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The Dynamic Linkage and Threshold Characteristics of E-commerce and Urban-Rural Integration: Empirical Evidence from Chinese Prefecture-level Data

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Abstract

This study constructs an e-commerce indicator system and an urban-rural integration indicator system based on panel data from 280 prefecture-level cities in China during 2013-2022 to measure the development levels of e-commerce and urban-rural integration in each city. A system GMM model is applied to investigate the impact of e-commerce on urban-rural integration, while a dynamic threshold model is employed to explore how specific variables influence the effect of e-commerce on urban-rural integration. The research findings reveal: (1) Over the past decade, the average level of urban-rural integration across the 280 cities increased from 0.4395 to 0.5587, with the coefficient of variation decreasing from 0.1991 to 0.1286. Similarly, the average e-commerce level rose from 0.3225 to 0.5587, with the coefficient of variation declining from 0.3543 to 0.1641. These results indicate significant improvements in the levels of urban-rural integration and e-commerce, alongside enhanced development equilibrium across cities. (2) E-commerce development has a significant positive impact on urban-rural integration, with a 1% increase in the e-commerce level resulting in a 0.190 percentage point rise in urban-rural integration. (3) The dynamic threshold model demonstrates that the impact of e-commerce on urban-rural integration is influenced by factors such as government intervention, financial development, technological advancement, and market consumption levels, with varying effects observed above and below the threshold values.

JEL classification numbers: O18.
Keywords: E-commerce; Urban-Rural Integration; GMM; Dynamic Threshold Model.

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1. Introduction

Urban-rural integration is a crucial strategy for promoting high-quality economic development, achieving social equity, and realizing common prosperity. With the acceleration of China's urbanization process, disparities between urban and rural areas continue to widen across many dimensions, particularly in economic development, public services, social security, education, and healthcare. These disparities not only affect the equitable distribution of social resources but also constrain the nation's overall sustainable development. The core objective of urban-rural integration is to break the urban-rural dual structure by optimizing resource allocation and factor mobility, fostering coordinated and integrated development between cities and rural areas across economic, social, cultural, and ecological dimensions, thereby achieving a higher level of common prosperity (Xu et al., 2019; Wei, 2020; Li et al., 2020).

China's long-standing urban-rural dual structure has placed rural areas at a disadvantage in social, economic, and political aspects. Cities concentrate vast amounts of capital, technology, talent, and policy support, while rural areas face challenges such as insufficient resource allocation, lagging development, and brain drain (Li et al., 2020). Even under the rapid economic growth driven by urbanization since the reform and opening-up, rural areas still lack sufficient economic momentum and social security, with significant gaps persisting—particularly in income levels, educational opportunities, healthcare access, and infrastructure. These disparities not only diminish the quality of life for rural residents but also hinder the comprehensive development of the rural economy. Thus, promoting urban-rural integration and narrowing these gaps has become an imperative for achieving social equity and sustainable economic development.

The significance of urban-rural integration extends beyond reducing disparities—it also facilitates the equitable flow of social resources and shared economic prosperity between urban and rural areas. By promoting two-way movement of resources and production factors, cities and rural areas can leverage each other’s strengths, forming more efficient production and consumption models (Zhou et al., 2021). At the same time, urban-rural integration helps address regional development imbalances, driving nationwide progress. Moreover, it plays a vital role in rural revitalization, enhancing the dynamism and competitiveness of the rural economy, strengthening rural self-development capacity, and effectively addressing issues such as poverty, employment, and social security—ultimately improving the well-being and living standards of rural residents (Liu, 2018).

In the process of advancing urban-rural integration, the rapid development of the digital economy, particularly the proliferation of e-commerce, has created unprecedented opportunities. As a key component of the digital economy, e-commerce reduces transaction costs, breaks down information barriers, and provides rural areas with broader market access and resource-sharing platforms (Li et al., 2024). Notably, with the implementation of policies such as "Broadband China" and "E-commerce into Rural Areas Comprehensive Demonstration Project,"

the penetration of e-commerce in rural areas has significantly increased. Agricultural products can now directly enter national and even global markets through e-commerce platforms, driving structural transformation in the rural economy and modernizing the agricultural industry.

However, despite e-commerce injecting new momentum into urban-rural integration, its application varies significantly across regions and sectors. First, disparities in infrastructure, uneven access to digital technologies, and varying levels of digital literacy among rural residents limit the widespread adoption and effectiveness of e-commerce. In some areas, particularly remote villages, e-commerce development still faces challenges such as limited technological access, information asymmetry, and weak logistics systems, hindering its full potential in promoting urban-rural integration (Guo et al., 2022). Second, existing research has predominantly focused on the unidimensional impact of e-commerce on the rural economy, while systematic studies on how e-commerce facilitates multidimensional integration—economic, social, and cultural—between urban and rural areas remain relatively scarce.

Therefore, investigating the specific role of e-commerce in advancing urban-rural integration—particularly how it promotes factor mobility, optimizes resource allocation, and fosters coordinated economic development through the digital economy—holds substantial academic and practical significance. By examining the impact of e-commerce on urban-rural integration, we can better understand its differential effects across regions and dimensions, providing a scientific basis for policymaking while offering new insights for narrowing the urban-rural gap and enhancing resource mobility.

2. Literature Review and Commentary

2.1 Study on the Measurement of Urban-Rural Integration

Urban-rural integration is a complex socioeconomic phenomenon that encompasses interactions and coordination across multiple dimensions. Early research primarily focused on economic integration, particularly measuring the progress of urban-rural integration through changes in income levels, productivity, and industrial structure. Since the flow of economic factors is intuitive and easily quantifiable, scholars often relied on economic indicators to assess the degree of urban-rural integration. However, as research has deepened, scholars have gradually recognized that urban-rural integration is not limited to economic aspects—the roles of non-economic elements such as social, spatial, and ecological factors are equally important (Zhou et al., 2019). The significance of these non-economic factors in urban-rural integration has gradually gained recognition, particularly social and spatial integration, which serve as crucial components of urban-rural integration and can more comprehensively reflect its multidimensional characteristics (Zhao et al., 2019).

When discussing the influencing factors of urban-rural integration, scholars generally focus on aspects such as resource allocation, technological progress, policy guidance, and regional disparities. According to the theory of urban-rural integration, the level of economic development and the balance of resource allocation form the foundation for integration. Research shows that imbalanced resource allocation is one of the main reasons for the lag in urban-rural integration. Technological progress and improvements in total factor productivity not only promote industrial upgrading but also significantly enhance the efficiency of resource allocation, thereby driving urban-rural integration (Huang et al., 2022). However, due to disparities in infrastructure development and policy support between urban and rural areas, the progress of urban-rural integration varies significantly across regions, with particularly pronounced differences between eastern and central-western China (Wang et al., 2022).

In summary, although China's theoretical framework for urban-rural integration has gradually improved, related research remains in the exploratory stage (Fang, 2022). Existing measurement methods still have considerable room for improvement, particularly in quantifying non-economic factors such as social and spatial integration. Future research should focus on balancing development across various dimensions and establishing more scientific measurement systems to provide stronger theoretical support for the practical advancement of urban-rural integration.

2.2 Study on the Relationship Between E-commerce and Urban-Rural Integration

With the continuous advancement of urban-rural integration, e-commerce has gained widespread attention in academia and practice as an important tool driving this process. Research shows that e-commerce not only provides new pathways for the flow of factors between urban and rural areas, but also effectively promotes the circulation of agricultural products and the distribution of industrial goods to rural areas, reducing information asymmetry and transaction costs between urban and rural regions (Zhang, 2018). Additionally, e-commerce has played a significant role in popularizing digital payments and financial services, substantially improving rural residents' consumption capacity and promoting balanced allocation of urban-rural resources (Chen et al., 2023). Through these mechanisms, e-commerce has demonstrated great potential in facilitating urban-rural economic interaction and integration, particularly in driving income growth and consumption equality.

However, although e-commerce's role in promoting urban-rural integration is significant, its effects are not equal across all regions. Urban areas, with their well-established logistics systems and widespread adoption of digital technologies, have achieved remarkable progress. In contrast, remote rural areas still face numerous challenges in infrastructure and digital technology penetration, which constrain the popularization and effectiveness of e-commerce (Zheng et al., 2023). In particular, the "last mile" logistics problem remains a bottleneck hindering the development of rural e-commerce, affecting the efficiency of agricultural product circulation and

thereby restricting deeper urban-rural integration (Zhang, 2024).
Moreover, while e-commerce platforms provide rural residents with more consumption options and convenient payment methods, enabling them to enjoy shopping experiences similar to urban residents, the digital divide means that some low-income and elderly populations cannot equally access these benefits. This has exacerbated consumption inequality between urban and rural areas (Zhang, 2018). Therefore, bridging the digital divide and improving rural residents' digital skills have become crucial steps in achieving comprehensive urban-rural integration (Yin et al., 2022).
In summary, e-commerce has demonstrated tremendous potential in promoting urban-rural integration, but its development still faces challenges such as inadequate infrastructure, the digital divide, and logistics bottlenecks. To further strengthen the synergy between e-commerce and urban-rural integration, future efforts should focus on improving infrastructure, increasing digital technology penetration, and addressing the "last mile" logistics problem, thereby ensuring that e-commerce can achieve more inclusive development between urban and rural areas (Chen et al., 2023; Zheng et al., 2023).

3. Research Mechanisms and Hypothesis Formulation

With the rapid development of e-commerce, it has been playing an increasingly important role in promoting urban-rural integration. Through network effects and extensive coverage, e-commerce facilitates deep integration between urban and rural areas in economic, social, spatial and ecological dimensions. Particularly in terms of resource flows, public services and infrastructure construction, e-commerce provides new momentum for urban-rural interaction. Based on this, this study proposes the following hypotheses to explore how e-commerce promotes various dimensions of urban-rural integration.

Hypothesis 1: E-commerce can promote economic integration between urban and rural areas.

With its unique network effects and extensive coverage, e-commerce provides strong impetus for urban-rural integration. In urban development, e-commerce leverages abundant human capital and technological accumulation to optimize urban industrial structures, particularly accelerating the development and expansion of tertiary industries. Moreover, e-commerce development better meets the consumption demands of large urban populations, enhances urban economic resilience, and further promotes urbanization (Wang et al., 2023). For rural areas, e-commerce introduces more efficient rural e-commerce platforms, enabling more agricultural products to enter domestic and even international consumer markets. This development significantly simplifies supply chains, allowing farmers to connect directly with consumers, improving transaction efficiency while substantially reducing transaction costs, thereby increasing farmers' income levels

and promoting rural entrepreneurship (Lin et al., 2024). Meanwhile, increased demand significantly boosts farmers' production enthusiasm, further advancing agricultural modernization. In summary, e-commerce development effectively promotes factor flows between urban and rural areas and drives coordinated economic development.

Hypothesis 2: E-commerce can promote social integration between urban and rural areas.

Since China's reform and opening-up, rapid economic growth has significantly improved industrialization and urbanization levels. However, uneven resource allocation has concentrated most resources in urban areas, gradually widening development gaps between urban and rural areas, particularly in public services such as healthcare, education and social security. Significant economic disparities and the dual household registration system have severely constrained urban-rural integration (Shan et al., 2021; Zhu et al., 2023). To address these issues, China proposed the Rural Revitalization Strategy and Regional Coordinated Development Strategy in 2017 and 2018 respectively. While these measures have narrowed urban-rural public service gaps to some extent, significant disparities remain in economically underdeveloped western regions (Li et al., 2020). In this context, e-commerce development is believed to effectively alleviate resource misallocation caused by inefficient factor flows. By analyzing urban-rural public service expenditure levels across regions, governments can allocate healthcare, education and other public service resources more rationally, especially critical human resources like doctors and teachers. Additionally, through online education, telemedicine and other services, e-commerce expands public service coverage in rural areas, gradually narrowing urban-rural public service gaps.

Hypothesis 3: E-commerce can promote spatial integration between urban and rural areas.

Driven by digital transformation, e-commerce continues to promote business model evolution and market boundary expansion through its unique technological innovation and operational convenience. As a transaction mode that transcends geographical limitations, e-commerce development accelerates urban-rural factor flows. Utilizing modern information technologies like big data, cloud computing and IoT, e-commerce effectively alleviates urban-rural information asymmetry, reduces resource waste and misallocation, thereby significantly improving resource allocation and utilization efficiency (Ding, 2020). Furthermore, e-commerce development, especially rural e-commerce, necessitates logistics service expansion to rural areas, which not only promotes synchronous development of rural transportation networks and internet communication technologies, but also shortens physical and information distances between urban and rural areas, enhancing integrated urban-rural transportation and information systems. Meanwhile, rural e-

commerce provides more employment and entrepreneurship opportunities for farmers, helping alleviate rural population outflow while mitigating urban-rural household registration contradictions. Finally, e-commerce development also promotes intensive and rational land use planning between urban and rural areas, optimizing land resource allocation to maximize benefits. In summary, e-commerce not only promotes urban-rural integration by optimizing market mechanisms, but also strengthens urban-rural interaction and integration by facilitating population flows and optimizing land use.

Hypothesis 4: E-commerce can promote environmental integration between urban and rural areas.

E-commerce influences urban-rural ecological integration by adjusting supply-side resource allocation and stimulating demand-side consumption patterns. From the supply side, e-commerce promotes online shopping, reducing consumer reliance on physical retail spaces and facilitating urban commercial land redevelopment. Some commercial lands are converted into public green spaces to enhance urban greening levels. Such land use transformation not only optimizes supply-side resource allocation but also improves ecological quality by reducing urban heat island effects and increasing carbon sinks, thereby enhancing urban living environments. From the demand side, e-commerce proliferation increases consumer reliance on delivery services, significantly raising packaging material usage and exacerbating environmental pollution from packaging waste. To address this, China introduced over ten policies between 2018 and 2023 to strengthen research on recyclable express packaging, advance standard systems for recyclable packaging, and accelerate green transformation of express packaging (Guo et al., 2023). In summary, although e-commerce development poses certain environmental governance challenges, with strengthened government regulation, promotion of recyclable materials and enhanced public environmental awareness, environmental pollution issues caused by e-commerce are expected to be gradually mitigated.

4. Empirical Design

4.1 Modeling

To investigate the impact mechanism of e-commerce development on urban-rural integration, this study employs panel data from 280 prefecture-level cities spanning 2013-2022 for regression analysis. Considering that urban-rural integration exhibits significant dynamic effects - where current values are easily influenced by past values - we construct the following dynamic panel model to more accurately measure the influence of e-commerce development on urban-rural integration levels. The specific model specification is as follows:

$$\boldsymbol{Uri_{i,t} = \beta_1 Uri_{i,t-1} + \beta_2 Ecom_{i,t} + \beta_3 Control_{i,t} + \varepsilon_{i,t}} \quad (\mathbf{1})$$

Where, $Uri_{i,t}$ represents the urban-rural integration index of city i in year t; $Uri_{i,t-1}$ is the one-period lagged dependent variable to capture dynamic effects; $Ecom_{i,t}$ denotes e-commerce development level of city i in year t; $Control_{i,t}$ is a vector of control variables; $\varepsilon_{i,t}$ is the random perturbation term.

4.2 Dependent variable

Based on existing research and considering data availability and statistical standards at the prefecture-level city scale, this study constructs a comprehensive urban-rural integration measurement system encompassing four dimensions (economic, social, spatial, and ecological) with a total of 12 indicators (Huang et al., 2022; Chen et al., 2023; Cui et al., 2023; Wang et al., 2023).

As shown in the table:

Economic integration primarily measures urban-rural economic disparities and development levels; Social integration focuses on the equalization of public services including healthcare, education, and social security; Spatial integration reflects market circulation, urbanization progress, and population mobility; Ecological integration mainly assesses gaps in environmental protection and ecological construction between urban and rural areas.

Table 1: Urban-Rural Integration Level Indicator System

Target Level	Dimension	Indicator	Indicator Description	Attribute
Urban-Rural Integration Level Index	Economic Integration	Urban-Rural Per Capita Disposable Income Ratio	Urban Per Capita Disposable Income / Rural Per Capita Disposable Income	Negative
		Share of Non-Agricultural Output Value	(Secondary + Tertiary Industry Output) / Total Industry Output	Positive
		Per Capita Regional GDP	Regional GDP / Total Population	Positive
	Social Integration	Medical Services Level	Number of Doctors per 10,000 People	Positive
		Education Level	Number of Teachers per 10,000 Secondary School Students	Positive
		Unemployment Insurance Coverage Level	Number of Unemployment Insurance Participants per 10,000 People	Positive
	Spatial Integration	Urban-Rural Market Circulation	Number of Large-Scale Wholesale and Retail Enterprises per Million People	Positive
		Urbanized Land Use Leve	Built-Up Area / Total Land Area	Positive
		Urbanization Rate of Population	Urban Population / Total Population	Positive
	Ecological Integration	Green Coverage Rate in Built-Up Areas	Green Area / Total Built-Up Area	Positive
		Harmless Disposal Rate of Domestic Waste	Harmless Disposal Rate of Domestic Waste (%)	Positive
		Industrial Sulfur Dioxide Emissions	Emission of Industrial SO_2 (tons)	Negative

4.3 Explanatory variable

As an important component of the digital economy, the measurement of e-commerce can draw on approaches used for digital economy assessment. This study integrates the e-commerce measurement system developed by Yang Jianzheng et al. (Yang et al., 2011) with digital economy measurement frameworks proposed by other scholars (Chen et al., 2023; Gan et al., 2024), while considering data availability at the prefecture-level city scale, to construct the e-commerce development level indicator system shown in Table 2.

Table 2: E-commerce Development Level Indicator System

Target Level	Indicator	Indicator Description	Attribute
E-commerce Development	E-commerce Transaction Volume	Total of e-commerce sales and purchases	Positive
	Inclusive Finance Development Level	Inclusive Financial Development Index	Positive
	Internet Broadband Access	Number of broadband users per 100 people	Positive
	Total Postal Service Volume	Total value of postal services (10,000 yuan)	Positive
	Total Telecommunications Service Volume	Total value of telecommunications services (10,000 yuan)	Positive

4.4 Control Variables

Drawing upon established research methodologies, this study incorporates the following control variables to account for potential confounding factors: (1) government intervention level (Gov), measured as the ratio of local general budget expenditure to GDP; (2) financial development level (Fin), represented by the ratio of total outstanding loans from financial institutions to regional GDP; (3) technological development level (Tec), calculated as R&D expenditure multiplied by 100 and divided by GDP; (4) industrial structure, comprising both the secondary industry's share of GDP (Iso1) and tertiary industry's share of GDP (Iso2) (Gong et al.,2023); and (5) market consumption level (Con), expressed as the ratio of total retail sales of consumer goods to regional GDP. These variables collectively control for institutional, economic, and structural factors that may influence the observed relationships.

4.5 Indicator Aggregation Methodology

Compared to the Analytic Hierarchy Process (AHP) and expert consultation method, the entropy weighting method provides a more objective approach to calculating weights (Wang et al., 2023). Therefore, this study employs the entropy weighting method to determine the weights for both the urban-rural integration level indicator system and the e-commerce development level indicator system.

The computational procedure of the entropy weighting method is as follows:

Data Standardization:

Indicators with positive effects:

$$X'_{ij} = \frac{X_{ij} - \min\{X_j\}}{\max\{X_j\} - \min\{X_j\}} \tag{2}$$

Indicators with negative effects:

$$X'_{ij} = \frac{\max\{X_j\} - X_{ij}}{\max\{X_j\} - \min\{X_j\}} \tag{3}$$

where X'_{ij} represents the standardized data and X_{ij} denotes the raw data.

To calculate the proportion of the j-th indicator in the i-th year, the following formula is applied:

$$Y_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{m} X'_{ij}} \tag{4}$$

The calculation of indicator information entropy is formally expressed as follows:

$$e_j = -k \sum_{i=1}^{m} \left(Y_{ij} \times \ln Y_{ij}\right) \tag{5}$$

where $k = -1/\ln m$.

Calculation of Information Entropy Redundancy Degree:

$$d_j = 1 - e_j \tag{6}$$

Calculation of Indicator Weights:

$$Uri_i = \frac{d_j}{\sum_{i=1}^{n} d_j} \tag{7}$$

5. Data Sources and Descriptive Statistics

The data for this study were sourced from the "China Statistical Yearbook," "China City Statistical Yearbook," "China Rural Statistical Yearbook," "China Environment Statistical Yearbook," and "China Urban Construction Statistical Yearbook" for the years 2014–2023, as well as statistical bulletins on national economic and social development from various prefecture-level cities. Missing data were supplemented using methods such as linear interpolation and average annual growth rates. The symbols and statistical characteristics of key variables are presented in Table 3.

Table 3: Descriptive Statistics of Variables

Variable	Symbol	Mean	Ste. Dev.	Min	Max
urban-rural integration index	*Uri*	0.4971	0.0871	0.2110	0.7778
E-commerce development level	*Ecom*	0.4767	0.1358	0.0320	0.9474
Government intervention level	*Gov*	0.2072	0.1025	0.0439	0.9155
Financial development level	*Fin*	1.1244	0.6198	0.1842	7.4502
Scientific and technological development level	*Tec*	0.2975	0.2918	0.0128	6.3010
Industrial structure level 1	*Iso1*	0.4363	0.1060	0.1068	0.7936
Industrial structure level 2	*Iso2*	0.4433	0.0948	0.1644	0.8387
Market consumption level	*Con*	0.3935	0.1086	0.0003	1.0126

6. Analysis of Empirical Results

6.1 Temporal Trend Analysis of Urban-Rural Integration Level and E-Commerce Development Level

The empirical results demonstrate significant improvements in both urban-rural integration and e-commerce development across China's 280 prefecture-level cities during 2013-2022. As shown in Table 4, the average urban-rural integration level exhibited steady growth from 0.4395 to 0.5587, while its coefficient of variation declined from 0.1991 to 0.1286, indicating not only absolute progress but also greater regional convergence in integration outcomes. Parallel trends emerged in e-commerce development, where the mean level nearly doubled from 0.3225 to 0.5925, accompanied by a substantial reduction in regional disparity as evidenced

by the coefficient of variation's decrease from 0.3543 to 0.1641. These findings collectively suggest that China has made remarkable strides in both promoting balanced urban-rural development and achieving more spatially equitable e-commerce growth during the study period.

Table 4: Average Values and Coefficients of Variation for Urban-Rural Integration and E-commerce Development Levels by Year

Year	*Mean_Uri*	*SD_Uri*	*CV_Uri*	*Mean_Ecom*	*SD_Ecom*	*CV_Ecom*
2013	0.4395	0.0875	0.1991	0.3225	0.1142	0.3543
2014	0.4537	0.0820	0.1807	0.3577	0.1086	0.3038
2015	0.4609	0.0817	0.1771	0.4006	0.1077	0.2689
2016	0.4774	0.0805	0.1687	0.4436	0.1044	0.2354
2017	0.4922	0.0774	0.1572	0.4839	0.1008	0.2084
2018	0.5017	0.0778	0.1550	0.5091	0.1008	0.1981
2019	0.5123	0.0780	0.1523	0.5307	0.1016	0.1914
2020	0.5288	0.0741	0.1402	0.5489	0.0995	0.1812
2021	0.5455	0.0728	0.1335	0.5779	0.0964	0.1668
2022	0.5587	0.0718	0.1286	0.5925	0.0972	0.1641

Notes: Uri represents the urban-rural integration index; Ecom represents e-commerce development level.

6.2 Regression Analysis

6.2.1 Baseline Regression and Model Selection

To investigate the impact of e-commerce development on urban-rural integration, this study employs multiple regression models, including OLS regression, fixed-effects models, and system GMM models, to ensure comprehensive and accurate results. Model (1), the OLS regression, shows that the coefficient of the one-period lagged urban-rural integration is 0.939, while the coefficient of e-commerce is 0.029, both statistically significant at the 1% level, indicating a significant positive relationship between e-commerce and urban-rural integration. However, the OLS model fails to control for unobserved individual effects, potentially leading to biased results. To address this issue, the study further adopts a panel fixed-effects model. The results of Model (2) reveal that the coefficient of the one-period lagged urban-rural integration is 0.664, and the coefficient of e-commerce is 0.151, both significant at the 1% level. This suggests that, even after controlling for individual heterogeneity, the positive effect of e-commerce on urban-rural integration remains statistically significant.

Although the panel fixed-effects model accounts for individual heterogeneity, it still has limitations in addressing endogeneity, heteroskedasticity, and autocorrelation. Therefore, this study further employs a system GMM model. The results of Model (3) show that the AR(1) test yields a p-value of 0.000, rejecting the null hypothesis of no first-order serial correlation, while the AR(2) test yields a p-value of 0.205, greater than 0.1, failing to reject the null hypothesis of no second-order serial

correlation, indicating model consistency. The Hansen test result of 0.177, exceeding 0.1, suggests that the instrumental variables are appropriately selected. The coefficient of the one-period lagged urban-rural integration is 0.861, significant at the 1% level, and the coefficient of e-commerce is 0.119, also significant at the 1% level. To avoid overestimating the impact of e-commerce due to the omission of control variables in Model (3), Model (4) incorporates control variables based on Model (3). The results show that the AR(1), AR(2), and Hansen tests all support the model's validity. The coefficient of the one-period lagged urban-rural integration is 0.570, significant at the 1% level, while the coefficient of e-commerce is 0.190, significant at the 1% level, further confirming the positive effect of e-commerce on urban-rural integration.

Table 5: Regression Results of E-Commerce on Urban-Rural Integration

Variable	Model (1) *OLS*	Model (2) *FE*	Model (3) *GMM*	Model (4) *GMM*
L.Uri	0.939*** (0.005)	0.664*** (0.020)	0.861*** (0.035)	0.570*** (0.120)
Ecom	0.029*** (0.004)	0.151*** (0.006)	0.119*** (0.035)	0.190*** (0.062)
Control	NO	NO	NO	YES
AR(1)	-	-	0.000	0.005
AR(2)	-	-	0.205	0.603
Hansen test	-	-	0.177	0.579
R-squared	0.971	0.948	-	-

Notes: L.Uri represents the one-period lagged urban-rural integration level. The p-values are in parentheses; *, **, *** represent significant at 10%, 5%, and 1% levels, respectively.

6.2.2 Regression Analysis of Urban-Rural Integration by Dimension

This study constructed an indicator system for urban-rural integration by dividing it into four dimensions - economic, social, spatial, and ecological - and proposed four hypotheses based on economic theory. To test these hypotheses, we established separate system GMM models for each dimension to examine the impact of e-commerce on different aspects of urban-rural integration. Models (5) through (8) present the regression results of e-commerce on economic, social, spatial, and ecological integration respectively.

For all four models, the AR(1) test statistics (0.000, 0.000, 0.042, 0.005) were below 0.1, rejecting the null hypothesis of no first-order serial correlation, while the AR(2) results (0.723, 0.138, 0.156, 0.366) all exceeded 0.1, failing to reject the null of no second-order serial correlation, indicating model consistency. The Hansen test results (0.164, 0.116, 0.479, 0.697) were all greater than 0.1, suggesting appropriate instrumental variable selection.

Model (5) results show the one-period lagged economic integration coefficient was 0.963 (significant at 1% level), indicating strong path dependence in economic

convergence. The e-commerce coefficient of 0.014 (significant at 1% level) suggests each 1% increase in e-commerce development raises economic integration by 0.014 percentage points, supporting hypothesis 1. Model (6) reveals the lagged social integration coefficient was 0.266 (significant at 1% level), while e-commerce's coefficient was 0.040 (significant at 1% level), meaning each 1% e-commerce growth increases social integration by 0.040 percentage points, confirming hypothesis 2.

Model (7) demonstrates the lagged spatial integration coefficient was 0.664 (significant at 1% level), with e-commerce showing a coefficient of 0.030 (significant at 10% level), implying each 1% e-commerce improvement raises spatial integration by 0.030 percentage points, validating hypothesis 3. Model (8) indicates the lagged ecological integration coefficient was 0.348 (significant at 5% level), while e-commerce's coefficient was 0.079 (significant at 5% level), showing each 1% e-commerce enhancement increases ecological integration by 0.079 percentage points, thereby supporting hypothesis 4.

The dimensional analysis confirms e-commerce's differential impacts across integration domains, with particularly strong effects on social and ecological dimensions, providing empirical evidence for targeted policy interventions in China's rural revitalization strategy. All models controlled for relevant socioeconomic factors and included proper fixed effects, with standard errors clustered at city level to ensure robust inference.

Table 6: Regression Results of E-Commerce on Multi-Dimensional Urban-Rural Integration

Variable	Model (5) *Uri1*	Model (6) *Uri2*	Model (7) *Uri3*	Model (8) *Uri4*
Ecom	0.014*** (0.033)	0.040*** (0.010)	0.030* (0.016)	0.079** (0.037)
L.Uri1	0.963*** (0.044)	-	-	-
L.Uri2	-	0.266*** (0.097)	-	-
L.Uri3	-	-	0.664*** (0.172)	-
L.Uri4	-	-	-	0.348** (0.171)
Control	YES	YES	YES	YES
AR(1)	0.000	0.000	0.042	0.005
AR(2)	0.723	0.138	0.156	0.366
Hansen test	0.164	0.116	0.479	0.697

Notes: Uri1, Uri2, Uri3, and Uri4 denote urban-rural economic integration, social integration, spatial integration, and ecological integration levels, respectively; L.Uri1, L.Uri2, L.Uri3, and L.Uri4 represent their one-period lagged terms. The p-values are in parentheses; *, **, *** represent significant at 10%, 5%, and 1% levels, respectively.

7. Robustness Tests

7.1 Regional Heterogeneity Analysis

To verify the robustness of our research conclusions, this study divides the 280 prefecture-level cities into four regions—Eastern, Central, Western, and Northeastern China—for regional heterogeneity analysis. This approach accounts for the economic, social, and cultural differences across regions that may influence variable relationships, while also identifying region-specific effects to enhance the accuracy and applicability of the findings (Lu et al., 2014). To mitigate potential endogeneity issues, we employ the system GMM model for estimation, with regression results presented in Table 7.

Models (9) to (12) display the system GMM regression results of e-commerce on urban-rural integration for the Eastern, Central, Western, and Northeastern regions, respectively. All four models exhibit AR(1) values of 0.000, rejecting the null hypothesis of no first-order serial correlation, while AR(2) values (0.527, 0.112, 0.520, 0.537) exceed 0.1, failing to reject the null of no second-order serial correlation, confirming model consistency. Hansen test results (0.143, 0.115, 0.926, 0.458) all surpass 0.1, indicating appropriate instrumental variable selection. The one-period lagged urban-rural integration coefficients for the Eastern, Central, Western, and Northeastern regions are 0.540, 0.709, 0.814, and 0.363, respectively, all statistically significant at the 1% level, demonstrating that current integration levels in all regions are significantly influenced by prior achievements.

For the Eastern region, the e-commerce coefficient is 0.198 (significant at 1%), implying that a 1% increase in e-commerce development raises urban-rural integration by 0.198 percentage points. The Central region shows a coefficient of 0.178 (significant at 1%), translating to a 0.178-percentage-point boost per 1% e-commerce growth. In the Western region, the effect is 0.060 (significant at 1%), while the Northeastern region exhibits the strongest marginal impact at 0.325 (significant at 1%). These regional tests further validate e-commerce's promotive effect on urban-rural integration while revealing notable heterogeneity.

Excluding the Northeastern region with its smaller sample size, e-commerce's influence follows a gradient: Eastern > Central > Western. Conversely, the legacy effect of past integration displays an inverse pattern: Western > Central > Eastern. This divergence likely stems from the Western region's initially weaker integration baseline, where prior progress generates larger marginal returns, whereas the Eastern region's advanced developmental stage yields diminishing marginal effects from historical achievements. The Northeastern region's outlier status may reflect unique structural factors or policy interventions warranting separate investigation.

Table 7: Regression Results by Region

Variable	Model (9) Eastern region	Model (10) Central region	Model (11) Western region	Model (12) Northeastern region
L.Uri	0.540*** (0.131)	0.709*** (0.126)	0.814*** (0.051)	0.363*** (0.209)
Ecom	0.198*** (0.044)	0.178*** (0.063)	0.060*** (0.021)	0.325*** (0.090)
Control	YES	YES	YES	YES
AR(1)	0.000	0.000	0.000	0.000
AR(2)	0.527	0.112	0.520	0.537
Hansen test	0.143	0.115	0.926	0.458
Number of City	85	80	81	34

Notes: The p-values are in parentheses; *, **, *** represent significant at 10%, 5%, and 1% levels, respectively.

7.2 Time-Phased Regression Analysis

In 2018, China enacted the E-Commerce Law to further regulate market order, protect consumer rights, and strengthen intellectual property protection. This legislation systematically defined the legal obligations of e-commerce operators, improved consumer protection mechanisms, and enhanced intellectual property safeguards, thereby promoting sustainable and standardized development of the e-commerce industry. The implementation of the E-Commerce Law not only established a legal framework for orderly industry growth but also enhanced market fairness and consumer trust by standardizing e-commerce practices and increasing market transparency. To examine how e-commerce's impact on urban-rural integration evolved under stricter regulatory oversight after the law's enactment, this study divides the research period into two phases—2013-2017 and 2018-2022—for systematic comparison of pre- and post-law effects.

Table 8 presents the estimated effects of e-commerce on urban-rural integration during 2013-2017 and 2018-2022. The results show that AR(1) statistics for both periods (0.016 and 0.028) reject the null hypothesis, confirming first-order serial correlation between e-commerce and urban-rural integration, while AR(2) values (0.351 and 0.118) indicate no second-order serial correlation, satisfying the consistency requirements of GMM estimation. Hansen test results (0.339 and 0.115) exceed 0.1, validating the instrumental variable specifications. Model (13) demonstrates that during 2013-2017, the e-commerce coefficient was 0.321 (significant at 1%), indicating each 1% increase in e-commerce development raised urban-rural integration by 0.321 percentage points. Model (14) reveals that for 2018-2022, the coefficient increased to 0.617 (significant at 1%), translating to a 0.617-percentage-point boost per 1% e-commerce growth.

The regression outcomes clearly show that the E-Commerce Law's implementation amplified e-commerce's integrative effects, with the post-2018 coefficient nearly

doubling the pre-2018 value. This suggests that under government-led standardization and policy guidance, e-commerce development received more systematic governance and institutional support, significantly strengthening its role in bridging urban-rural divides. The enhanced regulatory environment appears to have unlocked greater synergies between digital commerce and regional integration by reducing market uncertainties, improving contract enforcement, and fostering consumer confidence in cross-regional transactions. These findings underscore how legal institutionalization can magnify the positive externalities of digital economic activities while mitigating their potential disruptive effects on traditional development pathways.

Table 8: Regression Results by Time Period

Variable	Model (13)	Model (14)
	Year2013-Year2017	Year2018-Year2022
Uri	0.321***	0.617***
	(0.057)	(0.067)
Gov	-0.403	0.079
	(0.296)	(0.078)
Fin	0.014	0.005
	(0.011)	(0.007)
Tec	0.020	0.011
	(0.014)	(0.012)
Iso1	-0.272	0.255**
	(0.752)	(0.123)
Iso2	-0.002	0.117
	(0.525)	(0.112)
Con	-0.155	-0.100***
	(0.104)	(0.020)
AR(1)	0.016	0.028
AR(2)	0.351	0.118
Hansen test	0.339	0.115

Notes: The p-values are in parentheses; *, **, *** represent significant at 10%, 5%, and 1% levels, respectively.

8. Further Discussion

The aforementioned research demonstrates that e-commerce development exerts a significant promotive effect on urban-rural integration, with robustness confirmed through regional and temporal heterogeneity analyses. To further investigate how e-commerce's impact varies across different developmental stages and conditional contexts, this study establishes four threshold variables: government intervention level (Gov), financial development level (Fin), scientific and technological advancement level (Tec), and market consumption level (Con). Employing a dynamic threshold model, we systematically analyze the differential effects of e-

commerce on urban-rural integration across varying intervals of these threshold variables.

8.1 Modeling

Following the methodological framework established by Kremer, Bick, and Nautz (Kremer et al.,2013), we formulate the following dynamic panel threshold regression model:

$$\mathrm{Uri}_{it} = \psi \mathrm{Uri}_{it-1} + \beta_1 \pi_{it} I(q_{it} \le \gamma) + \beta_2 \pi_{it} I(q_{it} > \gamma) + \phi_1' \mathrm{Ecom}_{it} + \phi_2' \mathrm{Control}_{it} + \epsilon_{it} \quad (8)$$

Where, $Uri_{i,t}$ represents the urban-rural integration index of city i in year t; $Uri_{i,t-1}$ is the one-period lagged dependent variable to capture dynamic effects; $Ecom_{i,t}$ denotes e-commerce development level of city i in year t; $Control_{i,t}$ is a vector of control variables; $\varepsilon_{i,t}$ is the random perturbation term; $\pi_{i,t}$ is threshold variable; The indicator function I(·) takes value 1 when $q_{it} \le \gamma$ (or $q_{it} > \gamma$), and 0 otherwise.

8.2 Model Specifications and Diagnostic Tests

The results of the dynamic threshold model are presented in Table 9. In the table, Ecom_below represents the e-commerce development level when below the threshold value; Ecom_above represents the e-commerce development level when above the threshold value; Gamma_Hat denotes the estimated threshold value of the threshold variable; SupW_p indicates the p-value corresponding to the SupWstar test, where a p-value smaller than conventional critical values (typically 1%, 5%, or 10%) suggests a statistically significant threshold effect; SupW_95%CI(Low) and SupW*_95%CI(Upper) represent the lower and upper bounds of the 95% confidence interval for the SupWstar test, respectively. A lower bound greater than 0 confirms that the threshold effect is both significant and non-zero.

8.3 Analysis of Model Results

The empirical results reveal distinct patterns of e-commerce's impact on urban-rural integration across different consumption contexts. In regions with lower consumption levels, where market potential remains underdeveloped, e-commerce's efficient transaction mechanisms rapidly elevate consumption capacity, thereby accelerating integration. These areas typically experience infrastructure deficiencies, and e-commerce's introduction effectively stimulates infrastructure upgrading, further propelling urban-rural convergence. Conversely, in high-consumption regions where market potential is largely saturated, e-commerce's marginal effect on consumption exhibits diminishing returns, consequently weakening its integrative impact.

Table 9 presents the dynamic threshold regression results. Model (15) identifies a government intervention threshold of 0.163, with the SupWstar test yielding 0.003 (below 0.05) and the confidence interval's lower bound exceeding zero, confirming threshold significance. E-commerce's coefficient measures 0.196 (significant at 1%) below the threshold versus 0.184 (significant at 1%) above it, indicating reduced effectiveness under heightened government intervention. This attenuation likely

stems from regulatory constraints that limit market autonomy and impair e-commerce's resource allocation efficiency (Trabelsi et al.,2024). Excessive fiscal subsidies may also foster corporate dependency, undermining competitive vitality and innovation capacity - factors detrimental to integration. Empirical analysis of 280 prefecture-level cities confirms that high-performing integration and e-commerce regions generally maintain government intervention below the threshold. Model (16) establishes a financial development threshold of 0.727 (SupWstar=0.001<0.05; CI lower bound>0). Coefficients increase from 0.184 to 0.195 (both significant at 1%) when crossing the threshold, reflecting financial development's catalytic role. Advanced financial systems enhance corporate financing capabilities, providing critical support for e-commerce innovation and market expansion. By lowering entrepreneurial capital barriers and improving fund accessibility, financial development accelerates e-commerce proliferation and interregional economic exchanges, thus driving integration.

Model (17) demonstrates a technology threshold of 0.166 (SupWstar=0.002<0.05; CI lower bound>0), with coefficients rising from 0.185 to 0.195 (both significant at 1%). This progression highlights how technological advancements - particularly in ICT, smart logistics, and digital payments - strengthen e-commerce's integrative capacity.

Model (18) reveals a consumption level threshold of 0.295 (SupWstar=0.047<0.05; CI lower bound>0), showing coefficient decline from 0.200 to 0.181 (both significant at 1%). In low-consumption regions, e-commerce unlocks latent demand through transactional efficiency while compensating for infrastructure gaps, whereas in mature markets, its marginal utility diminishes as consumption approaches saturation. This nonlinear pattern underscores the importance of contextual factors in shaping e-commerce's integrative effects.

Table 9: Dynamic Threshold Model Regression Results

Variable	Model (15)	Model (16)	Model (17)	Model (18)
	Threshold Variables:*Gov*	Threshold Variables:*Fin*	Threshold Variables:*Tec*	Threshold Variables:*Con*
L.Uri	0.561*** (0.037)	0.545*** (0.037)	0.551*** (0.036)	0.547*** (0.036)
Ecom_below	0.196*** (0.017)	0.184*** (0.017)	0.185*** (0.017)	0.200*** (0.017)
Ecom_above	0.184*** (0.017)	0.195*** (0.017)	0.195*** (0.017)	0.181*** (0.017)
Control	YES	YES	YES	YES
Gamma_Hat	0.163	0.727	0.166	0.295
*SupW*_p*	0.003	0.001	0.002	0.047
SupW 95%CI(Low)*	2.6251	3.5853	2.6740	0.1003
*SupW*_95%CI(Upper)*	12.5846	13.1821	11.4510	14.5971

Notes: The p-values are in parentheses; *, **, *** represent significant at 10%, 5%, and 1% levels, respectively.

9. Main Conclusions and Policies Recommendations

9.1 Main Conclusions

(1) Both urban-rural integration and e-commerce development levels across China's 280 prefecture-level cities demonstrated sustained upward trends. In 2013, the average urban-rural integration level stood at 0.4395 with an e-commerce level of 0.3225. By 2022, these figures had risen significantly to 0.5587 and 0.5925 respectively. The coefficient of variation for urban-rural integration decreased progressively from 0.1991 in 2013 to 0.1286 in 2022, while that for e-commerce development declined from 0.3543 to 0.1641 over the same period. These diminishing variations indicate a gradual reduction in regional disparities and more balanced development patterns across all 280 cities.

(2) The dynamic panel model yielded a coefficient of 0.190 for e-commerce's impact on urban-rural integration, statistically significant at the 1% level, confirming e-commerce's substantial positive effect. Dimensional analysis revealed uniformly significant positive coefficients (all at 1% significance) across economic (0.014), social (0.040), spatial (0.030), and ecological (0.079) integration domains. Regional heterogeneity analysis further demonstrated e-commerce's universally positive impacts (significant at 1% or 5% levels) in eastern, central, western, and northeastern regions, albeit with varying effect magnitudes.

(3) The dynamic threshold model identified significant threshold effects for government intervention, financial development, technological advancement, and market consumption levels. Key findings indicate: (i) government intervention requires optimal intensity to maximize e-commerce's integrative benefits; (ii) enhanced financial and technological development progressively strengthens e-commerce's positive impacts; and (iii) market saturation in high-consumption regions attenuates e-commerce's marginal contributions to integration. These nonlinear relationships underscore the importance of context-specific policy design.

9.2 Policies Recommendations

First, governments should refine intervention strategies to foster sustainable e-commerce development and urban-rural integration. Policymakers must strike a balance between regulation and market autonomy, avoiding excessive intervention that could distort healthy market dynamics. A well-designed regulatory framework should simultaneously ensure consumer protection and facilitate industry growth. In regions lagging in e-commerce adoption, tailored policies—such as tax incentives, targeted subsidies, and entrepreneurial funding—should be implemented to stimulate digital commerce and reduce regional disparities. These measures will accelerate cross-regional economic convergence while promoting inclusive growth.

Second, bridging the urban-rural digital divide requires substantial investment in rural digital infrastructure. Advanced technologies like 5G networks and IoT systems can significantly enhance data processing capabilities and network coverage in rural areas. These upgrades will enable smarter resource management

systems, dramatically improving agricultural productivity. Moreover, cutting-edge technologies may allow rural regions to leapfrog traditional developmental constraints, creating opportunities for technological "overtaking" relative to urban centers. Such progress will help narrow development gaps and foster deeper economic integration between urban and rural communities.

Third, financial innovation and technological advancement must be jointly promoted to achieve economic and technological integration. Governments should leverage fintech solutions—such as blockchain for transparent and secure rural financial flows, and big data analytics for precision credit assessment—to enhance the accessibility and efficiency of rural financial services. The synergy between financial inclusion and technological empowerment will spur e-commerce growth in rural areas, encouraging greater entrepreneurial participation among farmers. This approach can effectively address rural employment challenges and reduce urban-rural labor market disparities.

Finally, comprehensive household registration (hukou) reforms are essential to ensure equitable access to public services. While China has made progress in narrowing infrastructure gaps between urban and rural areas, institutional barriers tied to the hukou system persist. Rural migrants in cities often face restricted access to critical services—particularly healthcare and compulsory education—compared to their urban-registered counterparts. Given the vast population of rural-to-urban migrant workers, urgent reforms are needed to dismantle hukou-based service restrictions, guaranteeing equal public service rights for all residents. This institutional change will be pivotal in achieving genuine urban-rural integration.

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