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Spatial Spillover Effects of Transport Infrastructure in Chinese New Silk Road Economic Belt ☆

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Abstract

Based on the inner-effect mechanism of transport infrastructure and regional economic growth, this paper builds a specialized spatial weight matrix by utilizing the panel data from 31 provinces in New Silk Road Economic Belt (NSREB) and other areas from 2005 to 2014, and combines with the spatial panel model to analyze the spatial spillover effects of transport infrastructure. According to the analysis, the transport infrastructure plays an obvious lead role in regional economy growth alongside the NSREB, and the economic growth invigorates common development in surrounding regions. In addition, differences were observed among the different transport infrastructure with regard to their influences on regional economic development, as the highway transport affects regional economic growth to a larger degree than railway transport.

Keywords: Transport Infrastructure, Regional Economic Growth, Spatial Spillover, Spatial Panel Mode

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1. Introduction

The relationship between transport infrastructure and regional economic growth is one of the hot issues in recent academic research fields. Many scholars keep on estimating the relationship between the traffic infrastructure and regional economic growth, and generally agree that construction of transport infrastructure not only has a multiplier effect, but also has the advantage of network characteristics in that it can help organizations to reduce their transportation cost (Banister and Berechman, 2001, p.209). Moreover, there is a positive effect of transport infrastructure construction in promoting economic growth (Pradhan and Bagchi, 2013, p.139).

Because of the network character and externality of the transport infrastructure, it also had spillover effects on regional economic growth. Berechman et al., (2006, p.537) found that transport infrastructure could lead to positive spillover effects on economic growth. Yu, et al. (2013, p.56) utilized Spatial Tobit Model to discuss Chinese transportation infrastructure's spillover effects, and found that between 1978 and 2009, differences existed in the spillover effects in different time periods and different areas, which were closely related to transfer of production factors in China. Condeço-Melhorado et al. (2014, p.96) noticed that spillover effects existed in different cities, which played an important role in saving travelling time and improving economic effectiveness. Some researchers (Chen and Haynes, 2015, p.663) insisted that the highway transport infrastructure's effects mode on economic growth in America contributed to it stability and took a leading role in this area. However, there were differences in the way railway transport infrastructure's effects mode impacted on economic growth in America. Dong (2016, p.200) found a significant double difference in the overall levels of economic growth in different areas in China and transport infrastructure, which led to practical improvements in transport infrastructure and local economic growth became a complex issue.

Most scholars believed that the spillover effects of transport infrastructure were mainly dominated by positive spillover effects. However, there were also some scholars holding the opinion that they were mainly dominated by negative effects. Ozbay et al. (2007, p.537), Sloboda and Yao (2008, p.505) launched the investigations into the effects of highway on output and the employment situation, in which the negative spatial spillover effects existed. VAR model was utilized by Chen and Ou (2015, p.111), who noticed that in the long run, the transport infrastructure had a positive effect in promoting economic growth in Xinjiang Province in China, but negative effects also existed in short term.

According to findings, economic growth should not be seen in isolation, as this easily leads to inaccurate of analysis of the economic phenomena; what is more, because of the differences existing between the different kinds of transport infrastructure and their spillover effects on economic growth, the effects should be grouped for more reasonable reference comments on related adjustments of economic growth.

This article found a close relationship among different areas due to the mutual connection between the New Silk Road Economic Belt and surrounding provinces. The surrounding provinces are in fact affected indirectly by their nearby provinces, therefore, panel data from 31 provinces in New Silk Road Economic Belt and other provinces between 2005 and 2014 were utilized to build a spatial weight matrix and spatial panel model, to make comprehensive systematic analysis.

This paper provides the introduction and literature review in first session. The second session focuses on the mechanism of transport infrastructure's spillover effects on regional economic growth. The third session describes the variables and the building of spatial models. Finally, it estimates the results and provides the results discussion and recommended policies.

2. Theoretical Foundation

With the continuous development of economic growth theory, people are constantly hunting for new research to make more reasonable explanations. However, an important issue is ignored by these theories: the effect of space elements on economic growth. Theory of new economic geography is an important theory in space economic theory, which believes that there are two deciding factors in the regional distribution of industry, one is the transport cost and the other one is the income effect. The high level of transport accessibility is capable of reducing the transport cost in operation, which plays an important role in reducing the total cost for the organizations. On this basis, the Pole-Axis Theory focuses on the role of transport conditions with regard to economic growth, and insists that the effects of pole-axis exploitation on economic growth is bigger than the effects of isolated economic growth pole exploitation, and pole-axis exploitation is more beneficial to the coordinated development of regional economy.

Infrastructure, especially economic infrastructure has scale effects and network effects (World Bank, 1994), which can not only promote the flow of production elements, improve the effectiveness of economic growth, but also affect surrounding areas with the spillover effects of its own region. Obviously, the effects can be both positive and negative. The economic growth of one area will be extended to other nearby areas with the help of transport lines, which means that some developing areas can be promoted and economic differences can be reduced. During the flow of capital, human and production factors, an economic increase in one area may cause an economic decrease in another area. At this time, transport infrastructure laid negative spillover effects on economic growth in other areas. Therefore, when we cast an analysis on the general effects of transport infrastructure on regional economic growth, the spatial spillover effects should be considered, or we may overvalue or undervalue the role of transport infrastructure on regional economic growth. Spillover effects can be treated as the basis for researching the coordinated development of the regional economy in the New Silk Road Economic Belt in China.

3. Index Selection and Model Building

3.1 Index Selection

Panel data from 31 provinces in the New Silk Road Economic Belt and other areas from between 2005 and 2014 are utilized to build specialized spatial weight matrix, and combine with the Spatial Panel Model to analyze the spatial spillover effects of transport infrastructure on the New Silk Road Economic Belt and its region economy growth. The key variable data was sourced from <China Statistical Yearbook>, < Traffic statistics yearbook> and related statistics yearbook of other provinces to guarantee a high level of consistency.

Gross Domestic Product (GDP): The real GDP of one region is an important indicator for measuring the development level economy. Zhang (2012, p.66) utilized GDP to analyze the spillover effects of transport infrastructure on economic growth, which can reflect the development of the economic in one region. As a result, this paper selected the actual GDP in each province to be the variable due to its dependability and validity.

Variables of transport infrastructure (TRANS): It is better to present transport infrastructure variables by their physical form to show their distribution. All kinds of transportation, such as railroad, highway, waterborne, aviation and pipeline, etc. have a powerful effect on a region's economic growth, but the effects on different regions are different from each other. As most provinces located on the New Silk Road Economic Belt lies in hinterland, the number of water transport routes is limited by poor quality, and since railway and highway transport are the most common transport modes on the belt, this article chooses density of railway network (RAIL, km/km2) and density of highway network (RAIL, km/km2） in the New Silk Road Economic Belt as its transport infrastructure variables.[1]

Capital input indicators (FAI): New-classical economic growth theory insisted that the input of capital will promote economic growth dramatically, and it assumed that capital is one of endogenous factors that affect economic growth. What is more, some researchers even chose only one specialized industry or field capital input as an indicator of capital input, which led to the underestimation of capital input. As a result, this article chose data of Total Investment in Fixed Assets from 31 provinces of China from between 2005 and 2014 as indicator of capital input.

Variable of Human Capital (EDU): Four main methods are used for measuring it: the years of education received by labor; the average number of students' enrollment per 10000 people, using the enrollment rate as the substitute variable to measure the level of education of human capital, using the rate of GDP or fiscal charges spent on education as the measure indicator (Shen and Zhu, 1997, p.9). As the college students stand for people who have gotten better education, they can be also used to stand for the human capital. As a result, this article uses college students (EDU) to measure human capital.

Variable of Labor (LAB): This article selects the entire workforce from between 2005 and 2014 in all provinces of China as the control variable to measure the economic

[1] Transportation density is presented by dividing trans port infrastructure stock by geographic area of each pr ovince. Highway transport density = highway mileage/ geographic area of each province (unit: km/km2), rail- way transport density = railway mileage/ geographic a rea of each province (unit:km/km2).

growth. As the workforce is the basic input of economic growth, it is an indispensable part of both Solow's Growth Model and the Endogenous Growth Model.

Economic openness (OPEN): the total volume of foreign trade of one region can embody the open extent. This article uses (total volume of imports and exports/ GDP) to stand for the degree of economic opening of one region (Li, 2011, p.77). In general, the higher the degree of economic opening, the better communication is between technology and economic management, and the development of trade can also improve the regional economic growth at the same time.

3.2 Spatial Weight Matrixes

Spatial weight matrix W (n×n), includes the spatial related exogenous information between Area i and Area j. As there is no universal standard for the spatial weight matrix to reflect economic distance and the research focus will also affect the weights, it is difficult to operate within an economics area. Therefore, the article mainly uses a special binary spatial weight matrix to prove the spatial correlation. The geographical distance spatial weight matrix is based on 0-1 matrix among spatial unities (Anselin, 2003, p.156). 0 and 1 are used to express the adjacency between two regional spaces. Generally, the two spatial unities are adjacent to each other if they share common boundary and are nonzero. Assign value 1 to it with its corresponding spatial matrix and assign value 0 to it within the spatial matrix if they have no common boundaries. The article is taking the Chinese New Silk Road economic belt as a whole. Assign value 0 to the combinations of the ten internal provinces within the spatial weight matrix. The value assigned to the spatial matrix for other provinces is the same as the previous geographical distance matrix to forecast the interaction between the Chinese New Silk Road Economic Belt and other provinces. Such settings will help more on the measurement of the spatial spillover between provinces within the economic belt and other provinces without it. Therefore the expression of weight matrix is as below:

$$w_{ij} = \begin{cases} 0, & \text{when } i = j, \text{ or } i \text{ is not adjacent to } j, \\ & \text{or } i \text{ and } j \text{ are both with in NSREB;} \\ 1, & \text{when } i \text{ is adjacent to } j, \text{and meanwhile} \\ & \text{only one of } i \text{ and } j \text{ is within NSREB.} \end{cases} \quad (3\text{-}1)$$

3.3 Empirical model

This article uses OLS model, SLM model, SEM model and SDM model to create an analysis and comparison on the empirical results, to gain better analysis on the transport infrastructure's spatial spillover effects in the New Silk Road Economic Belt.

(a) OLS model without considering the spatial spillover effects

$$lnGDP_{it} = a0 + \beta_1 lnFAI_{it} + \beta_1 lnEDU_{it} + \beta_1 lnOPEN_{it} + \beta_1 lnLAB_{it} + \theta_1 lnRAILit + \theta_2 lnROADit + \varepsilon_{it} \quad (3\text{-}2)$$

In the above formula, i stands for regions, t stands for time, β_i（i=1, 2, 3, 4）stands for parameters to be estimated for each of independent variables, θ_i（i=1, 2）stands for parameters to be estimated for the transport infrastructure variable. ε_{it} stands for random error, α_0 stands for constant. Moreover, FAI stands for capital inputs, EDU stands for human capital (the number of college students), OPEN stands for the degree of economic opening, LAB stands for the labor input of each province, RAIL and ROAD stand for the density of railway traffic and highway traffic.

(b) Spatial Lag Effect Model (SAR)

$$\ln GDP_{it} = \rho W \ln GDP_{it-1} + \beta_1 \ln FAI_{it} + \beta_2 \ln EDU_{it} + \beta_3 \ln OPEN_{it} + \beta_4 \ln LAB_{it} + \beta_5 \ln RAIL_{it} + \beta_6 \ln ROAD_{it} + \varepsilon_{it} \quad (3\text{-}3)$$

In the above formula, ρ is the coefficient of SAR, $WlnGDP_{it-1}$ is the spatial lag effect variable of the explained variable.

(c) Spatial Tobit Model

Spatial Tobit Model considers the lagged variable of explained variable and related explanatory variables when checking the spillover effects.

$$\ln GDP_{it} = \rho W \ln GDP_{it-1} + \beta_1 \ln FAI_{it} + \beta_2 \ln EDU_{it} + \beta_3 \ln OPEN_{it} + \beta_4 \ln LAB_{it} + \beta_5 \ln RAILit + \beta_6 \ln ROAD_{it} + \theta_1 W \ln FAI_{it} + \theta_2 W \ln EDU_{it} + \theta_3 W \ln OPEN_{it} + \theta_4 W \ln LAB_{it} + \theta_5 W \ln RAIL_{it} + \theta_6 W \ln ROAD_{it} + \varepsilon_{it} \quad (3\text{-}4)$$

In the above formula, $WlnRAIL_{it}$ and $WlnRoad_{it}$ is the corresponding spatial lag effect variable for each of the transport infrastructure variables, respectively. ε_{it} stands for the random error.

4. Empirical Result Analysis

4.1 Empirical Study of Spatial Lag Panel Model

Since the general panel model has no consideration of the spatial spillover effect, the result may be biased in its rational in detailing the whole economic situation. Therefore, it will reflect more realistically the phenomena and problems in actual development, when using the combination spatial panel model or panel data and the spatial econometric model.

When considering the choice between the SEM model and the SLM model, if the statistics of LMERR (Robust LMERR) are less significant than LMLAG (Robust LMLAG), then the SLM model is selected, if not, then the SEM model is selected. Through the Lagrange multiplier test and the robust Lagrange multiplier test, the result of LMLAG (Robust LMLAG) is vastly improved when compared to the LMERR (Robust LMERR). Therefore, the SLM model with spatial lag effect is selected.

The article uses a typical short-term panel data with n=31, t=10. Since the time period is short, it is difficult to measure its data characteristics accurately. Based on the Huasman test result, the panel random effect model is also rejected. From a practical viewpoint, the panel fixed effect model is considered to be a better choice (Baltagi, 2003, p.61). This article will compare the general fixed effect model with F-SLM model and analyze the spatial lag model and its fixed effects.

From Table 1, the R^2 value of F-SLM is the highest among the three models. Its fitting degree is the best and Log-likelihood value is also good. Therefore, the spatial lag model with its fixed effect should be able to clearly explain the practical result. In the F-SLM model, the spatial auto-regressive coefficient ρ value is 0.137 and it passed the 1% significance test, so the regional economic development has a significantly positive spatial spillover effect. There is a difference between the impacts of different transportation infrastructures on regional economic development.

Table 1 Spillover Empirical results of SAR model

	General Fixed Effects	F-SEM	F-SLM	F-SDM
ρ			0.137***	0.104*
			(2.630)	(2.630)
λ		0.138*		
		(1.940)		
lnFAI	0.462***	0.240***	0.242***	0.242***
	(20.270)	(12.630)	(12.880)	
lnEDU	0.124**	0.068*	0.056	0.048
	(1.980)	(1.740)	(1.430)	(1.200)
lnOPEN	-0.054***	-0.035***	-0.039***	-0.044***
	(-2.76)	(-2.880)	(-3.20)	(-3.340)
lnLAB	0.469***	0.202***	0.204***	0.214***
	(11.02)	(5.990)	(6.030)	(6.170)
lnRAIL	0.347	0.019	0.172	0.175
	(1.480)	(1.410)	(1.250)	(1.260)
lnROAD	0.113***	0.060**	0.054**	0.047*
	(4.100)	(2.340)	(2.130)	(1.740)
R^2	0.765	0.895	0.944	0.902
Log-likelihood		510.142	560.181	476.064
W * lnFAI				0.038
				(0.900)
lnEDU				0.056
				(1.430)
lnLAB				-0.018
				(-0.34)
lnRAIL				-0.023
				(-1.220)
lnROAD				0.020*
				(1.940)
Test	Z	P		
LMERR	31.262***	0.000		
Robust-LMERR	22.043***	0.000		
LMLAG	62.342***	0.000		
Robust-LMLAG	53.123***	0.000		

*Notice : ***stands for passing 1% significance test; ** stands for passing 5% significance test ; * stands for passing 10% significance test. It denoted not significant difference (P>10%) failed in passing the test. The value of t is shown within parentheses.*

For road density, its elastic coefficient is 0.054 and it passed the 5% significance test, which means that road transport has a relatively obvious contribution on economic development. Although the elastic coefficient of rail density is positive, it failed 10% significance test, so rail has a promoting impact on economic development but it is not statistically significant.

Compared to other control variables, the contribution of fixed asset investments to economic development is 0.242 according to Table 1. The contribution of labor force investment to economic development is 0.204. Both have passed the 1% significance test, which shows they all have a significant effect on promoting economic development. As for human resource, its elastic coefficient is 0.054. However it failed the 10% significance test, which indicates it has positive impact on economic development but it was not significant. For economic opening, which is expressed by the proportion of total import and export volume in GDP, its elastic coefficient is -0.039 and it passed the 1% significance test. That indicates the economic opening has a negative impact on economic development.

Comparing F-SDM with general panel model with fixed effects, the fitting result of F-SDM is better. It explains the economy phenomena more reasonably. Therefore, adding the explained variables spatial lag item and transportation infrastructure spatial lag item, F-SDM could provide a closer-to-actual explanation for the transportation infrastructure and regional economic development.

According to the results given by the spatial Tobit panel model, the auto-regressive coefficient of the spatial lag item of the explained variable, ρ is 0.104 and has passed the 10% significance test. For the transportation infrastructure variables, the elastic coefficient of road density is 0.047 and it passed the correlation test, which shows a positive impact on road development in promoting the economic growth. The elastic coefficient of rail density is 0.175 and exerts a positive force on economy development. However it failed the significance test and the positive force is not significant. Meanwhile, the elastic coefficient of FAI is 0.241 and it passed the 1% significance test. The elastic coefficient of labor force is 0.214 and it also passed the 1% significance test. Both of them have a positive impact on regional economic development. The elastic coefficient of human capital is 0.048 and it failed the 10% significance test. The elastic coefficient of economic opening is -0.044 and it passed the 1% significance test, which means that it has a negative impact on regional economic development.

Compared with the SAR model, spatial Tobit model include the spatial lag item of the explanatory variables. In Table 1, it is the coefficient of spatial lag item of the road infrastructure density is 0.02 and it has passed the 1% significance test. The spatial lag item of rail density is negative and not significant as it failed the 10% significance test. In general, there is a spatial spillover effect between the transportation infrastructure of Chinese New Silk Road Economic Belt and regional economic development. There is no obvious correlation between the spatial lag items of other control variables, as their spatial spillover effect on regional economic increase all failed the significance test.

4.2 Analysis on spatial spillover effects of transport infrastructure

The overall effects of transport infrastructure on regional economic growth can be divided into direct effects and indirect effects. If the OLS model is used, the direct effects of explanatory variables are equal to coefficient's estimated value of the variable (β_k) , and the indirect effects can be calculated to be 0. If an error term of spatial autocorrelation is added to the OSL model, a SEM model can be gained. However, the direct and indirect effects would not be changed, because when taking the partial derivatives with respect to explained variables, the disturbance term would not make a difference.

In terms of the SLM model, the direct effects are equal to premultiply a number which is finally 1 or higher. This number can be treated as the decomposition of spatial multiplier matrix. The decomposed form is listed as below:

$$(I-\delta W)^{-1} = I + \delta W + (\delta W)^2 + (\delta W)^3 \quad (4\text{-}1)$$

In the above formula, it stands for the spatial unit matrix, as the off-diagonal element is 0, this term only stands for the direct effects of X's changes. Accordingly, the second term on the right side is assumed to be 0, which only stands for the indirect effects of X's changes. What is more, the powers of W are seen to be 1, so the indirect effects should be restricted to effect of only 1st-order terms. The other terms on the right sides stand for influences of direct and indirect effects of 2nd-order or higher-order terms. The effects of higher-order terms are results of feedback effects, which make the final overall effects are greater than 1.

An important limitation of the spatial lag model is that the ratio of indirect effects and direct effects of a specialized explaining variable are independent on β_k. β_k in both molecule and denominator is reduced. This property shows that the ratios of direct and indirect effects with regard to each explaining variables are the same, depending on spatial auto-regressive parameters and spatial weight matrix W.

If the SDM model is used, the direct and indirect effects of specialized variables are depend on the estimated value of the spatial lag effect. The result is that the values of direct and indirect effects are not imposed constraints. As a result, the ratios of indirect and direct effects are different among different explaining variables.

In general, the choices of the OLS model, the SLM model and the SDM model are depend on the statistic of Lagrange multiplier and goodness of fit statistic and then choose the larger one to be the objective of statistical analysis (Shu, 2014, p.98). From the above models, the value of OLS panel model is 0.765, the value of F-SLM panel model is 0.944 and the value of F-SDM panel model is 0.902. By the look of goodness of fit statistic, the F-SLM is better. In terms of the overall model values, the value of F-SLM model is 560.181, and the value of F-SDM is 476.064. As a result, F-SLM should be chosen for explanation for a more rational understanding.

By using Stata10.0 to make calculations, the related values of spatial spillover effects of transport infrastructure in New Silk Road Economic Belt are listed in Table 2:

Table 2 Direct and Indirect Effects of Transport Infrastructure in F-SLM Model

F-SLM	Direct		Indirect		Total
		(%)		(%)	
lnRAIL	0.018	85.71	0.003	14.29	0.021
lnROAD	0.054		0.009		0.063

As shown above, the direct spillover effect of transport infrastructure made up of 85.71% of the total effects, while the indirect spillover effect made up 14.29%, which shows that fairly strong spillover effects are laid on region economic growth by transport infrastructure. Meanwhile, the spillover effects of highway transport are much greater than those of railway transport.

5. Conclusion and Recommendations

Accordingly, it would be more reasonable to choose Spatial Lag Model with fixed effects. As a result, this article conducted an analysis and conclusion on empirical results of this kind of model.

The spillover effects of New Silk Road Economic Belt on economic growth exist, and the economic growth is boosted by economic growth in nearby regions. With the fast development of highway transport, now plays a great role in promoting trade, the free flow of capital and production in the New Silk Road Economic Belt and surrounding areas. The railway transport also promotes economic growth, but the effects are not as obvious.

The capital and labor inputs promote regional economic growth. The transport infrastructure has positive spatial spillover effects on regional economic growth. Although the main effects are direct effects, the indirect effects cannot be ignored, which account for 14.29% of the overall effects.

Moreover, the overall effects and spatial spillover effects of highway transport on economic growth are much bigger than those of railway transport. If the spatial spillover effects are not considered, the positive effects of transport infrastructure on regional economic growth will be overvalued.

On the basis of the conclusions above, policy implications and recommendations can be concluded as follows: Firstly, strengthen the construction transport infrastructure in the New Silk Road Economic Belt, which promotes regional economic growth; it also brings multiplier effects to related regions. Moreover, not only the scale, but also the high quality of the construction should also be focused on. Secondly, strengthen the communication and cooperation to achieve balanced economic development between regions, and avoid the redundant construction of transport infrastructure. Thirdly, take good advantage of various factors to promoting balanced economic development. Firmly rely on the input of capital and advantages of labor resources to stimulate economic growth. In addition, promote role of economic growth and educational input, to emphasize the importance of the role of talent and technology in the process of economic growth. Last but not least, not only take the railway and highway miles into account, but also the quality improvement of operation. A modernized comprehendsive traffic system with complete functionality overall upgrade and interconnection should be built.

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