

Analysis of Spatial Spillover Effects of Logistics Agglomeration on Rural Consumption

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Abstract. With the rapid development of China's logistics industry, the relationship between logistics agglomeration and regional economic development has gradually become a research hotspot. Based on provincial panel data from 2011 to 2020, this article constructs a spatial econometric model to empirically test the impact of logistics agglomeration on rural consumption and its spatial spillover effects. The results show that there is a strong spatial correlation in rural consumption; logistics agglomeration has a significant positive effect on rural consumption growth, while it also has a negative spatial spillover effect on rural consumption; the level of fiscal support for agriculture, the level of economic openness, and the autonomy of government behavior have a positive impact on rural consumption, while the level of rural economic development and per capita education support have a negative impact on rural consumption.

Keywords: Logistics agglomeration, Rural consumption, Spatial Durbin model, Moran's I.

1. Background and Literature Review

1.1. Background

In recent years, China has entered a new stage of economic development, with international trade as a major pillar of economic growth, but it has been showing signs of sluggishness. At the same time, the domestic consumption market is also weak, and China's economic development has entered a challenging stage. Developing rural consumption is a key area to facilitate the domestic circulation and construct the new development pattern with domestic circulation as the mainstay. Promoting rural consumption [1] is a breakthrough for expanding domestic demand and an important way to promote rural revitalization. Moreover, the rural market contains huge consumption potential and has room for market development and expansion.

Meanwhile, since the reform and opening up, with the rapid development of China's logistics industry, logistics industry [2] as will be the basic, pioneering and war path industry of economic development, logistics industry has rapidly become a pillar industry supporting agriculture, unblocking the countryside and serving farmers, under the guidance of the new development concept, the pace of logistics industry agglomeration has accelerated, the level of agglomeration development has been continuously improved, and the effect of improving quality and efficiency has been remarkable. This is of great significance for promoting sustainable rural development and helping rural revitalization. Based on this, this paper constructs a spatial econometric model to study the impact of logistics industry agglomeration on rural consumption.

The logistics industry is essential for ensuring the supply of goods and services in society, and logistics agglomeration refers to the spatial concentration of logistics-related activities in a particular area [3]. With the continuous development of China's economy, scholars have begun to study industrial agglomeration. Pan Kang, He Feng, and Liu Rong [4] studied the impact of high-tech industry agglomeration on export products, and Yuan Gecheng, Pan Min, and Qin Fengqin [5] studied the impact of digital industry agglomeration on technological innovation in manufacturing enterprises.

Rural consumption refers to the consumption of agricultural production materials and rural residents' living materials. With the development of society, it is known that rural areas are indeed a vast market that needs to be explored in every possible way. Therefore, studying rural consumption is essential. Tang Can [6] studied rural consumption in various countries, and Lu Qi [7] studied rural consumption in various provinces.

Regarding the impact of logistics agglomeration on rural consumption, Fan Fangzhi and Peng Tiantian [8] studied the impact of digital inclusive finance on rural consumption, and Wen Ting, Zhang Fan, and Zhang Xiaoxue [9] studied the impact of logistics agglomeration on new urbanization. However, there are few studies on whether rural consumption exhibits spatial correlation and the impact of logistics agglomeration on rural consumption. Based on this, we use data from 2011 to 2020 and utilize spatial econometric models to analyze the impact of logistics agglomeration on rural consumption.

2. Research Design and Data Description

2.1. Construction of Spatial Weight Matrix

Professor Waldo Tobler proposed the first law of geography, which states that things are not isolated and are related to each other [10]. The primary task of spatial econometrics is to establish a spatial weight matrix to measure the spatial correlation of economic variables. In this study, a reverse distance spatial weight matrix is constructed, which refers to the Euclidean distance between two regions calculated based on their spatial geographical coordinates [11]. Generally, it is calculated based on the centroid coordinates of the regions. The specific expression is as follows:

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \quad (1)$$

$$W = \frac{1}{d_{ij}} \quad (2)$$

Here, W represents the reverse distance spatial weight matrix, and d_{ij} represents the Euclidean distance between two regions.

2.2. Construction of Spatial Econometric Model

Taking into account the influence of spatial factors, a spatial econometric model is constructed to explore the impact of logistics agglomeration on rural consumption [10]. The specific model is as follows:

$$Y = \rho W Y + X \beta + \theta W X + \mu \quad (3)$$

$$\mu = \lambda W \mu + \varepsilon, \varepsilon \sim N[0, \sigma^2 I] \quad (4)$$

Here, Y represents the dependent variable, X represents all the independent variables, W represents an $n \times n$ dimension reverse distance spatial weight matrix, β represents the coefficient of X , ρ and θ represent spatial correlation coefficients, λ represents spatial error coefficient, μ and ε represent random errors, and ε follows a normal distribution. When $\rho \neq 0$, $\theta = 0$, and $\lambda = 0$, the model is consistent with spatial autoregressive model (SAR). When $\rho = 0$, $\theta = 0$, and $\lambda \neq 0$, the model is consistent with spatial error model (SEM). When $\rho \neq 0$, $\theta \neq 0$, and $\lambda = 0$, the model is consistent with spatial Durbin model (SDM). Then, the model form is selected based on the test and significance results.

2.3. Variable Description

① Dependent variable. Rural consumption (Rur): This indicator measures the proportion of total rural resident consumption expenditure to the current GDP, using the rural resident consumption rate of each province. Considering the availability of data on rural residents' total consumption expenditure, we refer to relevant literature [12] and express rural residents' total consumption expenditure as the product of per capita consumption expenditure and the number of permanent residents in rural areas.

② Core explanatory variable. Logistics industry agglomeration (log): There are many methods for measuring industry agglomeration. We refer to relevant literature [13] and choose location quotient (LQ_i) to measure the degree of regional agglomeration of the logistics industry in China. Location quotient is an important indicator for measuring industry specialization, and it can be used to compare the degree of agglomeration of the logistics industry in different regions, thereby determining the position of the logistics industry agglomeration in the country. The calculation formula is as follows:

$$LQ_i = \frac{e_i/e}{E_i/E} \quad (5)$$

In the formula, e_i represents the number of employees engaged in the logistics industry in region i , e represents the number of employees engaged in all industries in region i , E_i represents the number of employees engaged in the logistics industry nationwide, and E represents the number of employees engaged in all industries nationwide [14]. Furthermore, there is no "logistics industry" in the industry classification system. However, since it can be found from the statistics of the added value of China's logistics industry in various years that transportation, warehousing, and postal industries account for more than 80% of the total added value of the logistics industry, they can basically represent the development of China's logistics industry. Therefore, this paper defines the transportation, warehousing, and postal industries as the logistics industry.

③ as for the control variables, the level of financial support for agriculture and rural areas (afw) is measured by local expenditures on agricultural, forestry, and water affairs. The level of rural economic development (edr) is measured by the per capita agricultural output value of each province to reflect the level of rural economic development in each province. The level of economic openness (eop) is represented by the ratio of imports and exports to regional GDP in each province. The autonomy of government behavior (aga) is measured by the proportion of fiscal expenditure to GDP in a given year. The level of education support per capita (edu) is measured by the proportion of local education expenditures to the permanent population in a given area.

2.4. Data sources

Due to incomplete data in some years for Tibet, this paper selects panel data from 30 other provinces in mainland China from 2011 to 2020. The sample data comes from the CSMAR database, the "China Rural Statistical Yearbook," "China Statistical Yearbook," "China Population and Employment Statistics Yearbook," as well as the statistical yearbooks of various provinces. Some missing data is handled using interpolation.

3. Empirical Analysis

3.1. Spatial Correlation Analysis

3.1.1. Global Moran's I

In this paper, we use the Global Moran's I to test the spatial autocorrelation of rural resident consumption rates in 30 provinces, municipalities, and autonomous regions in mainland China from 2011 to 2020. The value range of the Global Moran's I is $[-1, 1]$, with positive values indicating

positive spatial correlation and negative values indicating negative spatial correlation. From table 1, it can be seen that from 2011 to 2020, the Moran's I index of the consumption rate of rural residents, although fluctuating, is positive and passes the significance test, indicating that the consumption rate of rural residents has obvious characteristics of positive spatial correlation and the spatial dependence is relatively stable. Therefore, the spatial correlation effect is significant on the whole, and the choice of spatial econometric model is appropriate.

Table 1. Global Moran's I of rural residents' consumption rate

Year	Moran's I	Z	P
2011	0.092	3.443	0.000
2012	0.085	3.234	0.001
2013	0.080	3.097	0.001
2014	0.082	3.132	0.001
2015	0.075	2.935	0.002
2016	0.066	2.699	0.003
2017	0.064	2.669	0.004
2018	0.066	2.734	0.003
2019	0.041	2.073	0.019
2020	0.050	2.288	0.011

3.1.2. Local Moran's I

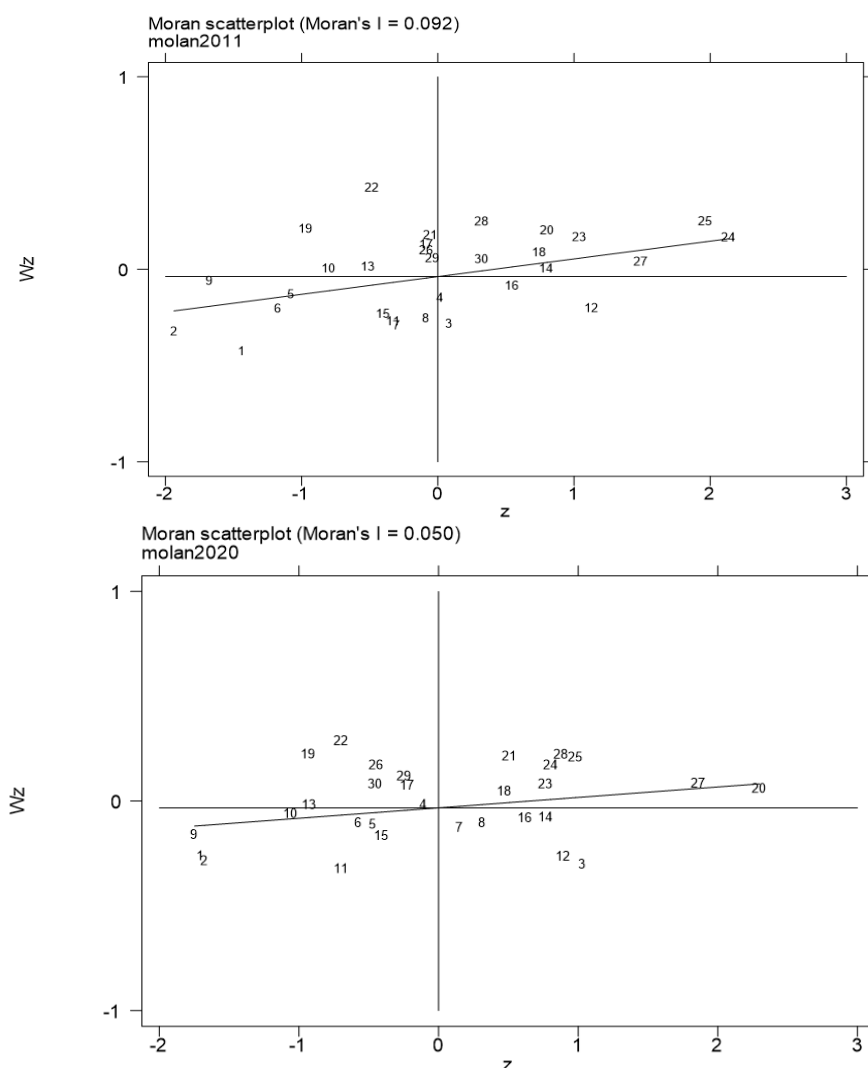


Figure 1. Local Moran's Maps of Rural Resident Consumption Rate in 2011 and 2020

This paper uses Local Moran's I to examine the spatial correlation of a specific area, and draws a Local Moran's plot of rural resident consumption rate. Due to space limitations, only the results of 2011 and 2020 are reported in this paper. In the plot, numbers 1 to 30 represent the 30 provinces, municipalities, and autonomous regions of China.

Based on Fig.1, the points corresponding to the Moran's index of rural resident consumption rate between provinces are mostly distributed in the first and third quadrants, indicating a trend of high-high and low-low in local space between provinces, consistent with the results of the global Moran's index test. From the local Moran's map of 2011-2020, it can be observed that the number of provinces falling into the first and third quadrants has increased, reflecting an increase in the degree of correlation of rural resident consumption rate in local areas. Therefore, the significant positive spatial correlation features suggest the consideration of spatial factors in choosing spatial econometric models.

3.2. Regression Results

As previously stated, rural household consumption has significant spatial correlation. Therefore, a spatial econometric model is established to more accurately measure the impact of logistics agglomeration on rural consumption.

The first step is to conduct an LM test. By testing the spatial correlation of the ordinary static panel regression, we can determine the type of spatial effect and model selection.

Table 2. LM Test

test	LM	P
LM-Lag test	36.236	0.000
Robust LM-Lag test	14.060	0.000
LM-Error test	22.264	0.000
Robust LM-Error check	0.089	0.765

According to table 2, the LM-Lag, robust LM-Lag, and LM-Error reject the null hypothesis H_0 , while the robust LM-Error fails to reject the null hypothesis H_0 .

In the second step, model comparison was conducted based on the LM test results, and SAR and SDM models were constructed. Due to space limitations, only partial regression results are reported. Based on the results of the Hausman test, the model selection was determined to have a random effect.

In the third step, the LR test was performed on the spatial Durbin random effect model to verify that the spatial Durbin model does not degenerate into a spatial autoregressive model or a spatial error model.

In summary, this study selects the spatial Durbin random effects model to explore the impact of logistics industry agglomeration on rural consumption.

Table 3. Model Regression Results

Rur	SDM
log	0.001*** (0.000)
afw	0.002** (0.001)
edr	-0.026*** (0.004)
eop	0.011(0.008)
aga	0.025*** (0.006)
edu	-0.058*** (0.005)
Wx	-0.001*** (0.000)
rho	0.499*** (0.109)
lgt_theta	-1.689*** (0.175)
sigma2_e	0.000*** (0.000)

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

According to the results of the SDM model in table 3, the coefficient of regional agglomeration degree of the logistics industry is a positive value and passes the hypothesis test at the 1% significance level, indicating that the higher the regional agglomeration degree of the logistics industry in this province, the higher the rural consumption level will be.

As shown in table 4, both the direct and indirect effects of logistics industry agglomeration have passed the significance test, indicating that the logistics industry agglomeration in this province has a positive promoting effect on the rural consumption level, while also causing negative spatial spillover effects on rural consumption. Ignoring the interaction effects of spatial factors would lead to an underestimated effect of logistics industry agglomeration on rural consumption, thus proving the choice of spatial econometric model to be reasonable.

Among the control variables, the three effects of fiscal support for agriculture, economic openness, and government autonomy are all positive. The effects of fiscal support for agriculture and government autonomy have passed the significance test, indicating that the overall improvement of fiscal support for agriculture, economic openness, and government autonomy may increase the purchasing power of rural residents, improve the rural consumption environment, and stimulate their consumption growth. The overall economic development level of rural areas and the per capita educational support level have a negative effect on the rural consumption rate, which may be due to the promotion of the economic development level and per capita education support level of rural areas increasing the income and education level of rural residents, making their consumption more rational, with more income used for financial management and savings, thus leading to a decrease in the rural consumption rate.

Table 4. Decomposition of Spatial Effects

Variable	LR_Direct	LR_Indirect	LR_Total
log	0.001*** (0.000)	-0.001** (0.000)	0.000(0.000)
afw	0.002*** (0.001)	0.013*** (0.004)	0.015*** (0.004)
edr	-0.026*** (0.003)	0.014(0.022)	-0.012(0.022)
eop	0.008(0.008)	-0.093(0.070)	-0.085(0.071)
aga	0.024*** (0.005)	-0.039(0.051)	-0.015(0.051)
edu	-0.059*** (0.005)	-0.051(0.052)	-0.110** (0.053)

3.3. Robustness tests

To ensure the robustness of the results, we conducted several tests by changing spatial weight matrices, running regressions without using spatial econometric models, and analyzing only a subset of the data. The results are presented in Table 5 as follows:

Table 5. Robustness Checks

Rur	Economic distance nested matrix	OLS	2013-2020
log	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
afw	0.002** (0.001)	0.001(0.001)	0.002** (0.001)
edr	-0.027*** (0.004)	-0.026*** (0.004)	-0.027*** (0.004)
eop	0.010(0.008)	0.005(0.007)	0.016(0.010)
aga	0.024*** (0.006)	0.023*** (0.005)	0.021*** (0.007)
edu	-0.057*** (0.005)	-0.061*** (0.005)	-0.062*** (0.007)
Wx	-0.001*** (0.000)		-0.001*** (0.000)
rho	0.519*** (0.115)		0.536*** (0.114)
lgt_theta	-1.659*** (0.176)		-1.731*** (0.185)
sigma2_e	0.000*** (0.000)		0.000*** (0.000)
Id		Yes	
Year		Yes	

The comparison between the results in table 3 and table 5 shows that the signs and significance of the coefficients have not changed significantly, indicating that the results are robust.

4. Research Findings and Implications

Rural markets contain tremendous consumption potential and have room for market development and expansion. As a foundational, leading, and strategic industry for socio-economic development, the logistics industry can promote rural sustainable development and contribute to rural revitalization. This can help to increase the consumption level of rural residents [15]. Based on this, this paper systematically studied the impact of logistics industry agglomeration on rural consumption and spatial spillover effects in theory, and empirically tested it using panel data from 30 provincial-level regions in China from 2011 to 2020, constructing a spatial Durbin's random effects model.

The research results show that logistics industry agglomeration can significantly promote the increase in rural residents' consumption level, while logistics industry agglomeration can have a negative spatial spillover effect on rural consumption. Moreover, each province has a strong positive effect on local spatial promotion. Among them, the control variables of financial support for agriculture, level of economic openness, and government autonomy all have positive effects, which may be due to the increase in financial support for agriculture, level of economic openness, and government autonomy, which would increase the purchasing power of rural residents, improve the rural consumption environment, and stimulate consumption growth. The level of rural economic development and per capita educational support have negative effects, which may be because rural residents have become more rational in their consumption, with more income being used for financial management and savings, leading to a decrease in the rural residents' consumption rate.

Based on the research findings of this paper, the following policy implications can be drawn: First, promote the development of logistics industry agglomeration. Logistics industry agglomeration plays an important role in promoting the increase in rural residents' consumption level. It is necessary to accelerate the construction of the logistics industry in rural areas and maximize the role of logistics industry development. Second, reduce government intervention in the development of the logistics industry, gradually relax the control of railway transportation, aviation transportation, express delivery, and other industries, promote the development of logistics industry agglomeration, and positively impact the increase in rural residents' consumption level. Third, stimulate rural consumption goals through multiple channels of logistics industry agglomeration. Based on the promotion effect of logistics industry agglomeration on rural consumption, continue to promote the improvement and development of logistics industry in rural areas and contribute to the growth of rural consumption. Fourth, develop the logistics industry according to local conditions. Improve the regulatory system for logistics industry development in economically developed areas; strengthen cooperation and exchange between medium and economically developed areas, form a virtuous competition, and achieve win-win results; increase investment in financial infrastructure in economically underdeveloped areas to support and assist the development of their logistics industry.

Regarding the shortcomings of this paper's research and how related research can be developed in the future, the limitation is due to the availability of data, resulting in the use of fewer years, and the study of the impact of provincial-level logistics industry agglomeration on rural consumption without ascending to the prefecture-level cities and counties. In future related research, transportation and logistics high-quality development should be considered in terms of their impact on rural consumption, and further analysis can be conducted on how the development of the logistics industry can promote rural economic flow and consumption.

References

- [1] Wang Fang, Hu Lijun. The Impact of Urbanization on Rural Residents' Consumption in China and the Path of Transmission: Empirical Analysis Based on the Multiple Mediating Effects of Income Effect and Income Gap. *Macroeconomic Research*, 2022 (09): 64 - 77.
- [2] Yan Caozheng, Yin Lujiang, He Bo. Logistics Industry Agglomeration, Spatial Spillover Effects, and Green Total Factor Productivity of Agriculture: An Empirical Analysis Based on Provincial Data in China. *China Commerce*, 2022, 36 (09): 3 - 16.

- [3] Chen Xiaoyue. Analysis of Influencing Factors of Logistics Industry Agglomeration: Empirical Analysis Based on Provincial Panel Data. *Journal of Guangdong Communication Polytechnic*, 2012, 11 (03): 76 - 79.
- [4] Pan Kang, He Feng, Liu Rong. Has the Agglomeration of High-Tech Industries Promoted the Upgrading of Exported Products? An Analysis Based on the Perspectives of Technological Innovation and Opening-up. *Journal of Beijing Technology and Business University (Social Science)*, 2023, 38 (02): 28 - 39.
- [5] Yuan Gecheng, Pan Min, Qin Fengqin. Agglomeration of Digital Industry and Technological Innovation of Manufacturing Enterprises. *Journal of Zhongnan University of Economics and Law*, 2023 (01): 146 - 160.
- [6] Tang Can. A Comparative Study on the Legal Mechanisms of Promoting Rural Consumer Credit in China and Abroad. *Southwest University of Political Science and Law*, 2013.
- [7] Lu Qi. Empirical Study on the Influencing Factors of Rural Consumer Behavior in China. *Macroeconomic Research*, 2022 (01): 115 - 129.
- [8] Fan Fangzhi, Peng Tiantian. The Impact of Digital Inclusive Finance on Rural Residents' Consumption in China. *Social Science Front*, 2023 (01): 82 - 91.
- [9] Wen Ting, Zhang Fan, Zhang Xiaoxue. The Impact of Logistics Industry Agglomeration in the Yangtze River Economic Belt on New Urbanization. *Statistics and Decision*, 2021, 37 (20): 62 - 66.
- [10] Li Cuimei, Zhou Ying. The Impact of Digital Inclusive Finance on Rural Consumption: Based on Spatial Econometric Model. *Economic Geography*, 2021, 41 (12): 177 - 186.
- [11] Guo Li, Zou Mengyao. Study on the Factors Influencing Carbon Emission Intensity from the Perspective of Spatial Spillover. *Ecological Economy*, 2020, 36 (09): 32 - 37.
- [12] Wang Cuiqin, Li Lin, Xue Huiyuan. The Impact of Population Age Structure and Basic Pension Insurance for Urban and Rural Residents on the Consumption Rate of Rural Residents: Empirical Analysis Based on Provincial Panel Data of China from 2010 to 2017. *Social Security Research*, 2020(3):85-93.
- [13] Zhong Zuchang. Logistics Industry Agglomeration and Influencing Factors from the Perspective of Spatial Economics: Empirical Evidence from 31 Provinces and Cities in China. *Journal of Shanxi University of Finance and Economics*, 2011, 33 (11): 55 - 62.
- [14] Gao Pumei, Zhan Jun. Logistics Industry Agglomeration and Industrial Structural Transformation in the Yangtze River Delta: An Analysis Based on Grey Correlation Analysis. *Resource Development and Market*, 2019, 35 (02): 149 - 155.
- [15] Zhu Fangming, CAI Pengzhen. How does supply-side structural Reform improve the quality of manufacturing supply? [J]. *Shanghai Economic Research*, 2022 (03): 63 - 76.