The Impact Study of E-commerce on the Regional Economic Development of Shandong Province

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Abstract. In 2022, the Shandong Provincial Department of Commerce actively implemented the digital economy's "key breakthrough" action plan and adopted multiple measures to promote the high-quality development of e-commerce across the province, injecting strong impetus into the regional economic growth, gradually becoming a powerful driving force for the economic development of the province. This paper analyzes the current status of e-commerce development in Shandong Province, employs econometric models to conduct empirical research on the relationship between e-commerce development and economic growth. Finally, corresponding strategies for e-commerce development are proposed.

Keywords: E-commerce; Regional economy; Factor analysis; Regression analysis

1 Introduction

Over the past decade, e-commerce has experienced rapid development in Shandong Province, with its impact on economic life continuously increasing, gradually becoming the primary driving force behind the economic development of the province [1]. Therefore, conducting research on the impact of e-commerce on regional economic development is of utmost importance [2]. This research not only contributes to a comprehensive understanding of the development of e-commerce in Shandong Province but also provides scientific and effective theoretical foundations and feasible decision-making recommendations for the strategic development of the province [3].

2 Current Status of E-commerce Development in Shandong Province

2.1 Regional Imbalance in Development

In 2022, the online retail sales in Shandong Province showed astonishing growth momentum, with a high growth rate of 22.7% [4]. However, at the same time, the

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development among different cities within the province exhibited obvious imbalances [5].

The top three cities in terms of e-commerce sales in Shandong Province were Qingdao, Jinan, and Dongying [6]. Among them, the e-commerce sales in Qingdao reached 602.72 billion yuan, accounting for 35.15% of the total e-commerce sales in the province. Qingdao has consistently held the top position in e-commerce sales for five consecutive years, while cities such as Zaozhuang, Jining, and Tai'an have remained at the bottom for the same period, with their shares of total e-commerce sales in the province not exceeding 1% [7]. This indicates that the development of e-commerce in different regions of Shandong Province remains unbalanced.

2.2 Rapid Growth in E-commerce Transaction Volume

According to statistics, the total e-commerce transaction volume in Shandong Province reached 1.7 trillion yuan in 2022, representing a growth rate of over 30% compared to the previous year [8]. Overall, the development of the e-commerce market showed a favorable trend [9]. The B2B transaction volume reached 1.5 trillion yuan, registering a substantial increase of 28.6% compared to the same period last year, while the B2C transaction volume reached 1.2 trillion yuan [10], showing a year-on-year growth of 32.8%. Furthermore, with the continuous evolution of consumer online shopping habits, the cross-border e-commerce market in Shandong Province is also expanding. According to statistics, the cross-border e-commerce transaction volume in the province exceeded 100 billion yuan in 2022, representing a year-on-year increase of over 50%.

3 Empirical Analysis of the Impact of E-commerce Development on Regional Economic Development in Shandong Province

3.1 Setting the Basic Model Framework

This study is based on the C-D production function and incorporates E-commerce into the production function model, resulting in an improved production function model. The model variation investigated in this study is as follows:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} E_t^{\lambda} \tag{1}$$

E represents the level of E-commerce development; λ, α, and β are the elasticity coefficients of output.

In addition to capital, labor input, and the level of E-commerce development, there are other factors that influence regional economic growth in Shandong Province. To comprehensively understand the impacts of various factors on regional economic growth and the magnitude of E-commerce's influence on regional economic development, this study employs total factor productivity analysis, which takes into account

factors such as technological progress and transportation capacity. The total factor productivity (A_t) in the production function is defined as follows:

$$A_t = A\exp(\varphi Tran_t + \theta \ln Tech_t + \varepsilon_t) \tag{2}$$

where $Tran_t$ and $\ln Tech_t$ are used to measure the transportation capacity and technological progress (logged) for year t, respectively; ert represents the random disturbance term. Substituting Equation (2) into Equation (1) and taking the logarithm on both sides, we obtain:

$$\ln Y_t = \alpha \ln K_t + \beta \ln L_t + \lambda E_t + \varphi Tran_t + \theta \ln Tech_t + \varepsilon_t \tag{3}$$

3.2 Data Sources

The actual output Y for the years 2013 to 2021 can be directly obtained from the National Bureau of Statistics' published data on per capita real GDP. Human capital L, as a critical production factor, is measured using the number of regular higher education students per ten thousand people in Shandong Province.

Collecting the above-indicated data and consolidating the various indicators, the final dataset is summarized in Table 1 below.

Table 1. Summary of Indicator Data

Year	Per Capita Real GDP (in ten thousand yuan)	Number of Regular Higher Education Students per Ten Thousand People	Number of R&D Personnel	R&D Expenditure (in billion yuan)	Road Length per Ten Thousand People (kilometers/ten thousand people)	Capital Investment Quantity
2013	4.87	174.28	227403	1052.8097	16.28	3.77
2014	5.19	183.18	227403	1175.5482	16.64	4.33
2015	5.62	192.64	241395	1291.7718	16.97	4.89
2016	5.92	200.12	241761	1415.0035	16.92	5.34
2017	6.3	200.87	239170	1563.6785	17.23	5.50
2018	6.63	202.51	236515	1418.4975	17.82	5.70
2019	6.99	216.10	198205	1210.9485	18.21	5.20
2020	7.18	225.42	255281	1365.6187	19.08	5.36
2021	8.17	238.92	349379	1565.3402	19.37	5.45

Data Source: Shandong Provincial Statistical Yearbooks 2014 to 2022

3.3 Empirical Analysis Process and Results

Ridge Regression Estimation.

In SPSSAU, the range of k is set to [0, 1], with a step size of 0.20, and the resulting ridge trace plot is shown in Figure 1:

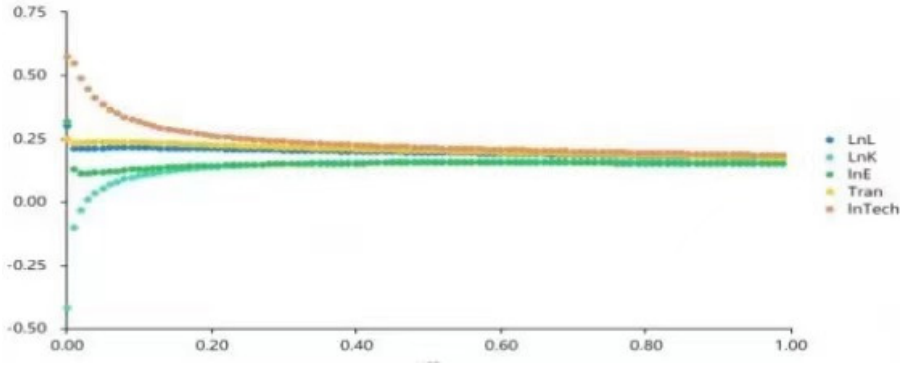

Fig. 1. Ridge Trace Plot

When the value of k reaches 0.25, all five ridge traces begin to stabilize. which meets the required conditions.

To ascertain whether the model and individual variable coefficients are significant when k equals 0.25, ridge regression is conducted again in SPSSAU with k=0.25, and the results are presented in Table 2 below:

Table 2. Model Summary

Sample Size	R^2	Adjusted R^2	Root Mean Square Error (RMSE)
9	0.986	0.964	0.018

As shown in Table 2, ridge regression analysis was conducted for the five independent variables LnK, LnL, lnE, Tran, LnTech, and the dependent variable LnY. The results indicate that when k is set to 0.250, the value of R-squared (R^2) is 0.986. This implies that the five independent variables in the econometric model developed in this study can explain 98.64% of the variation in the dependent variable LnY, demonstrating the appropriateness of the econometric model proposed in this research.

Table 3. ANOVA Test

	Sum of Squares	df	Mean Square	F	p-value
Regression	0.215	5	0.043	43.402	0.005
Residual	0.003	3	0.001		
Total	0.218	8			

Using ridge regression ANOVA test (also known as F-test), the overall significance of the model can be evaluated. The F-test results show that the model has passed the F-test (F=43.402, p=0.005<0.05) as shown in Table 3, indicating that the conclusions drawn from the empirical model constructed in this paper are reliable and stable. This implies that at least one of the variables, LnK, LnL, lnE, Tran, and LnTech, has a significant relationship with LnY.

Table 4. Ridge Regression Analysis Results

	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Standard Error	Beta		
Constant	-4.054	0.582	-	-6.961	0.006**
LnL	0.345	0.062	0.207	5.568	0.011*
LnK	0.133	0.029	0.145	4.577	0.020*
lnE	0.019	0.006	0.147	3.209	0.049*
Tran	0.034	0.008	0.220	4.242	0.024*
lnTech	0.161	0.026	0.249	6.217	0.008**
R^2	0.986				
Adjusted R^2	0.964				
F	F (5,3)=43.402,p =0.005				
Dependent Variable：LnY					
* p<0.05 ** p<0.01					

From Table 4, when conducting ridge regression analysis with LnK, LnL, lnE, Tran, LnTech as independent variables and LnY as the dependent variable, and setting k=0.250, the model shows an R-squared value of 0.986, indicating that LnK, LnL, lnE, Tran, and LnTech can explain 98.64% of the variation in LnY.

After comprehensive analysis, it is found that LnL, LnK, lnE, Tran, and lnTech all have significant positive relationships with LnY.

3.4 Empirical Results Analysis

The regression model indicates that during the period from 2013 to 2021, for every 1% increase in the Electronic Commerce Index (ECI) in Shandong Province, there is a corresponding 0.019% increase in GDP growth. Similarly, a 1% increase in labor input leads to a 0.345% increase in GDP growth, a 1% increase in capital input results in a 0.133% increase in GDP growth, and a 1% increase in technological progress contributes to a 0.161% increase in GDP growth. The empirical research reveals that the development of electronic commerce has a positive impact on the regional economic growth in Shandong Province.

4 Conclusion and Policy Recommendations

4.1 Research Conclusion

The empirical research results demonstrate that the development of electronic commerce in Shandong Province has a positive and stimulating effect on regional economic growth. Therefore, emphasizing the study of the impact of electronic commerce development on the regional economy in Shandong Province is beneficial for deepening and expanding the research on the role of electronic commerce in the region's economic development.

4.2 Policy Recommendations

Strengthen Talent Development.

In the field of e-commerce, having a specialized and highly skilled workforce is crucial. Especially in areas where e-commerce development is relatively lagging, such as Zaozhuang, Jining, and Tai'an, the provincial government should encourage college students to return to their hometowns and participate in rural development, thus mitigating the imbalanced regional development.

Enhance Network Infrastructure Construction.

Enhance the construction of network infrastructure in cities with relatively slow development within the province, particularly in rural areas, to improve the penetration rate of mobile phones and the number of internet broadband access ports .

Boost Transportation Infrastructure Construction.

In regions where transportation infrastructure is relatively backward within the province, there is a need to strengthen the construction of transportation infrastructure to maximize the impact of electronic commerce development.

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