

The Causal Effect of Cross-Border E-Commerce Pilot Zones on Urban Export Growth: Evidence from Multi-period Difference-in-Differences

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Abstract. Amid the rapid expansion of digital trade, China's Cross-border E-commerce Comprehensive Pilot Zones (CECPZs) represent a key institutional innovation to boost urban foreign trade. Using the CECPZ rollout as a quasi-natural experiment in a prefecture-level city panel (2000-2024) and a multi-period Difference-in-Differences design, baseline TWFE estimates indicate that designation substantially raises urban exports. The point estimate is about 0.24 log terms (roughly 27% increase) and remains robust to excluding pandemic years and municipalities, using alternative clustering schemes, and conducting spatial placebo tests. Province-level clustering yields around 0.244 ($p < 0.01$); robustness checks with municipality and pandemic-year exclusions give about 0.236-0.258 ($p < 0.05-0.01$). Heterogeneity shows larger gains in eastern coastal cities (~ 0.247 , $p < 0.01$) and in regions with lower government intervention (~ 0.208 , $p < 0.05$); inland and high-intervention areas display smaller effects. Subsample analyses suggest stronger effects where digital infrastructure and policy absorption are most developed. The results reveal spatially differentiated macro-level benefits and imply that policy design may need regional tailoring. Limitations include potential measurement error and residual endogeneity concerns; future research could employ alternative identification strategies and investigate downstream export composition and firm-level mechanisms.

Keywords: Cross-border E-commerce Pilot Zones, Urban Export Growth, Multi-period DID, Quasi-natural Experiment, Heterogeneity Analysis

1. Introduction

While the global spread of digital trade is reshaping traditional international trade, many firms still face practical obstacles in conventional foreign trade. Dependence on various intermediaries pushes up transaction costs and impedes information acquisition and communication with overseas purchasers. Slow, complicated cross-border logistics and customs clearance stem from redundant paperwork, prolonged inspections and poor interdepartmental coordination. These constraints greatly burden small and medium-sized enterprises with scarce capital and organizational capacity[1-3]. Furthermore, foreign trade develops unevenly by region. Eastern coastal cities possess

better ports, logistics, digital infrastructure and trade services, while inland cities endure higher transport costs, fewer service providers and weaker market ties[4]. To lower costs, optimize logistics and customs clearance and cultivate new foreign-trade channels, China set up Cross-border E-commerce Comprehensive Pilot Zones (CECPZs) in selected cities from 2015 onwards. While research on digital economy policy innovations has proliferated, the bulk of literature focuses on firm-level operational efficiency, industrial restructuring, or localized labor market stability [5-7]. Systematic assessments examining total urban export growth across nationwide panels remain underexplored. Additionally, empirical clarity is still lacking regarding how the trade dividends of CECPZs vary with geographic endowments and the degree of local government intervention over an extended period [8, 9]. To address these empirical gaps, this paper evaluates the aggregate impact of CECPZs on urban export growth using panel data from Chinese prefecture-level cities spanning 2000 to 2024. Employing a multi-period Difference-in-Differences model with two-way fixed effects, the empirical routine incorporates descriptive profiling, baseline estimation, and several robustness checks (adjusting sample windows, modifying standard error clustering, removing administrative municipalities, and executing placebo simulations), alongside two heterogeneity evaluations based on geography and fiscal intervention. This research contributes to the empirical literature on digital trade policy by providing city-level evidence regarding regional export determinants.

2. Literature review and hypotheses

By reducing reliance on traditional trade intermediaries, cross-border e-commerce platforms alleviate information asymmetries and lower overall transaction overhead [5]. The integration of digital logistics, electronic payment networks, and expedited customs processing within CECPZs facilitates direct access to foreign markets for local manufacturers [4, 8]. These operational efficiencies can improve firms' access to overseas markets and strengthen export-related agglomeration. Recent empirical evidence shows that the establishment of CECPZs significantly increases exports in pilot cities and generates positive spillover effects in neighboring non-pilot cities [10].

Evaluations of CECPZ implementation to date have concentrated mainly on micro-level firm behaviors, the technological complexity of exports, or isolated economic zones such as the Yangtze River Delta [6, 8]. For example, Yang et al. examine the regional effects of cross-border e-commerce pilot zones and find that their sustainable development significantly promotes regional economic growth through industrial upgrading, institutional innovation, and consumption upgrading [11]. At the firm level, Wang et al. [8] show that CECPZs can alleviate corporate financial constraints by promoting exports, digital transformation, and industrial agglomeration [12]. Nevertheless, a broader city-level assessment encompassing diverse regional institutional contexts over an extended multi-year timeframe remains relatively limited.

Grounded in trade cost theory and institutional economics, this paper proposes three hypotheses:

- H1: Establishing a CECPZ leads to a statistically significant increase in aggregate urban export growth.
- H2: The positive effect of CECPZs on exports is more pronounced in eastern coastal cities than in inland cities, owing to their superior digital infrastructure and trade support systems.
- H3: The trade-promoting effect of CECPZ is amplified in cities with lower municipal government intervention, where market allocation mechanisms operate with greater flexibility.

3. Research design

3.1. Model specification

To identify the causal influence of CECPZ implementation on urban export volume, we specify a multi-period Difference-in-Differences model featuring two-way fixed effects:

$$Y_{it} = \alpha_0 + \beta \cdot did_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Here, Y_{it} measures total export volume for the city i in year t . The binary indicator did_{it} equals 1 starting from the year city i establishes a CECPZ, and 0 otherwise. The vector X_{it} captures city-level control variables. City fixed effects (μ_i) and year fixed effects (λ_t) control for time-invariant urban traits and macro trends, respectively, while ε_{it} is the error term. Standard errors are clustered at the city level. Addressing the heterogeneity in treatment timing brought about by the staggered rollout of CECPZs, this paper adopts two-way fixed effects as the benchmark specification. To mitigate potential dynamic treatment bias and to validate the identification strategy, we employ placebo tests and subsample heterogeneity analyses in subsequent sections. The rationality of the benchmark model is supported by the contemporary literature on staggered DID, which highlights interpretation issues and potential biases under staggered adoption.

3.2. Variable definitions and data sources

- Dependent Variable (Y): Operationalized as the natural logarithm of total urban export value.
 - Core Independent Variable (did): A policy dummy indicating formal CECPZ designation.
 - Control Variables: Derived from urban attributes recorded between 2000 and 2024, control variables comprise economic development level (log per capita GDP), trade openness (total imports and exports divided by GDP), human capital (ratio of higher education students to total population), educational expenditure (education spending relative to general local public expenditure), financial development (loan balance to GDP ratio), and government intervention (general budget expenditure divided by GDP).

The dataset spanning 2000 to 2024 combines city-level statistics from the China City Statistical Yearbook with official administrative approvals issued by the State Council of China [13]. For macroeconomic indicators with lagged publication or missing values in 2024, data were supplemented using provincial statistical bulletins and linear interpolation to maintain a balanced panel.

4. Empirical results and discussion

4.1. Descriptive statistics

Table 1 outlines summary metrics for the principal variables ($N = 7,075$ across 2000–2024). The dependent variable Y averages 8.280 with a standard deviation of 2.411, spanning from 0 to 14.850, ranging from 0 to 14.850, indicating substantial variation in export scale across cities. The policy indicator did exhibits a mean of 0.106, indicating that 10.6% of sample observations fell within active policy treatment during the window.

Table 1. Descriptive statistics

Variable	N	Mean	SD	Min	p50	Max
Y	7075	8.280	2.411	0.000	8.340	14.850
did	7075	0.106	0.308	0.000	0.000	1.000
Economic Development	7075	10.230	1.063	7.297	10.350	19.920
Opening-up Level	7075	0.203	0.357	0.000	0.081	4.034
Human Capital	7075	0.988	22.490	0.000	0.009	858.800
Educational Expenditure	7075	0.186	0.130	-0.002	0.181	4.999
Financial Development	7075	2.603	2.599	0.000	2.112	67.850

4.2. Benchmark regression

Table 2 reports baseline multi-period DID estimates. Model (1), containing only city and year fixed effects, displays a positive treatment coefficient of 0.087 ($p < 0.05$). Incorporating city-level control variables in Model (2) shifts the *did* coefficient to 0.244 ($t = 7.739$, $p < 0.01$). Model (3) clusters standard errors at the city level, with the coefficient remaining unchanged at 0.244 ($t = 3.626$, $p < 0.01$). Controlling for other variables, the cities with the cross-border e-commerce pilot zones exhibit an average 24.4% higher logarithmic equivalent in export scale compared to cities without such zones. These estimates confirm that CECPZ implementation effectively drives urban export growth, aligning with Hypothesis H1. Furthermore, acknowledging recent econometrics literature on staggered DID designs, the baseline standard two-way fixed effects (TWFE) setup in this study serves as a robust benchmark, minimizing potential bias from heterogeneous treatment effects across cohort rollout timing.

Table 2. Benchmark regression results

	FE Baseline	With Controls	Further clustering to individual entities
	(1)	(2)	(3)
	Y	Y	Y
did	0.087** (2.398)	0.244*** (7.739)	0.244*** (3.626)
Economic development level		0.998*** (18.615)	0.998*** (7.301)
Level of opening up to the outside world		1.396*** (18.632)	1.396*** (5.840)
Level of human capital		-0.003*** (-6.712)	-0.003*** (-4.005)
Level of educational spending		0.109**	0.109

Table 2. (continued)

		(2.249)	(1.402)
Level of financial development		0.054***	0.054**
		(7.279)	(2.404)
_cons	8.271***	-2.397***	-2.397*
	(880.260)	(-4.344)	(-1.694)
Individual fixed effects	Yes	Yes	Yes
Fixed year effects	Yes	Yes	Yes
N	7075	7075	7075
R2	0.913	0.930	0.930

Note: ***, **, and * represent significance at 1%, 5%, and 10% levels respectively. t-statistics are in parentheses.

4.3. Robustness tests

Four robustness checks are conducted to assess the stability of the baseline estimates (Table 3):

- Restricting the Sample Window: To mitigate distortion from exogenous global shocks, observations from the pandemic period (2020–2022) were excluded from the 2000–2024 sequence. As shown in Column (1), the policy coefficient remains statistically significant at 0.258 ($p < 0.01$).
- Re-clustering Standard Errors: Re-estimating the specification with province-level clustering yields a coefficient of 0.244 ($p < 0.01$), addressing broader regional error correlation (Column 2).
- Excluding Municipalities: Omitting direct-administered municipalities (Beijing, Shanghai, Tianjin, and Chongqing) yields a policy effect of 0.236 ($p < 0.01$), indicating administrative hierarchy does not drive the result (Column 3).
- Placebo Test: Randomly assigning pseudo-treatment groups over 500 Monte Carlo iterations produces a coefficient distribution centered near zero, with most estimates statistically insignificant (Figure 1), suggesting unobserved omitted variables are unlikely to account for the benchmark findings.

Table 3. Robustness tests

Variables	(1) Adjusting Sample Period	(2) Province-level Cluster	(3) Exclude Municipalities
did	0.258*** (3.547)	0.244*** (2.956)	0.236*** (3.424)
Controls	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	6226	7075	6975

Table 3. (continued)

R-squared	0.928	0.930	0.926
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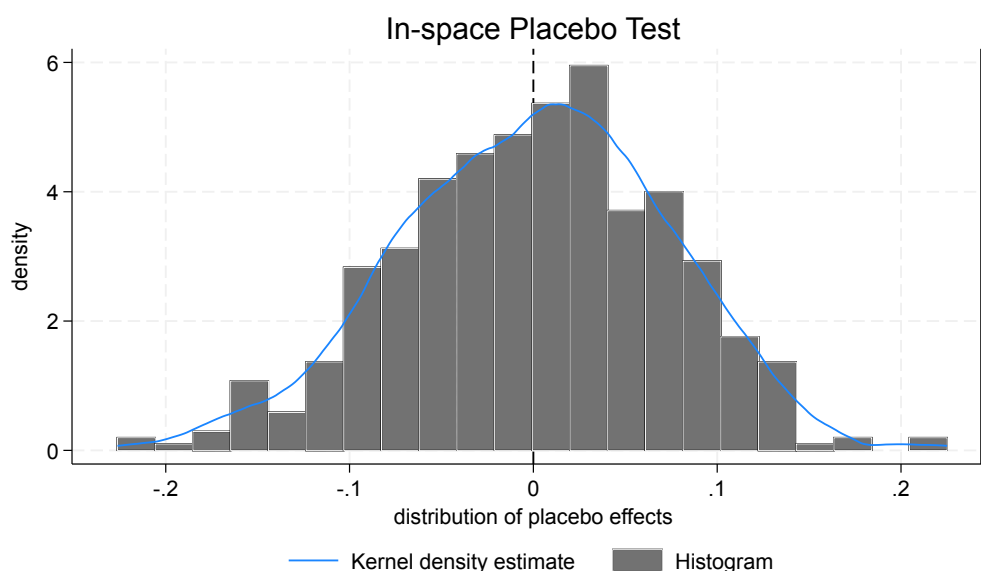


Figure 1. Spatial placebo test simulation results

4.4. Heterogeneity analysis

As reported in Table 4, the policy coefficient is estimated at 0.247 ($p < 0.01$) for eastern coastal cities, compared with 0.227 ($p < 0.05$) for non-eastern cities. This disparity supports Hypothesis H2, reflecting superior port access, mature digital trade environments, and enhanced policy absorption capacity along the eastern coast [8].

The observed east–west disparity is likely transmitted through a set of differentiated channels. Eastern coastal regions enjoy superior port connectivity, more advanced digital infrastructure, denser external trade ecosystems, and better-aligned logistics networks, which collectively amplify the policy's effect on exports relative to non-eastern areas.

Table 4. Heterogeneity analysis: geographic location

	Eastern	Non-Eastern
	(1)	(2)
	Y	Y
did	0.247*** (3.711)	0.227** (2.473)
Economic development level	0.992*** (5.870)	1.040*** (5.936)
Level of opening up to the outside world	0.808*** (4.528)	2.908*** (3.498)

Table 4. (continued)

Level of human capital	-0.003*** (-3.229)	-8.626* (-1.894)
Level of educational spending	0.060 (1.325)	-0.602 (-0.571)
Level of financial development	-0.004 (-0.282)	0.042** (2.084)
_cons	-0.883 (-0.494)	-3.259* (-1.818)
Individual fixed effects	Yes	Yes
Fixed year effects	Yes	Yes
N	2550	4525
R2	0.970	0.877

Local government intervention is proxied by general fiscal budget expenditure as a share of GDP, partitioning the sample at the median into high and low intervention groups. Table 5 shows that the policy coefficient is statistically significant in the low-intervention group (0.208, $p < 0.05$), but not in the high-intervention group (0.158, $p > 0.10$). This supports Hypothesis H3, indicating that market-oriented environments permit more efficient transmission of digital policy incentives [9].

Table 5. Heterogeneity analysis: government intervention

	High intervention level (1) Y	Low Intervention level (2) Y
did	0.158 (1.293)	0.208** (2.468)
Economic development level	1.226*** (5.999)	0.668*** (4.093)
Level of opening up to the outside world	2.085*** (4.920)	0.984*** (4.305)
Level of human capital	-0.005*** (-3.857)	-3.950 (-1.204)
Level of educational spending	0.227** (2.414)	-1.490* (-1.674)
Level of financial development	0.057** (2.450)	0.022 (0.783)
_cons	-5.532***	2.413

Table 5. (continued)

	(-2.703)	(1.405)
Individual fixed effects	Yes	Yes
Fixed year effects	Yes	Yes
N	3550	3525
R ²	0.885	0.949

5. Conclusion

This study provides robust evidence that the establishment of CECPZ significantly boosts urban export growth, with the baseline estimates remaining economically meaningful and statistically significant after controlling for city characteristics and broader time trends. The validity of these findings is reinforced by a comprehensive set of robustness checks—alternative sample windows, different clustering schemes, exclusion of municipalities, and placebo simulations—that confirm the observed gains are not artifacts of model specification or data choice. The analysis further reveals two channels shaping heterogeneity: third-tier cities exhibit distinct responses relative to top-tier and central cities, reflecting differences in policy diffusion, firm composition, and local institutional capacity, while regions with higher levels of marketization translate policy incentives into export gains more effectively, underscoring the crucial role of market-oriented governance in converting digital trade infrastructure into real trading activity. Taken together, these results suggest that local economic structure and governance conditions shape the effectiveness of CECPZs. From a policy perspective, national authorities should embed scalable digital trade policies and bolster nationwide coordination to reduce cross-regional frictions; eastern coastal zones should capitalize on digital infrastructure and port connectivity; interior pilot cities should tailor designs to local constraints and link incentives to targeted sectors; local governments must pursue reforms that sustain market-driven allocation, enhance transparency, and strengthen implementation capacity to sustain gains.

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