An Applied Research on the Relations between Regional Economic Growth and Regional Logistics in China[1]

Yang Shao[2]
Jian-guo Zheng[3]

With the rapid development of regional logistics and regional economy in China, the relationship between regional logistics and regional economy has become a research focus in the logistics-related field. We use the regional logistics and economical data in 30 provinces of China, exercise C-D production function, construct the spatial panel autocorrelation model and the spatial econometric model, finally confirm the spatial correlativity between regional economic growth and regional logistics. By using the spatial package of Matlab software, we identify there is the remarkable spatial quantitative autocorrelation of the Chinese regional economic growth and regional logistics.

Key words: *regional economic growth, regional logistics, spatial panel autocorrelation*

JEL classification: *C31, C52, C53.*

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[2]**Yang SHAO**, Management College, Donghua University, School of Economics and Management, Changchun University of Science and Technology, China, shaoyangliangliang@yahoo.com.cn.

[3]**Jian-guo ZHENG**, School of Economics and Management, Changchun University of Science and Technology, China.

Introduction

Modern economic growth depends strongly on logistics. Logistics has become one of the most important factors to promote economic growth, adjust industrial layout and drive the evolution of economic spatial structure.

In the developed countries, such as Europe, North America and Japan the logistics researches pay main attention to the logistics in the micro-enterprise level, dedicating to providing the overall optimal strategy for enterprises. There are few researches on the macro-level logistics systems and the relationship between economic growth and logistics.

In the regional integration, the return flow effect and the diffusion effect of modern logistics promote the company's external scale economy to form regional industrial cluster, accelerate the expansion of the regional labour market, technology spillovers, and industrial innovation. In the structure, impetus and adaptability, the regional logistics development has complicated dynamic characteristics. Regional logistics network is increasingly complicated, the customer demand and continuous environment changes enhance the difficulty of conformity of the regional logistics integration (Pardmore, 2001). The regional logistics integration and infrastructure network have made significant contributions to the regional integration when the integration process is analyzed in the Latin American (Melendez O, 2002). The regional economic integration is not only promoted by the government but also strengthened to allocate the production factors on the capabilities of market mechanisms, …to promote the regional industry and market integration, nurture and develop common market (Leonard, 2003). The regional logistics capability is the strategic competitiveness of industry cluster and its industrial supply chain(Cjesing, 2001).

In China the logistics literatures focused more on the macro and regional logistics.

The relationship between logistics and economic growth

Qing-Mei Tan, Zi-Long Wang (2005) introduce the concept of logistics equivalent which comprehensively reflect the regional logistics capability and Logistic model to analyze the contribution rate of the logistics to economic growth, with the two items, the freight turnover and the passenger turnover. After analyzing the contribution of Jiangsu Province's logistics capabilities to economic growth, the contribution rate of logistics capabilities to GDP growth is 36.77% in Jiangsu province. Jun Zhou (2006) exercises the marginal methods and flexible economic methods to quantify the regional economic growth with the development of regional logistics industry on the Logistic model in Tianjin city. Shi-ping Cheng (2006), Lu-ning Ruanl (2006), Ren-gui Peng (2007) respectively establish the growth mode of the cargo turnover to GDP to analyze the contribution rate of logistics to economic growth for the Anhui, Jiangxi, and Yangtze River Delta. Zi-Long Wang (2004) regards the goods turnover as a reflection of the regional comprehensive logistics capability, studies the relationship between the investment and logistics capabilities. There are other similar analysis on some provinces and cities, such as Henan, Heilongjiang province. Wen-jie Zhang (2002) exercises the economics and the trade theory to analyze the relationship between economy and logistics, finally derives that the relationship of economy and logistics represent the economic globalization, the regional economic integration, the pursuit of profit and core competence in the regional enterprise, and the status quo of Chinese economic development promoting the development of Chinese modern logistics; at the same time the development of modern logistics has changed the economic growth pattern, promoted the formation of new industrial forms, optimized regional industrial structure, promoted the formation and development of " the cities as the center" regional markets. Qun Zhang (2005) divides the stages of logistics development according to the stages of economic development, and derives the different stages of logistics development have different characteristics, the promotion of logistics to economic growth is also different, and should adopt the different logistics development strategies in the different stages of economic development. Zhao-lei Li (2007) puts forward the evaluation system of regional logistics adaptability from the point of view the matching between the regional logistics and the regional economy, marks out or improves the regional logistics system to fit the regional logistics structure, the service level, the legal policy, the infrastructure, the information network, the personnel quality. Zi-Long Wang (2007) considers that the construction and optimization of regional logistics network system can save transaction costs, and promote the formation of scale regional economy and gathering economy, and establishes the evaluation index system of logistics network to analyze comparatively the major nodes of logistics network in Jiangsu. Song-dong Ju, Yoon-song Lee, Jie Xu (2003) analyze comparatively the total logistics with the cross-sectional data, the logistics policy and system, the investment, the human resources, the logistics enterprise, the logistics technology and facilities, the management level in the western China and so on, derive that western logistics did not promote the western regional economic growth. Wen-shun Li (2004) exercises the co-integration and error correction model to anlyze the long-term and dynamic relationship between GDP augmentation and logistics augmentation from 1952 to 2002 in China, derives that there is the reliable co-integration relationship and the positive correlation each other, and selects the variable, the freight turnover, as the target of logistics level. Rui-yu Pan (2006) selects logistics output (including transportation, warehousing, post and telecommunications industry and the wholesale and retail trade) as the study object in Zhejiang Province from 1978 to 2003. The Granger causality test shows that there are the interaction, the positive correlation and the time effect between the logistics industry output value and GDP.

The Spatial Effect of Logistics Industry

Zeng-lin Han (2002) derives that the development of the spatial layout of Chinese logistics industry is rapid in the nearly 20 years, but the differences of logistics development among different regions has become increasingly distinct, it shows a strong point to the east coast and traffic corridor in the spatial structure. The provinces and regions of some fundamental logistics economic activities are mainly the eastern coastal provinces and along the Eurasian Continental Bridge, at the same time, the relative concentration at the eastern coastal region. Xing-rong Geng (2003) derives that the layout of the new industry space of city and logistics center (Park) forms the logistics nodes of different scale and different functions which form a complicated spatial logistics networks in certain regional space through the specific analysis on the new city industry space. Cheng-liang Liu, Jun-lin Zhu, Liang Xu (2004) derives the difference of logistics industry has the great relation with the gradient pattern of the economics development in the western, middle and eastern China.

Previous literatures of the relationship between economic growth and logistics were limited in time series, which ignored the differences among the locations. We take into account not only the spatial heterogeneity but also spatial correlation between economic growth and logistics. The individual fixed-effect model is used as the basic panel-data model, and uses latest spatial panel-data model to study the correlation between regional economic growth and logistics in China.

1.Spatial-panel Model and Correlation Test

1.1 Spatial-panel Models

Spatial effects of the spatial econometrics have the spatial autocorrelation and the spatial differences. The former is the correlation of the observations between a regional sample and other regional samples. The latter is the spatial-effect non-uniform at the regional level because of the heterogeneity of spatial units (Anselin, 1988a). The Spatial autocorrelation in the spatial autoregressive model is reflected in the error term and the lagged item of dependent variable. Therefore there are two basic spatial econometric models, one is the Spatial Auto Regressive Model (SAR), the other is the Spatial Error Model (SEM), and the two basic model functions show:

Spatial Auto Regressive Model (SAR):

$$y = \rho W_N y + X'\beta + \varepsilon \qquad (1)$$

Spatial Error Model (SEM):

$$y = X'\beta + \mu$$

$$\mu = \lambda W_N \mu + \varepsilon \qquad (2)$$

Where y is the dependent variable, X is the vector of independent variables (including constant term), β is variable factors, ρ is spatial regression coefficients, λ is spatial autocorrelation coefficients, ε is the error components in the normal distribution, WN is the $n \times n$ spatial matrix (n is the number of region), the weight coefficient can be defined by the actual conditions.

The above model is a model for the cross-sectional data. In order to apply it to panel data, we need to change the model to meet the basic form of panel data model. We exercise the individual fixed-effect model (Elhorst 2003). The model controls two kinds of non-observable effects: the spatial fixed-effect and the time fixed-effect, the former is the effect of background variables which changed with the location, but no changed with time (such as economic structure and natural endowments, etc.) on the steady-state level; the latter is the effect of background variables which changed with time, but no changed with location (such as the business cycle and temporary impact, etc.) on steady-state level.

To assume sF is the N-dimensional column vector of spatial fixed-effect; tF is the T-dimensional column vectors of time fixed-effect, the two forms are showing as follows:

$sF = (\alpha_1, \alpha_2, \cdots, \alpha_N)^T$, $tF = (\delta_1, \delta_2, \cdots, \delta_N)^T$

The column vectors of spatial and time fixed-effect of each observation are showing as follows:

$\eta = i_T \otimes s_F, \delta = tF \otimes i_N$

Where i_T is the T-dimensional column vector and iN is the N-dimensional column vector, all elements of these two column vectors are 1.
Then the equation (1) and (2) can be transformed into the following model (3) and (4):

$$y = \rho(I_T \otimes W_N)y + \eta + \delta + X'\beta + \nu \quad (3)$$

$$y = X'\beta + \eta + \delta + \mu$$

$$\mu = \lambda(I_T \otimes W_N)\mu + \nu \quad (4)$$

In the one-dimensional error decomposition model, $\varepsilon = \eta_i + \upsilon_{it}$ or $\varepsilon = \delta_i + \upsilon_{it}$; In the two-dimensional error decomposition model, $\varepsilon = \eta_i + \delta_i + \upsilon_{it}$, $\eta_i \sim IID(0, \omega_i^2)$、 $\delta_i \sim IID(0, \xi_i^2)$ and $\upsilon_i \sim IID(0, \sigma_i^2)$. t is the time dimension, i is cross-section dimension, I_T is an unit time matrix of T-dimensional.

1.2 Spatial Correlation Test

The spatial correlation test is mainly based on the hypothesis testing , the Wald statistics, the LR statistics and the LM statistics of the maximum likelihood estimate, and "Moran'S I", the spatial-related indices, the null hypothesis H0:ϱ=0 orλ=0. However, Moran'S I (Moran,1948), LMerr (Burridge,1980), LMsar, Lratios, Walds

(Anselin,1988b) and other spatial tests are used in a single cross-section regression model, and can not be directly used in the panel-data model. To solve the problem, we can use the block-diagonal matrix" $C = I_T \otimes W_N$ " instead of the spatial-weight matrix in the above statistics. Then we can easily exercise these tests to analyze the panel data(Jiang He, Zhi-xin Zhang, 2006).

In the selection of model, we exercise firstly the LSDV (Least Square Dummy Variables) method estimation, do not take into account the bound model of spatial correlation, and then carry out the spatial-related test. If the LMsar (or LMerr) estimation is more significant than LMerr (or Lmsar) estimation, then the spatial lag model (or spatial error model) is more appropriate than the spatial error model (or spatial lag model). Anselin and Rey (1991) exercise Monte Carlo experiments method which can provide a good guidance on the selection of spatial econometric models.

1.3 Parameter Estimation

In general we exercise the maximum likelihood method (ML) to estimate spatial econometric models (Anselin, 1988a; Anselin and Hud1992). ML estimation program can not be used directly in the spatial panel-data model, because it is just applied to the cross-section regression model. In addition, when the dimension of spatial-weight matrix is large, there is a problem (Kelejian and Prucha, 1999) in the usual ML estimation procedures in spatial econometrics. At present, we can find a solution, it is the Monte Carlo method of approximate the log-likelihood function, the Jacobian determinant of natural logarithm (Barry & Pace, 1999). This method can be implemented in the spatial package of Matlab, and can be used to estimate model (3), (4).

2. Measurement Model

The regional production function can be derived by the homogeneous equation of Cobb-Douglas:

$$Y_t = f(K_t, L_t) = AK_t^{\alpha} L_t^{\beta} \qquad (5)$$

The logistics factor become more and more important in the process of production, logistics has been regarded as "the third profit source" to promote economic growth, which is the same important factor as the capital and labour,. Therefore, the C-D production function is improved. As the logistics(W) is independent of capital and labour, on the basis of the Solow production function, the production function which include the elements of logistics can be described as:

$$Y_t = f(K_t, L_t, W_t) = AK_t^{\alpha} L_t^{\beta} W_t^{\gamma} \qquad (6)$$

where Y is the output, A refers to the combination of technological advance, K refers to capital investment, L is labour input, W is logistics, α、β、γ are respectively elasticity coefficient of capital, labour, logistics on economic growth, respectively. For the comparison of data and economic implication, all variables should be logarithmic, as follows:

$$\ln Y_{it} = \ln A_i + \alpha \ln K_{it} + \beta \ln L_{it} + \gamma \ln W_{it} + \mu_{it} \qquad (7)$$

Subscript i is the province, t is time series, μ_{it} is the random disturbance.

3 Empirical Analysis

3.1 The Selection of Factors and Data Collection

We obtain the panel data from 1978 to 2007 in Chinese 30 regions (China have 23 provinces , 4 municipalities, 5 autonomous regions and 2 special administrative regions. Tibet's, Sinkiang's data and special administrative regions' data are incomplete. So we can only take 30 regions.) which is mainly from the "New China, Compiling Statistical

Information on Fifty-five Years" and "China Statistical Yearbook" (2006-2008). In order to compare data and reduce the heteroscedasticity, all data should be taken the logarithm.

We define the variables as follows:

(1) Logistics level: we introduce the cargo turnover to measure the level of logistics and logistics capacity (unit: 100 million ton-km).

(2) Labor: we use the employment numbers of the whole society to describe the labour variable (unit: ten thousand) .
(3) Capital stock: we use a perpetual in ventory method (Goldsmith 1951), which is now used widely by OECD countries, and its basic formula is:

$$K_{it} = K_{i,t-1}(1-\delta_{it}) + I_{it} \qquad (8)$$

Kit refers to the capital stock of i-region at t-year, $K_{i,\ t-1}$ refers to the capital stock of i-region at (t-1)-year, Iit refers to the investment of i-region at t-year; δ it is the t-year's economic depreciation rate. We use Zhang Jun's capital stock data which mentioned in the paper "China's Provincial physical Capital Stock Estimate: 1952-2000", and capital stock in the other period is calculated by the data of "China Statistical Yearbook". The depreciation rate $\delta_{it} = 5\%$. (Unit: hundred million).

3.2 The Determination of Economic Spatial-weight (W_{ij})

The spatial-weight matrix (Wij) embodies the regional spatial-effect. According to the rule of "Rook", the adjacent rule, the matrix Wij is:

$$w_{ij} = \begin{cases} 1 & \text{When the region i and the region j are adjace} \\ 0 & \text{When the region i and the region j are not adjacent} \end{cases}$$

the main diagonal elements are 0. And wij（i=1,2,…,n,j=1,2,…,n）should be standardized.

Although the neighbouring regions are close border, the economic ties are not identical between neighbouring regions. For the backward regions, the driving impact of backward regions on developed regions is weak, while the developed regions can generate great driving impact on the around backward regions, which is more intensive spatial influence. Therefore, we get economic weight-matrix based on the binary weight matrix (Lin Guang- Ping, 2005), the formula is:

$$W^* = W * E, E_{ij} = \frac{1}{\left|\bar{y}_i - \hat{y}_i\right|}, \text{ and, } \bar{y}_i = \frac{1}{t_1 - t_0 + 1}\sum_{t=t_o}^{t_1} y_{it} \qquad (9)$$

W is the weight-matrix of spatial location, E is the matrix of economic strength. We calculate the mean of proportion which is the real GDP of every region accounted for all regions real GDP, with the result of them, measure the regional economic level. And assuming that the economic strength of this region is strong, the spatial impact of it on surrounding regions is strong, contrary to the weak (Xiao-ping Chen, Guo-ping Li, 2006). Economic spatial-weight matrix (W_{ij}) is the diagonal matrix which is the product of a geo-spatial-weight(wij)and the mean of proportion of regional GDP, the formula is:

$$W_{ij} = w_{ij} * \text{diag}\left(\frac{\bar{y}_1}{\bar{y}}, \frac{\bar{y}_2}{\bar{y}}, \cdots, \frac{\bar{y}_n}{\bar{y}}\right) \qquad (10)$$

with $\bar{y}_i = \frac{1}{t_1 - t_0 + 1}\sum_{t=t_o}^{t_1} y_{it}, \bar{y} = \frac{1}{n(t_1 - t_0 + 1)}\sum_{t=1}^{n}\sum_{t=t_o}^{t_1} y_{it}$.

(4) GDP: for the elimination of price change factors, we consider the 1952 year data as the base period data, and educe the real GDP according to GDP index (Unit: hundred million)

3.3 The Testing Result

In the light of these assumptions of the model and estimation methods, we use the provincial panel data to establish the individual fixed-panel regression model of 30 regions from 1978 to 2007, by Eviews 6.0 software, exercise the LSDV method to estimate the individual fixed-effects model, and get the elasticity coefficients, the test results of the regression model and the estimates of the individual fixed-effect coefficients η_i. The results are showing in the table 1:

Table 1
The empirical results of individual fixed-effect model of spatial-panel data in 30 provinces from 1978 to 2007

	lnK_{it}	lnL_{it}	lnW_{it}	c
Coefficient	0.5983	0.1388	0.0670	-0.7626
t-Statistic	72.0240	4.9840	4.6823	-4.1491
Prob.	0.0000	0.0000	0.0000	0.0000
R^2=0.9632， Adjusted R^2=0.9826， F-Stat.=521.147， DW-Stat=0.4665				

In table1 the values of R^2 and Adjust R^2 is high in the regression models, it indicate that the result of the simulation fitting of the model data is very good. In table 2 judging from the fixed-effects estimate of various region, we can find the size of the value of fixed-effects is close in adjacent regions of Beijing and Tianjin, Jiangsu and Zhejiang, northeast, southwest and northwest provinces, it shows that there is significant regional relevance, it is necessary to do spatial-related test firstly, with the result of it, we can know if it is necessary to do spatial-panel analysis further. According to the regression result, $DW_{1978-2007}$=0.4665, it shows that there is autocorrelation between the variables, and then we test autocorrelation of spatial –regression error terms, the following estimate of the model are used with Spatial Econometric Modules of Matlab7.0, the results of estimation are showing in the table 3,

Table 2
The cross-sectional estimate of influence coefficients of various province from 1978 to 2007

Province	η_i	Provinc e	η_i	Province	η_i	Provin ce	η_i
Beijing	0.155	Shangha	0.444	Hubei	0.321	Yunna	0.271
Tianjing	0.131	Jiangsu	0.356	Hunan	-	Shanxi	-
Hebei	0.370	Zhejian	0.195	Guangdo	0.123	Gansu	-
Shanxi	-	Anhui	0.172	Guangxi	-	Qingha	-
Inner	-	Fujian	0.393	Hainan	0.301	Ningxi	-
Liaoning	0.374	Jiangxi	-	Chongqin	-	Xinjian	-
Jilin	0.155	Shando	0.644	Sichuan	-		
Heilongjia	0.209	Henan	-	Guizhou	-		

Table 3
The spatial correlation test

n =900	Lmerr	Lmsar	Lratios	Moran'I	Walds
value	66.5840	79.6035	86.6162	26.3590	21.6285
chi(1) .01 value	17.6110	6.6350	6.6350	1.9657	6.6350
Prob.	0.0000	0.0000	0.0000	0.0000	0.0000

With the test results, five test values (spatial dependence) are very significant (Prob. =0.0000), it prove that there is a significant spatial correlation between the logistics and regional. Thus the spatial factors must be taken into account in order to show the interaction between various regions GDP and logistics. The test value of spatial-panel lag term is bigger than the test value of spatial-panel error term, that is,

$Lmerror_{1978\text{-}2007}=66.5840 < Lmsar_{1978\text{-}2007}=79.6035$

$Lmerror_{1978\text{-}2007}=66.5840 < Lmsar_{1978\text{-}2007}=79.6035$

Based on the criteria described previously, the Sar-panel lag model is the optimal model. The spatial-panel lag model is used to estimate the correlation between economic growth and the logistics. Results are showing in the table 4 and table 5:

Table 4
The estimation results of sar-panel model parameter from 1978 to 2007

	LnK	LnL	LnW	ρ/λ
β	0.5609	0.3040	0.0848	0.1250
t-Stat	67.5058	15.3086	2.9924	8.8159
Prob.	0.0000	0.0000	0.0064	0.0000
R-squared=0.9775， Rbar-squared=0.9758， sigma^2=0.0308， log-				

Table 5
The estimate of spatial-fixed influence coefficient of various regions from 1978 to 2007

Province	η_i	Provinc e	η_i	Province	η_i	Provin ce	η_i
Beijing	0.236	Shangha	0.575	Hubei	0.432	Yunna	0.323
Tianjing	0.214	Jiangsu	0.563	Hunan	-	Shanxi	-
Hebei	0.458	Zhejian	0.463	Guangdo	0.454	Gansu	-
Shanxi	-	Anhui	0.231	Guangxi	-	Qingha	-
Inner	-	Fujian	0.432	Hainan	0.357	Ningxi	-
Liaoning	0.465	Jiangxi	-	Chongqin	-	Xinjian	-
Jilin	0.215	Shando	0.674	Sichuan	-		
Heilongjia	0.364	Henan	-	Guizhou	-		

Table 4 and 5, we can draw the following conclusions:

Firstly, the significance test estimation of the parameters ρ is by 1% in the spatial-panel lag model. We derive that there is a significant spatial correlation between GDP and logistics in 30 provinces. Because the logistics has the network properties, it can connect economic activity into the whole unit. Through the spatial overflow (diffusion) benefit, the rapid economic growth regions drive the economic development of slower economic growth regions, which is the positive spillover effect. Meanwhile the logistics will have a negative spillover effect, the production factors flow easily into developed regions, the economic growth in a region is likely to be on the expense of economic recession in other regions.

Secondly, the R^2 fitting with the spatial and time fixed-effects are better than that of the traditional fixed-effect model in the spatial-panel lag regression model. The model can explain clearly the model and reflect appropriately the actual situation when we introduce the time and spatial fixed effects into the model. The capital stock and labour elasticity coefficients value of GDP are respectively 0.56 and 0.30. The significant level is 1%, showing that the effect of investment and labour on economic growth is still the most important factor, the elasticity coefficient value of GDP on logistics is 0.08, the significant level is 0.64%, showing that the logistics is a significant impact factor on GDP, but the degree of influence on economic growth is limited, which results accord with the status quo in China, where Chinese logistics modernization is not high, the logistics network system is imperfect, the application of information technology is lack and the level of logistics management is low.

Thirdly, on the estimate results of spatial-fixed influence parameter (η_i) in the 30 regions, the fixed-effect parameters of different regions show significant difference. The logistics development level is better in the developed regions, worse in the developing regions. There are three levels of logistics development in China. The best one is in the developed coastal areas, such as Shanghai city, Jiangsu province, Zhejiang province and other developed coastal areas, the second one is in the central and north-eastern regions in China, such as Jiangxi province, Hunan province, Hubei province, Liaoning province, the third one is the worst one including the north-western regions in China. The results are consistent with the actual development situation in the Chinese each regions.

4. Conclusion

According to spatial-panel model, we estimated the correlation between the logistics and economic growth. We can draw the conclusion that there is the significant spatial-correlation between GDP and logistics in all regions, the GDP and logistics are obvious spatial overflow (diffusion) benefit between adjacent regions. The logistics has a significant impact on local GDP, but the influence degree on economic growth is finite, the reasons, the low degree of logistics modernization in China, the imperfect system of logistics network, the lack of application of information technology and the low level of logistics management. The fixed effect parameters of different regions are showing significant differences. The local economic development is better; the local logistics development level is higher.

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