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The Impact of Infrastructure Construction on Economic Growth -- A Study based on Spatial Panel Data of 16 Cities in Shandong Province

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Abstract

Based on the panel data of 16 cities in Shandong Province from 2011 to 2020, this paper explores the effect of infrastructure construction on the existence of economic growth in 16 cities in Shandong Province using the spatial Durbin model. It is found that there is a positive effect of infrastructure construction on economic growth under the condition of inverse economic distance spatial weighting, while there is a negative effect of infrastructure construction on economic growth under the condition of inverse geographic matrix spatial weighting, but its direct effect is positive. It is concluded that there is a certain promotion effect of infrastructure construction on economic growth in Shandong Province, and infrastructure investment can be increased in the region, but it is necessary to focus on the balanced development of infrastructure construction in the region and other regions.

Keywords

Infrastructure Development; Spatial Durbin Model; Direct Effect; Indirect Effect.

1. Introduction

Infrastructure refers to the material engineering facilities that provide public services for social production and residents' lives, and is a public service system used to ensure the normal conduct of social and economic activities in a country or region, and is the general material conditions for the survival and development of society. Infrastructure includes transportation, post and telecommunications, water and electricity supply, commercial services, scientific research and technical services, landscaping, environmental protection, culture and education, health and other municipal public Engineering facilities and public life service facilities, etc., are the basis for the development of all national economic undertakings, and are characterized by precedence, natural monopoly, quasi-public goods, positive externality, etc. From the study of the relationship between infrastructure construction and economic growth, Rodan (1943)[1] put forward the theory of "big push", through the construction of infrastructure and other industrial sectors to carry out the smallest critical size investment, external economic effects. Aschaucer (1988)[2] used a time-series study to discover the role of infrastructure construction in promoting the economic output rate, which provided a new perspective for research in related fields. Demurger (2000)[3] found that there is a link between infrastructure investment and economic growth in China, and that investment in the construction of infrastructure plays an important role in the coordinated development of the regional economy. Berechman (2006)[4] examined the spillover effects of transportation in U.S. states and counties and found that transportation infrastructure investment has significant externalities. found that transportation infrastructure investment has significant externalities. Arif et al. (2021)[5] calculated TFP for 16 manufacturing industries in 19 Asian countries from 2006-2016 and found that transportation infrastructure is crucial for less technology-intensive industries. Based on the positive externality of infrastructure construction, many scholars believe that the degree of perfection of infrastructure construction in a region will play an important role in the level of economic growth and regard it as an indicator of the level of regional economic growth and an economic factor that promotes regional economic growth, so scholars have launched a detailed study on the relationship between infrastructure construction and economic growth. At this stage, the research on the relationship between infrastructure construction and economic growth in China mainly focuses on the analysis of the current situation, financing methods and development paths, and there are fewer empirical studies on the impact of infrastructure construction on regional economic growth. In the decade of the 20th century, relevant empirical studies showed that infrastructure construction had a positive effect on the economic growth of districts, regions, and urban and rural areas, and that it had a positive effect on stimulating economic growth and alleviating the problem of poverty, and that there was a bi-directional causal relationship between infrastructure construction and economic growth.

Infrastructure development has spatial effects on economic growth. The new economic geography theory proposed by Krugman (1996)[6] explains the spatial spillover effects of transportation, and argues that the investment in and use of transportation infrastructure generates economic agglomeration effects, economic diffusion effects, and externalities to neighboring regions. Yilmaz et al. (2002)[7] use panel data for the 48 U.S. states for the period 1970-1997 to study the spatial spillover effects of state-level investment in telecommunications infrastructure on state output. Data to study the spatial spillover effects of state-level telecommunication infrastructure investment on state output, and found that a state can benefit from its own telecommunication investment, but telecommunication investment in other states can have negative spillover effects on its output growth. Cao Y Q et al. (2021)[8] provide an in-depth study of spatial spillovers of transportation infrastructure in Central and Eastern European countries over the 1995-2018 period found that transportation infrastructure can promote regional economic growth through the three paths of commodity export, service export and residential consumption. The construction, distribution and renovation of infrastructure will bring about spatial effects, and in the context of spatial network development, changes in spatial location advantages will lead to changes in spatial economic location. Many studies have attempted to explore the spatial effects of infrastructure construction using spatial econometric models. In this paper, we also study the spatial effects of infrastructure development, and the indicators of infrastructure development include public transportation, the number of cell phone users, and the scale of Internet use, etc., in an attempt to study the spatial effects of infrastructure development for individual provinces.

2. Research Hypotheses

This paper assumes that there are two spatial direct effects and indirect effects of infrastructure construction on the economic growth of cities in Shandong Province. The direct effect refers to the fact that infrastructure construction, as a prerequisite for smooth economic operation and a guarantee for industrial development, can not only directly promote local economic growth, but also promote the economic growth of other cities, which again feeds back into the synergistic economic growth of the region. The effect comes from the large-scale construction of information and communication technology, public transportation and other infrastructure, which is conducive to the deep integration of industrial chains and promotes the flow of production factors and synergistic economic development in the region and other regions. The indirect effect refers to the spatial spillover effect of infrastructure construction, i.e., the impact of infrastructure construction in other regions on the economic growth of the region. The effect comes from the fact that infrastructure construction strengthens the connection between cities and regions, and the transportation lines and network connections across cities and regions promote the common economic growth.

3. Model Construction and Variable Description

3.1. Model Construction

According to the theoretical analysis, infrastructure construction has spatial spillover effects. Therefore, the basic spatial models in this paper are the Spatial Durbin panel Model (SDM), the Spatial Auto-regressive panel Model (SAR) and the Spatial Error panel Model (SEM), where the Spatial Durbin panel Model is the basic model and the Spatial Auto-regressive panel Model and the Spatial Error panel Model can be obtained by transformation of the Spatial Durbin Model. The model settings are as follows.

$$eco_{it} = \rho W eco_t + \beta X_{it} + \delta D X_t + \mu_i + \gamma_t + \omega_{it}$$
$$\omega_{it} = \varphi E \omega_t + v_{it}$$

eco_{it} is the level of economic growth, X_{it} is the core explanatory variables and other control variables, $\delta D X_t$ is the spatial lagged terms of the core explanatory and control variables, W, D, E, is the spatial weights, μ_i is the individual effects, γ_t is the time effects, ω_{it} is the presence of spatially dependent random error terms, and ρ, β, δ, φ is the coefficients. When $\varphi = 0$, the model is a Spatial Durbin Model (SDM); when $\varphi = \delta = 0$, the model evolves into a Spatial Auto-regressive Model (SAR); when $\varphi = \delta = \rho = 0$, the model evolves into a Spatial Error Model (SEM).

In the selection of spatial weights, the inverse economic distance spatial weight and inverse geographical distance spatial weight are selected in this paper. The inverse economic distance is measured by the inverse of the absolute value of GDP difference between two places, and the inverse geographic distance is obtained by processing the longitude and latitude of municipal governments by querying them on the Gaode map platform.

3.2. Variable Description

In this paper, 16 cities in Shandong Province (City Laiwu was transferred to Jinan in 2019, so it is not analyzed here considering the influence on the spatial weight setting) are selected as the research object to construct the spatial panel data from 2011 to 2020, and the explanatory variable is the regional economic growth level, which is measured using GDP per capita of each city; the core explanatory variable is for the infrastructure construction level, and each city is selected to The number of cell phone subscribers, the number of Internet access subscribers, the length of public bus and tram operating line network, and the length of highway were selected as the indicators of the core explanatory variables, and the weights of each indicator were determined by the entropy value method to finally obtain the infrastructure construction level index of 16 cities in Shandong Province.

In terms of control variables, this paper selects the structure of industrial , which is measured by the ratio of tertiary industry to secondary industry output value in each year in each region; the scale of population, which is measured by the number of people at the end of the year; degree of openness to the outside world, which is measured using the scale of actual foreign capital utilization; support of government , which is measured by the general public budget expenditure of the government; development of financial industry , which is measured by the financial institutions' domestic and foreign currency deposit balance of financial institutions; the level of education, which is measured by the average years of education of elementary school students, middle school students, and high school students in each city, where the

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average years of education = (primary and middle school students in school × 9 + high school students in school × 12)/total number of students in school.

3.3. Data Sources and Descriptive Statistics

This paper mainly selects the relevant economic data of 16 cities in Shandong Province (from 2011 to 2020). Each data is mainly from Shandong Statistical Yearbook, the Statistical Yearbook of each city and the website of National Bureau of Statistics, EPS database, etc. In the specific analysis, in order to avoid problems such as heterosexuality caused by quantitative differences of different data, this paper use the logarithm of the level of economic growth, population size, degree of openness to the outside world, government support, and level of financial industry development. Table 1 shows the descriptive statistics of the main variables.

Table 1. Descriptive statistics

Variables	Name	Observations	Maximum	Minimum	Mean	Standard deviation
Level of economic growth	eco	160	13.2490	9.8379	11.0643	0.4925
Index of the infrastructure construction	infra	160	0.0256	0.0004	0.0063	0.0046
The structure of industrial	indus	160	3.6637	0.5596	1.1621	0.5690
The scale of population	pop	160	7.0986	5.2228	6.3035	0.4959
Degree of openness to the outside world	open	160	13.6754	8.6447	10.7799	1.1373
Support of government	gov	160	16.5785	11.6463	13.1750	1.1638
Development of financial industry	fin	160	9.9554	6.8817	8.2608	0.6832
Level of education	edu	160	9.6311	9.2909	9.4452	0.0760

3.4. Analysis of Empirical Results

3.4.1. Spatial auto-Correlation Test

This paper uses stata17.0 software to carry out empirical tests and analysis, firstly, the Moran index is used to test whether there is spatial dependence of economic growth in Shandong province, and the global Moran index of economic growth level based on the inverse economic distance and inverse geographical distance as spatial weights in Shandong province from 2011 to 2020 is summarized in Table 2. From the table 2, we can see the results of the metric using two spatial weights, indicating that there is a spatial effect of economic growth in Shandong province and it is more significant in most years, and the spatial effect of economic growth in Shandong province is not particularly obvious from the inverse geographical distance spatial weights, which may be related to the spatial weight matrix setting.

Table 2. Moran' I

Year	Inverse economic distance	Inverse geographical distance
2011	0.109*	0.014**
2012	0.104*	0.013**
2013	0.104*	0.012**
2014	0.113*	0.009*
2015	-0.071	-0.016
2016	0.155**	0.028**
2017	0.153*	0.025**
2018	0.139*	0.013*
2019	0.269**	0.036**
2020	0.260**	0.026**

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The inverse economic distance and inverse geographic distance spatial weight matrices were further constructed separately and LM tests were conducted to determine the applicability of the spatial econometric model. The results show that both weight matrix conditions pass the LM test and the original hypothesis is rejected at the 1% significance level, i.e., there is spatial dependence of the explanatory variables and the spatial econometric model can be used.

3.4.2. Selection of Spatial Model

After confirming that the spatial econometric model can be used, the optimal model among the SDM, SAR, and SEM models needs to be determined, and the LR test is used to determine whether the SDM model will degenerate into a SAR model or a SEM model. The results are shown in Table 4, and the original hypothesis is rejected under both spatial weight conditions, indicating that the SDM model will not degenerate into the SAR and SEM models, so the following empirical regression will be performed using the SDM model.

Table 3. LR Test

LR Test	Null hypothesis	Inverse economic distance		Inverse geographical distance		Conclusion
		Statistical values	P-value	Statistical values	P-value	
	SDM model degraded to SAR model	44.01	0.0000	36.88	0.0000	Reject the null hypothesis
	SDM model degraded to SEM model	23.92	0.0012	18.56	0.0050	Reject the null hypothesis

After choosing the model, the Hausman test was performed to determine whether the spatial panel data model used fixed effects or random effects, and the results are shown in Table 4. The original hypothesis was rejected at the 5% significance level in the inverse economic distance spatial weighting condition, and fixed effects should be used, while the original hypothesis was not rejected in the inverse geographic distance spatial weighting condition, and random effects were chosen.

Table 4. Hausman Test

Hausman Test	Inverse economic distance		Inverse geographical distance	
	Statistical values	P-value	Statistical values	P-value
	16.69	0.0195	1.5	0.9824
Conclusion	Select fixed effects		Select random effects	

3.4.3. Regression Results

The regressions were conducted under the inverse economic distance spatial weight and inverse geographic distance spatial weight conditions with fixed effect model and random effect model, respectively, and both controlled for regional variables and time variables, and the regression results are shown in Table 5. Among them, the regression results named with Main are the effects of local municipal infrastructure construction and related economic variables on local economic growth, and the regression results named with Main are the effects of other local municipal infrastructure construction and related economic variables on local economic growth. For the regression results under the condition of inverse economic distance spatial weighting, the infrastructure construction in this region has a promoting effect on the level of

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economic growth in this region and passes the significance level test, and the regression coefficients of other control variables are also positive; the infrastructure construction in other regions has a spatial spillover effect on this region and can promote economic growth in this region, and the regression coefficients of government support and the level of financial industry development are The possible reason for the negative coefficients is that the general public budget expenditures of the governments of other regions and the support for the financial industry will promote the economic growth of the region, making the differences in the economic growth levels of different regions. For the regression results under the condition of inverse geographic distance spatial weight, the infrastructure construction in this region also has a promoting effect on the economic growth level of this region and passes the significance level test, but there are other control variables that cannot explain the economic growth level well; and there is a negative effect of infrastructure construction in other regions on the economic growth level of this region, and most of the control variables are not significant, the reason It may be that there is a problem with the setting of the spatial weights of the inverse geographical distance, and there is a large error in measuring the distance between the two municipal governments as the geographical distance between the two regions using only the latitude and longitude data, and a more precise way should be adopted to measure the arc distance between the two regions. The spatial correlation coefficients under both weight conditions are positive, which can indicate that there is a positive effect of infrastructure construction on regional economic growth.

Table 5. Regression results

	Inverse economic distance		Inverse geographical distance	
	(1)	(2)	(3)	(4)
	Main	Wx	Main	Wx
infra	23.8321*** (4.03)	34.9382*** (12.61)	32.7299*** (4.51)	-1443.509*** (292.58)
indus	0.1001* (0.05)	0.1678 (0.22)	-0.1269* (0.07)	5.4702 (4.85)
gov	0.0445 (0.04)	-0.2253* (0.12)	0.0621 (0.03)	-5.5210 (1.72)
pop	0.4555** (0.46)	2.2761** (0.87)	-0.8740*** (0.08)	4.2744 (4.52)
open	0.0145 (0.01)	0.0193 (0.03)	-0.0009 (0.02)	0.8533 (0.79)
fin	0.4468*** (0.07)	-0.2336 (0.17)	0.3821*** (0.06)	2.0077 (2.00)
edu	0.0706 (0.12)	-0.6603*** (0.23)	0.0067 (0.15)	-14.5629*** (3.88)
Time fixed effect	Yes		Yes	
Region fixed effect	Yes		Yes	
Spacial rho	0.3151		4.9251	
Observations	160		160	

3.4.4. Spatial Effect Decomposition

After the regression is completed, the SDM model is decomposed into spatial effects, and the results are represented in Figure 6. The direct effect mainly reflects the impact of local infrastructure construction development on local economic growth, the indirect effect, i.e. spillover effect, mainly reflects the impact of infrastructure construction development in other

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local cities on local economic growth, and the total effect mainly reflects the impact of infrastructure construction development in all regions on the economic growth of the region. When inverse economic distance is used as spatial weight, the results show that infrastructure construction has direct and indirect effects on economic growth, and basically passes the significance test, which indicates that the improvement of infrastructure construction level in both the region and neighboring regions can play a favorable role in promoting economic growth in the region. In contrast, when the inverse geographical distance is used as the spatial weight, infrastructure construction only has a direct effect on the economic growth of the region, and the development of infrastructure construction in other municipalities does not further promote the economic growth of the region, and there is an inconsistency of economic reality.

Table 6. Infrastructure construction Spatial effect decomposition

	Spatial weights	
	Inverse economic distance	Inverse geographical distance
Direct effect	21.1152*** (0.51)	27.4280*** (4.93)
Indirect effect	15.57228 (10.06)	-163.303*** (37.37)
Total effect	36.68745*** (7.54)	-135.8751*** (39.24)

4. Conclusion and Recommendations

Through the empirical analysis of the model, it is found that under the condition of inverse economic distance spatial weighting, infrastructure construction in both local city and other local cities has a promoting effect on local economic growth, and its direct effect and indirect effect are both positive from the decomposition of spatial effect. Under the condition of inverse geographic distance spatial weighting, infrastructure construction in local city has a promoting effect on local economic growth, but infrastructure construction in other local cities has a negative effect on local economic growth, i.e., its direct effect is positive and its indirect effect is negative.

Based on the above findings, the following suggestions are made: First, in view of the positive effect of infrastructure construction on the economic development of local municipalities in Shandong Province, it is necessary to further promote the optimization and upgrading of infrastructure such as transportation arteries, public transportation, information technology and mobile communication, and to improve the level of infrastructure construction through optimizing the investment structure, innovative investment methods, and effective government supervision and support in order to promote regional economic growth. Second, we should focus on the balance, coordination and systematization of infrastructure construction areas in different cities and regions, accelerate the coverage of infrastructure construction networks in different cities and regions, strengthen economic ties between cities and regions, and promote integrated economic development. Third, in view of the differences in industrial structure, population size, degree of openness to the outside world, and general public expenditure of the government in different cities and regions, we should formulate corresponding infrastructure construction plans, reduce the border effect between cities and regions, and break down potential barriers to information exchange and factor flow.

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