensure our findings aren't swayed by unknown variables. Our system has randomly generated policy shocks for 500 iterations. As seen in Figure 2, the regression coefficients of our pseudo-core explanatory variables are mostly close to zero and display a normal distribution pattern, not overlapping with the coefficient of 3.710 from our baseline regression. Most P-values for these coefficients also fall above the 0.1 threshold, affirming that, generally, our regression results do not attain statistical significance (significantly higher than 10%). Thus, the comprehensive cross-border e-commerce pilot zone policy seems untroubling to the city's economic resilience and poses only minimal effects on the baseline regression results.

Figure 2 Placebo test



5.2.3.Lag effect test

In light of the potential endogeneity issue associated with the time gap of the cross-border e-commerce comprehensive pilot zone policy, this study employs a lagged effect of 1 and 2 years to analyze the policy variables. The findings are presented in Table 3, with columns (1) and (2) presenting the effects of a 1-year lag without and with control variables respectively. A notable finding is that the coefficient of L. did on Economic resilience is significant at 5%, without control; it remains significant at 3.652 after control. Column (3) underscores the fact that after a 2-year lag, with no control, the policy impact is significant at 1%, with a coefficient of 4.809. Column (4), which includes control variables, shows a significant result at 5% with a coefficient of 3.646. In summary, the policy's delay effect intensifies with time and persists robustly after control, aligning well with the benchmark regression's conclusion. This validates the significance of cross-border e-commerce in bolstering economic resilience.

Table 3 Robustness: lag test

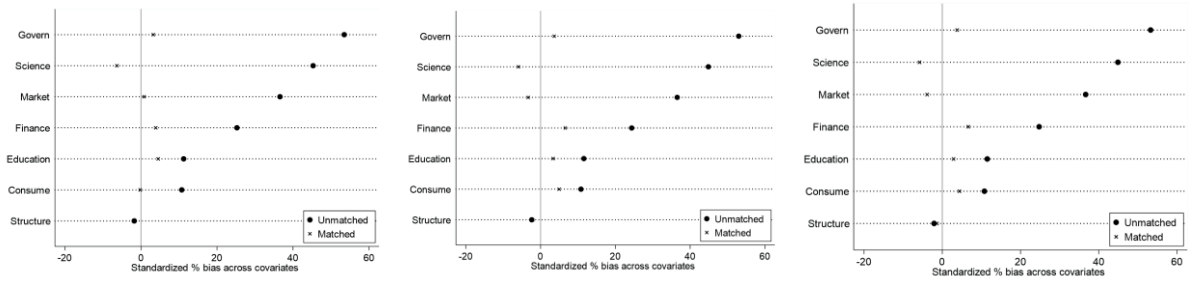
	(1)	(2)	(3)	(4)
	1- year lag		2-year lag	
Variables	Resilience	Resilience	Resilience	Resilience
L.did	4.728**	3.652**		
	(1.830)	(1.544)		
L2.did			4.809***	3.646**
			(1.822)	(1.571)
Constant	7.203***	-23.720***	9.271***	-25.180***
	(0.577)	(6.299)	(0.615)	(7.612)
Control	NO	YES	NO	YES
Individual fixed effect	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
Observations	2,849	2,849	2,590	2,590
R-squared	0.780	0.815	0.778	0.813
Number of id	259	259	259	259

5.2.4.Propensity Score Matching-Double Difference (PSM-DID)

Comprehensive cross-border e-commerce pilot zones selection is not arbitrary, but determined by the government considering each city's features. This might result in notable disparity among comprehensive pilot zone cities (experimental group) and non-comprehensive pilot zone cities (control group) regarding e-commerce progress, government focus on foreign trade, and import/export scales. This disparity impairs the comparison between both groups

and induces the issue of self-selection bias. To mitigate this bias, the paper employs the propensity score matching method to construct the PSM-DID model (Heckman et al., 1998). Three distinct matching methods are utilized to align the experimental group with the most similar control group based on control variables. The variance comparison before and after matching is illustrated in Fig. 3, comparing the variance of variables before and after the application of 1:1 proximity matching method, radius matching, and the kernel matching approach, respectively. The findings indicate no significant difference between the experimental and control groups post-matching, indicating a successful matching process. This suggests that the self-selection bias in the impact of cross-border e-commerce pilot zones on economic resilience has been effectively eliminated.

Figure 3 Comparison of Variance of Variables under Three Different Matching Methods



Matched data underwent regression analysis. Results are presented in Table 4, with columns (1)-(3) representing the estimated coefficients of cross-border e-commerce policies' influence on city's economic resilience post-matching via three techniques. As demonstrated, the estimated coefficients of the comprehensive pilot zone policy are markedly positive across all three methods, confirming the robustness of this paper's findings, affirming the vigorous influence of cross-border e-commerce on urban economic resilience while controlling for self-selection bias.

Table 4 Robustness: the PSM-DID test

	(1)	(2)	(3)
	close match	radius match	nuclear matching
Variables	Resilience	Resilience	Resilience
Cross-border e-commerce	21.750***	22.250***	21.950***
	(2.621)	(2.647)	(2.637)
Constant	26.190**	26.550**	26.260**
	(10.690)	(10.690)	(10.680)
Control	YES	YES	YES

Individual fixed effect	YES	YES	YES
Time fixed effect	NO	NO	NO
Observations	2444	2439	2441
R-squared	230	230	230
Number of id	0.355	0.357	0.356

5.2.5.Excluding other policy disturbances

Tables (1)-(2) of Table 5 illustrate that cross-border e-commerce significantly impacts economic resilience irrespective of control variables, and the policy of a comprehensive pilot zone for integrating science and technology with finance has no correlation with economic resilience. The estimated coefficients of cross-border e-commerce remain significant post-exclusion of the policy of comprehensive pilot zone, signifying minimal interference from other policies during the sample observation period, thereby validating the robustness of the baseline regression results. This suggests that cross-border e-commerce can bolster the economic resilience of cities.

Table 5 Robustness: excluding policy disturbances

	(1)	(2)
Variables	Resilience	Resilience
Cross-border e-commerce	5.178***	3.876**
	(1.835)	(1.575)
Comprehensive Pilot Zone for Integrating Science, Technology and Finance	-5.810	-5.724
	(5.776)	(5.196)
Constant	4.898***	-24.38***
	(1.056)	(5.865)
Control	NO	YES
Individual fixed effect	YES	YES
Time fixed effect	YES	YES
Observations	3088	3086
R-squared	0.787	0.822
Number of id	259	259

5.2.6.Other Robustness Tests

To mitigate the effect of outliers, the explanatory variables are reduced by 5%. The municipality directly under the central government presents a substantial development advantage over

others, and its inclusion may exaggerate the influence of the cross-border e-commerce comprehensive experimental zones policy on economic resilience, hence, this entity would be eliminated post-analysis. The resilient economic features exhibit distinct spatial distributional patterns, highlighting different clustering levels which could potentially induce sample variations. Therefore, altering the clustering levels could facilitate excluding these disparities. As illustrated in Tables 6, columns (1) and (6), cross-border e-commerce can bolster the economic resilience of cities.

Table 6 Other robustness tests

	(1)	(2)	(3)	(4)	(5)	(6)
	Have one's tail reduced		Excluding municipalities		Replacing the clustering hierarchy	
Variables	Resilience	Resilience	Resilience	Resilience	Resilience	Resilience
Cross-border e-commerce	3.547***	2.511**	3.588***	2.293**	3.588**	2.293**
	(1.228)	(1.083)	(1.270)	(1.129)	(1.275)	(1.001)
Constant	3.090***	-12.01***	3.103***	-11.64***	3.103*	-11.64**
	(0.598)	(3.947)	(0.603)	(3.958)	(1.697)	(4.874)
Control	NO	YES	YES	NO	NO	YES
Individual fixed effect	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES
Observations	2798	2798	2754	2754	2754	2754
R-squared	0.816	0.845	0.816	0.845	0.816	0.845
Number of id	259	259	255	255	259	259

6. Mechanism analysis

As shown in Table 7, columns (1)-(2) are the estimated coefficients of the impact of cross-border e-commerce on the total digital financial index and the total digital financial index on the economic resilience of the city, and the results show that the two paths are all established at a significant level of 1%, and the mediating effect exists. The results show that both paths are valid at 1% significant level, and the mediation effect exists. It indicates that cross-border e-commerce can increase the economic resilience of the city by promoting the development of digital finance, i.e., the path of “cross-border e-commerce → digital finance development → economic resilience” is valid. Columns (3)-(4) are the estimates of the impact of cross-border e-commerce on the breadth of digital financial coverage and the breadth of digital financial coverage on the city's economic resilience, all of which are significantly positive. It indicates that cross-border e-commerce expands the trade market size and participating subjects, and drives the breadth of digital financial coverage, which enhances the city's

economic resilience. Hypothesis 2 is established. Columns (5)-(6) are the estimated coefficients of the impact of cross-border e-commerce on financial digitalization activity, financial digitalization activity on urban economic resilience, and Cross-border e-commerce, and the coefficients indicate significantly positive. It indicates that cross-border e-commerce can enhance the city's economic resilience by promoting the depth of digital financial use, and Hypothesis 3 holds. Columns (7)-(8) are the estimated results of the role of cross-border e-commerce policy on the impact of the degree of financial digitization and the impact of digital financial activity on the city's economic resilience, and both paths are significantly positive at the 1% level of significance, which indicates that cross-border e-commerce can enhance the city's economic resilience through the promotion of digital financial activity, and Hypothesis 4 is valid.

Table 7 Mechanism analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total Digital Finance Index		Breadth of digital financial coverage		Depth of use of digital finance		Digital Financial Activity	
Variables	Intermediary	Resilience	Intermediary	Resilience	Intermediary	Resilience	Intermediary	Resilience
Cross-border e-commerce	3.840***		1.425*		4.710***		10.23***	
	(0.755)		(0.832)		(0.980)		(1.768)	
Intermediary		0.442***		0.344***		0.210***		0.0540***
		(0.068)		(0.067)		(0.047)		(0.017)
Constant	45.090***	45.030***	44.880***	40.540***	52.090***	36.010***	33.080***	26.870***
	(3.047)	(6.278)	(3.636)	(6.534)	(3.602)	(6.194)	(7.226)	(5.852)
Control	YES	YES	YES	YES	YES	YES	YES	YES
Individual fixed effect	YES	YES	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES	YES	YES
Observations	3108	3108	3108	3108	3108	3108	3108	3108
R-squared	0.995	0.828	0.994	0.826	0.990	0.823	0.964	0.820
Number of id	259	259	259	259	259	259	259	259

7. Heterogeneity analysis

7.1. Heterogeneity of demographic characteristics

Applying demographic variations among cities, cross-border e-commerce's impact on enhancing economic resilience varies. Cross-border e-commerce demands adequate human resources for optimal policy implementation, thereby augmenting city resilience. This paper classifies prefecture-level cities into two groups: large and medium-sized cities, and small cities. Results are illustrated in Table 8, where column (1) depicts that the estimated coefficient of large and medium-sized cities on economic resilience is 6.870, significantly positive at 1% significance level; column (2) denotes the non-significant coefficient of non-large and medium-sized cities on economic resilience. Policies advocate for constructing digital financial infrastructure, including enhancing network penetration and optimizing payment systems, to establish a robust foundation for cross-border e-commerce. Larger cities benefit from infrastructure improvement as it expands user reach, enhances digital finance coverage, and notably bolsters economic resilience.

Analyzed from a dynamic perspective, population mobility may cross-border e-commerce have different effects on the enhancement of economic resilience (Xie et al., 2022). In this paper, cities are categorized into inflow and outflow cities based on their resident population[5]. The results are shown in Table 8, the coefficients and significance of the interaction terms in columns (3) and (4) can be concluded that population inflow cities do not have a significant effect on the enhancement of economic resilience; population outflow cities enhance the economic resilience of the city at the 10% level, with a coefficient of 4.587. the probable reason is that population mobility affects the labor market of the city. Population outflow can reduce the employment pressure in the outgoing places, especially in areas with limited resources or insufficient employment opportunities. This helps optimize the allocation of labor resources, increase labor productivity, and enhance economic resilience. In addition, if the human capital level of the inflowing population is relatively low, in the face of external shocks, changes in population size in the short term will make it difficult to improve the structure of human capital, affecting the speed of employment recovery in the labor market and making it difficult to increase labor productivity, which will not lead to an increase in economic resilience.

Table 8 Heterogeneity: demographic characteristics

	(1)	(2)	(3)	(4)

[5] Subtracting the year-end resident population of cities in 2020 and 2010 from the China Urban Statistical Yearbook.

	Large and medium-sized cities	Non-large and medium-sized cities	Influx cities	Cities with outflow of population
Variables	Resilience	Resilience	Resilience	Resilience
Interaction term	6.870***	-1.305	2.030	4.587*
	(1.983)	(2.243)	(1.784)	(2.537)
Constant	-23.68***	-24.79***	-24.77***	-25.83***
	(5.805)	(5.905)	(5.888)	(5.823)
Control	YES	YES	YES	YES
Individual fixed effect	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
Observations	3108	3108	3108	3108
R-squared	0.822	0.822	0.819	0.820
Number of id	259	259	259	259

7.2. Resource endowment heterogeneity

It has been demonstrated in the literature that there are differences in the economic resilience of different resource-based cities. Then, cross-border e-commerce may have different effects on the economic resilience of different resource-based cities. In this paper, cities are divided into resource-based cities and non-resource-based cities, and resource-based cities are divided into whether they are growth and maturity cities.[6] The results are shown in Table 9, columns (1) and (2) can be concluded that resource-based cities do not have a significant impact on the improvement of economic resilience; non-resource-based cities have a positive impact on economic resilience at the 1% confidence level. Non-resource cities usually have a more diversified industrial structure and are better able to utilize cross-border e-commerce platforms to expand their markets and increase exports, thus enhancing economic resilience. Resource-based cities, on the other hand, may be overly dependent on the development and export of specific resources, resulting in a single industrial structure and a weaker ability to adapt to changes in external markets. Although cross-border e-commerce provides new trade channels, it may be difficult to change the economic vulnerability brought about by their homogeneous industrial structure.

To further analyze and study the heterogeneity of resource endowment. In this paper, resource-based cities can be categorized into whether they are growing and mature cities. The results

[6] Circular of the Chain State Council on the Issuance of the National Sustainable Development Plan for Resource-Based Cities (2013-2020).

of the interaction term coefficients in columns (3)-(6) show that cross-border e-commerce is enough to promote the economic resilience of non-growing and non-mature cities, while the promotion effect for growing and mature cities is not significant. Non-growing and non-mature cities usually have a low starting point for the development of cross-border e-commerce, with a small number of enterprises, a small market size, and a relatively backward technological level. Therefore, when the comprehensive cross-border e-commerce pilot zone policy is implemented in these cities, it can quickly attract the entry of enterprises and capital, promote the rapid development of the industry, and thus be more capable of enhancing economic resilience.

Table 9 Resource endowment heterogeneity

	(1)	(2)	(3)	(4)	(5)	(6)
	resource-based city	Non-resource-based cities	growing city	Non-growth cities	Mature cities	Non-mature cities
Variables	Resilience	Resilience	Resilience	Resilience	Resilience	Resilience
interaction term	-4.030	5.720***	-9.248	3.964**	-1.854	3.964**
	(3.702)	(1.594)	(5.812)	(1.570)	(5.980)	(1.570)
Constant	-25.020***	-25.080***	-24.970***	-25.090***	-25.020***	-25.090***
	(5.895)	(5.721)	(5.929)	(5.817)	(5.929)	(5.817)
Control	YES	YES	YES	YES	YES	YES
Individual fixed effect	YES	YES	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES	YES	YES
Observations	3108	3108	3108	3108	3108	3108
R-squared	0.819	0.822	0.819	0.820	0.819	0.820
Number of id	259	259	259	259	259	259

7.3. Administrative hierarchy heterogeneity

In addition to demographic characteristics and resource endowments that may make cross-border e-commerce contribute differently to economic resilience. This paper also considers the heterogeneity in the administrative hierarchy of cities. The results are shown in Table 10, with columns (1)-(2) showing the estimation results for provincial capitals and non-provincial capital cities, respectively. The results show that cross-border e-commerce is more able to enhance the economic resilience of provincial capital cities with a coefficient of 8.703. while the enhancement effect on the economic resilience of non-provincial capital cities is not significant. The reason may be that provincial capital cities usually have a stronger

economic foundation, and these areas can allocate resources more effectively, including capital, talents, technology, etc., to meet the needs of the rapid development of cross-border e-commerce. At the same time, the industrial chain and supply chain systems in these regions are relatively well-developed, which helps cross-border e-commerce enterprises to reduce costs improve efficiency, and enhance the economic resilience of the cities.

To further validate the cross-border e-commerce of high administrative level cities on the city's economic resilience. This paper divides municipalities, sub-provincial cities, and provincial capitals into central cities, and other prefecture-level cities into peripheral cities, the results are shown in Table 8, columns (3) and (4) are the estimation results of central and peripheral cities, respectively. The effect of cross-border e-commerce on the economic resilience of the center city is significant, with a coefficient of 7.086, while that of the peripheral cities is not significant. The central city contains the economy of sub-provincial cities, whose regression coefficients promote economic resilience to a lesser extent than those of the provincial capital cities. It is further verified that the effect of cross-border e-commerce in promoting economic resilience is stronger in cities with higher administrative levels.

Table 10 Heterogeneity: urban class

	(1)	(2)	(3)	(4)
	provincial capital	non-provincial capital	center city	outlying city
Variables	Resilience	Resilience	Resilience	Resilience
interaction term	8.296***	0.818	7.086***	0.911
	(2.684)	(1.835)	(2.422)	(1.962)
Constant	-23.690***	-25.220***	-23.400***	-25.300***
	(5.812)	(5.892)	(5.848)	(5.877)
Control	YES	YES	YES	YES
Individual fixed effect	YES	YES	YES	YES
Time fixed effect	YES	YES	YES	YES
Observations	3108	3108	3108	3108
R-squared	0.821	0.819	0.821	0.819
Number of id	259	259	259	259

8. Conclusions and recommendations

In the relentless pursuit of economic high-quality development, economic stability amidst intricate internal and external changes is paramount. This study examines the role and mechanism of cross-border e-commerce on urban economic resilience utilizing data from 259 Chinese prefecture-level cities from 2011 to 2022. Utilizing digital finance as a medium,

we investigate the function of cross-border e-commerce on economic stability. We aim to extend the current literature, providing insights for fostering economic stability and high-quality growth. Our findings reveal that cross-border e-commerce enhances the development of digital finance in the city, enhancing economic resilience in three dimensions: breadth, depth, and activity. Heterogeneous analysis indicates the varied impacts of cross-border e-commerce on economic resilience according to demographic, resource, and administrative levels. Firstly, cross-border e-commerce increases economic resilience in cities with larger populations and outbound flows. Secondly, it bolsters economic resilience in non-resource-based, non-growth, and non-mature cities. Lastly, it positively influences the economic resilience of capital and center cities with higher administrative hierarchies but exhibits no effect on periphery cities.

These findings can provide a reference for different cities to enhance their economic resilience with the help of cross-border e-commerce. First, cross-border e-commerce should have a full effect on the digital finance of cities to stimulate the breadth, depth and activity of digital finance, to enhance economic resilience and promote the high-quality development of the local economy. Second, cross-border e-commerce policies should be formulated based on the characteristics of cities to enhance economic resilience. For non-resource-based, non-growing and non-mature cities with high administrative levels, large populations and population outflows, the state should increase investment in cross-border e-commerce to ensure stable economic growth. For resource-based, growing, and mature cities with lower administrative levels and smaller populations but with an inflow trend, more attention needs to be paid to factors other than cross-border e-commerce that affect economic resilience.

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