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Infrastructure, Agglomeration and Regional Economic Growth in China: A Panel VAR Analysis

Li WANG[1,*], Ningning JIA[1] and Fei XUE[2*]

[1] Northwest University, Xi'an, China; wlily218@126.com; 1135038662@qq.com
[2] University of Chinese Academy of Social Sciences, Beijing, China; 201620145@stumail.nwu.edu.cn
* Corresponding author: 201620145@stumail.nwu.edu.cn

Abstract: Infrastructure is considered as an important social advance capital. Infrastructure construction is a crucial tool in China for stabling employment, expanding domestic demand, adjusting the economic structure, and promoting economic growth and development. Based on a panel vector autoregressive model, this paper uses China's provincial panel data from 1993 to 2015, to examine the relationship among infrastructure, agglomeration, and regional economic growth. We find statistically significant long-term positive effect on infrastructure to regional economic growth and economic agglomeration, for increasing level of infrastructure capital stock density. According to the results of the prediction error variance decomposition, the contribution of infrastructure construction to regional economic growth is between 1.56% and 18.53%, and the contribution of infrastructure construction to agglomeration is between 0.14% and 12.67%. Obviously, it can be seen that there is a certain degree of difference in the contribution of infrastructure construction to the positive effect of regional economic growth and aggregation.

Keywords: infrastructure; agglomeration; regional economic growth; A Panel VAR Analysis

JEL Classification: R11

1. Introduction

Considered as an important social advance capital in China, infrastructure construction is a basic tool to promote regional economic development and urbanization. Over the last half of the century, the relationship between infrastructure and economic growth has been a hot topic of the economic policy debate. A vast literature has examined the empirical evidence on the role in promoting economy. In an influence article, Aschauer (1989) used the US public landfall data from 1949 to 1985 and found that the US core infrastructure capital had a significant positive effect on US economic growth. Cook and Munnell (1990) studied the public infrastructure of American expressways and drainage systems and found that infrastructure investment has a positive effect on economic growth. In addition, Canning (1999), Haque and Kim (2003), Straub et al. (2008), Calderón et al. (2014), and others have conducted thorough studies of the economic growth effects of infrastructure around the world.

Researches on the economic effect of infrastructure in China began in the 21st century. Fan et al. (2004a, b) investigated the relationship between China's infrastructure investment and economic growth based on the model constructed by Barro (1990). Based on a detailed estimate of the capital stock of China's infrastructure, Ge (2012, 2016) found that the elasticity of economic infrastructure capital output is between 0.12-0.13, and social infrastructure capital-output elasticity is between 0.10-0.12. Zhang (2013) examined the spillover effects of transport infrastructure to regional economic growth.

The above-mentioned literature promotes the research of infrastructure in China. Due to the different understandings of the specific scope of the infrastructure, the differences in research methods, especially the diversity and differences in the choice of variable indicators, the mechanism and impact effects of infrastructure investment reflect different conclusions. Most studies used the flow data of infrastructure from the perspective of physical stock or investment in infrastructure. Few articles studied the impact of infrastructure capital stock. Besides, most of the literature will focus on the economic growth effects of infrastructure but ignoring the infrastructure of the economic growth of the transmission mechanism of the study. As an attempt to estimate the long-term and dynamic effect, a panel vector autoregressive model is used to describe the dynamic effect between infrastructure, agglomeration, and regional economic growth, by using China's provincial panel data from 1993 to 2015.

2. Data and Methodology

In order to comprehensively assess the mutual effect of infrastructure, agglomeration, and regional economic development, and to explain the mechanism of interaction between the three, we choose the three variables, which are capital stock density, economic agglomeration index, and GDP per capita to construct the model to estimate the parameters. This section describes the data and the econometric methods.

2.1 Infrastructure Capital Stock

We use the ratio of infrastructure capital stock to the administrative area of each province to represent the density of infrastructure capital stock. We obtain data on infrastructure capital stock from Ge (2012) and the time series of the data is extended to 2015. To eliminate the impact of price factors, we use the fixed asset investment price index to reduce the stock data, converting to 1993 as the base of the constant price.

2.2 Economic Agglomeration Index

A vast literature showed that infrastructure plays an important role in economic agglomeration, and the tertiary industry is most sensitive to changes in infrastructure among all industries. Therefore, we select the tertiary industry location entropy as an indicator to describe the regional tertiary industry agglomeration situation. The formula of the location entropy of the tertiary industry is as follows:

$$LQ_{it} = (L_{3it} / L_{it}) / (L_{3t} / L_t) \tag{1}$$

In equation(1), LQ_{st} is the tertiary industry location entropy in province s in year t. L_{3st} and L_{st} are represented the number of employed persons in the tertiary industry and the total employed persons in province s, respectively; L_{3t} and L_t are the tertiary industry employed persons and the total employed persons in China.

2.3 The Level of Economic Development

To measure the economic development of the region, according to the general practice in the literature, we use the real GDP per capita of the region as a substitute variable. Considering the comparability of the data, we convert data to constant price GDP and the base year is 1993. Besides, the data of GDP per capita of the region is calculated by dividing the "real GDP of the region by the resident population at the end of the year".

2.4 Data Sources and Descriptive Statistics

This paper uses the panel data of 31 provinces and autonomous regions in China from 1993 to 2015. To maintain the comparability, the data of Chongqing and Sichuan are combined since Chongqing was separated from Sichuan as a municipality in 1997. In the three variables above, the basic data of the infrastructure is derived from the research results of Ge (2012) and defer the data to 2015 according to the method provided. Other raw data are derived from the "China Statistical Yearbook" and "New China 60 years of statistical information". Besides, to eliminate the possible heteroscedasticity, we make the logarithmic processing of the infrastructure capital stock and the GDP per capita in each region. As the third industry location entropy is not carried out logarithmic processing, due to the ratio form.

2.5 Methodology

To describe the interaction between infrastructure, agglomeration and economic growth better, we use a panel vector autoregressive (PVAR) model in further study. The panel autoregressive model is proposed by Holtz-Eakin et al. (1988) for the first time and has been continuously extended and perfected by Arellano and Bover (1995), McCoskey and Kao (1998), Hsiao (2014), Andrews and Lu (2001), Love and Zicchino (2006). Becoming a mature model with both time series analysis and panel data analysis. The panel vector autoregressive model not only inherits the advantages of the vector autoregressive model but also overcomes the limitations of the traditional time series vector autoregressive model on the amount of data and the heterogeneity of the spatial individual. We construct the following model to examine the impact of infrastructure on economic growth and economic agglomeration: We construct the following model:

$$y_{st} = \beta_0 + \sum_{j=1}^{n} \beta_{nj} y_{st-j} + \mu_s + \eta_t + \varepsilon_{st} \tag{2}$$

In which $y_{st} = (\Delta Lnkd, \Delta LQ, \Delta Lnpgdp)'$; β_{nj} is a 3×3 coefficient matrix; β_0 is a 3×1 vector of intercept terms; u_s and η_t are 3×1 vectors of the province and year dummy variables for province and year fixed effects. ε_{st} is a 3×1 residual term. s and t denote province and year, respectively.

2.6 Estimation Issues

Before estimating the equation, there are still some issues to be solved. The first issue is the existence of fixed effects. Since the regressors are predetermined rather than strictly exogenous, mean-difference which is traditionally used to eliminate the fixed effect would create biased estimates (Love & Zicchino, 2006). Therefore, we use the Helmert transformation (Arellano & Bover, 1995), which uses forward mean-differencing to preserve orthogonality between transformed errors and untransformed original variables.

To prevent pseudo-regression, it is necessary to test the stationary of variables. We select Levin-Lin-Chu Test (LLC) and Im-Pesaran-Shin Test (IPS), which is more effective than Augmented Dickey Test (ADF). These two ways are non-stationary for the original data of the panel, if both test results are significantly rejected the original hypothesis, then the description of the stationary data, otherwise the panel data is non-stationary. As results are shown in Table 1, both stationary tests suggest that the first differences of the variables are stationary and integrated of order 1.

Table 1. Unit root test

Variables	Levin-Lin-Chu Test		Im-Pesaran-Shin Test	
	Individual Intercept First Difference	Individual Intercept & Trend First Difference	Individual Intercept First Difference	Individual Intercept & Trend First Difference
Ln_KD	-5.3458***	-3.6429***	-4.2599***	-4.9619***
Ln_PGDP	-7.5992***	-5.7743***	-7.6251***	-7.8177***
LQ	-10.5967***	-8.0752***	-12.6913***	-13.5152***

Indicates the *significance at 10%, **significance at 5% and ***significance at 1%.

The choice of lag order is also a crucial aspect based on a panel vector autoregressive (PVAR) model. We use the PVAR2 package and consider the Akaike information criterion (AIC), Schwartz information criterion (BIC) and Hannan-Quinn information criterion (HQIC) to choose optimal lag order for our model. As shown in Table 2, we set the optimal hysteresis of the model to 1 according to AIC and HQIC.

Table 2. Optimal order-selection

lag	AIC	BIC	HQIC
1	-11.2856	-10.5601	-11.0031
2	-11.2582	-10.4348	-10.9369
3	-11.2202	-10.2904	-10.8566
4	-11.2759	-10.2298	-10.8658
5	-11.3814	-10.2075	-10.9199

3. Results

In order to comprehensively assess the mutual relationship of agglomeration, infrastructure, and regional economic in China, and to explain the mechanism of interaction between them, more comprehensively, we examine the internal logic through three dimensions: Generalized Method of Moment Estimation, Impulse Response Graph and Variance Decomposition.

3.1. GMM Estimation

Table 3 is a comparative table in which each equation can be analyzed and analyzed as an independent function. The primary interest is column (2). An analysis of the results shows that infrastructure in China has positively contributed to the development of the regional economy. This result is similar to Ge (2012), show that infrastructure capital stock has a significant positive effect on regional economic growth. There are other interesting results, from column (1) and column (3). It is noted that an increase in infrastructure or economic growth in China can lead to agglomeration. On the other hand, regional economic growth can lead to agglomeration. Moreover, column (3) shows that GDP per capita and agglomeration have no statistically significant impact on infrastructure capital stock density.

Table 3. The result from PVAR

	h_LQ	**h_LnPGDP**	**h_Lnkd**
	(1)	**(2)**	**(3)**
L.h_LQ	0.0627	-0.0220	-0.0371
	(0.056)	(0.025)	(0.049)
L.h_LnPGDP	0.5346***	0.6999***	0.1414
	(0.179)	(0.099)	(0.150)
L.h_LnKD	0.2207**	0.1002**	0.6653***
	(0.093)	(0.040)	(0.093)
Observations	600	600	600

Indicates the *significance at 10%, **significance at 5% and ***significance at 1%

3.2. Impulse Response

Figure 1 visualize the impulse-response functions derived from the estimated equation (2). The results show the estimated impulse functions using the standard deviation of change in each variable. The dotted line in the following figures denotes the 95% confidence interval which is generated by Monte-Carlo with 1,000 bootstrap simulations. The standard errors are calculated using the bootstrap method.

Figure 1(2) and Figure 1(8) show the impact on regional economic growth and economic agglomeration after a standard deviation of infrastructure capital stock density, which is of our main interest. As shown in Figure 1(2), for the impact on a standard deviation of infrastructure capital stock density, the response of the changes of GDP per capita of the region is obvious in phase 1, reaching the highest value in phase 2 and 3 and then gradually decay. Figure 1(8) depicts the impact on agglomeration for ten years after a standard deviation of infrastructure capital stock density. The results show that the change response of agglomeration last longer and reach the highest value at the beginning. Though the response gradually decays after phase 2, it keeps the positive response all the time.

Moreover, the change response of regional economic growth after a shock to agglomeration is also our interesting results. A positive shock to agglomeration does however hurt GDP per capita shown in Figure 1(3), reaching the lowest in phase 2. Though the response increases gradually after phase 2, it always keeps a negative response in ten years.

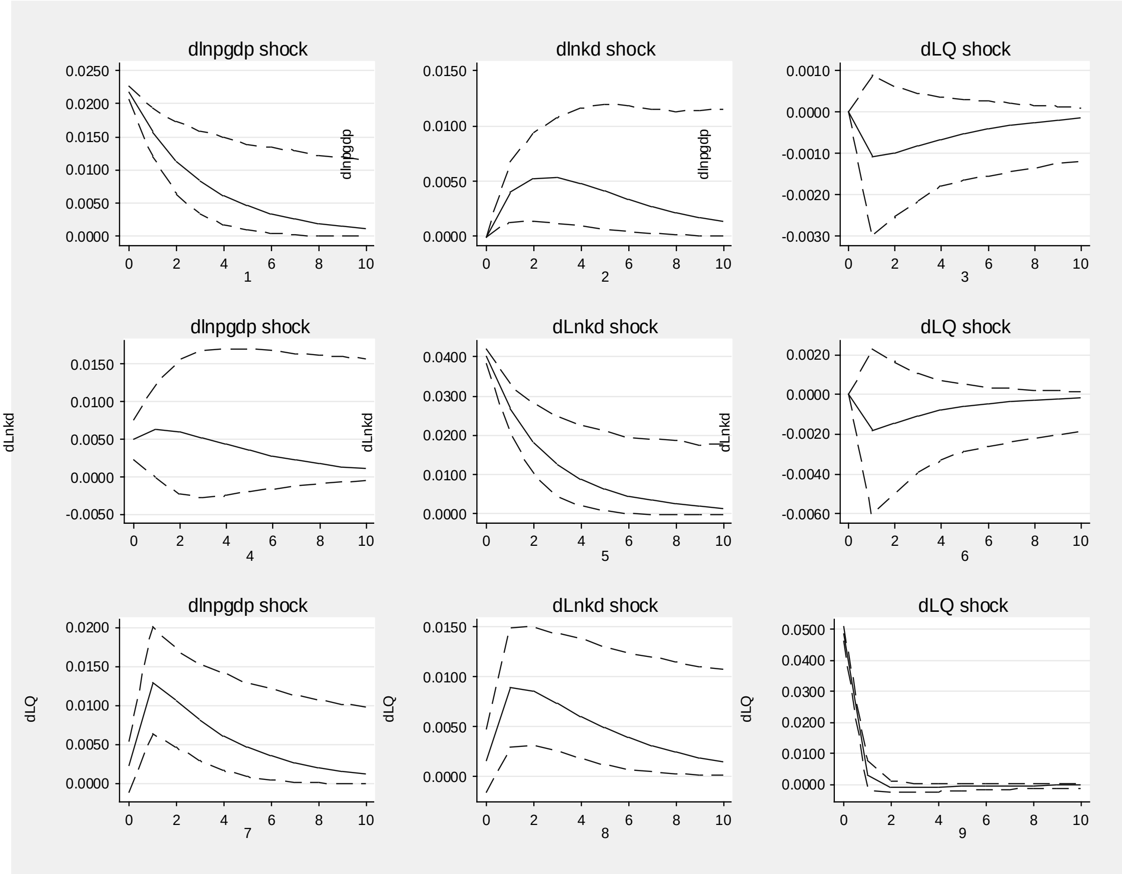

Figure 1. Impulse Response Graph

3.3. Forecast-Error Variance Decomposition

Finally, we use forecast-error variance decomposition to help us analyze the contribution of variables between each other more clearly. Table 4 shows the result of variance decomposition with 1,000 Monte Carlo simulations. The results show that the contribution of infrastructure construction to regional economic growth is between 1.56%~18.53%, the contribution of infrastructure construction to agglomeration is between 0.14%~12.67%. The results show that the infrastructure construction can explain the contribution to regional economic growth is between 1.56%~18.53%, the contribution of infrastructure construction to agglomeration is between 0.14%~12.67%.

Table 4. Variance decomposition

	s	dLnkd	dLQ	dLnPGDP
dLnkd	1	1	0	0
dLQ	1	0.00140654	0.99859346	0
dLnPGDP	1	0.01546156	0.00173496	0.98280348
dLnkd	5	0.98269557	0.00193032	0.01537411
dLQ	5	0.10779599	0.79252236	0.09968165
dLnPGDP	5	0.14916848	0.00168066	0.84915085
dLnkd	10	0.97709252	0.00202274	0.02088474
dLQ	10	0.12666002	0.7657049	0.10763508
dLnPGDP	10	0.18531971	0.00183378	0.812846

4. Discussion

We select the PVAR model to examine the long-term effects among infrastructure, agglomeration, and regional economic growth, in which the variables are endogenous. Although this method is useful to estimate the long-run effect, it is not very informative about the estimation of short-run effects. Moreover, this approach fails to find the spatial correlation and spillover effect among infrastructure and agglomeration. Therefore, what can be further expanded is introducing more control variables in the economic model and examining the spatial spillover effect.

5. Conclusions

According to the estimation result of the PVAR model, there is a significant positive relationship between infrastructure and regional economic growth in China. In the long run, it is found that increasing the density of infrastructure capital stock can still have a positive impact on regional economic growth and economy agglomeration. Specifically, GDP per capita growth has a positive effect on the tertiary industry location entropy, but the tertiary industry location entropy has an opposite effect on the GDP per capita growth. This means that economic agglomeration is negatively correlated with regional economic growth, which needs to be further studied. We also find that the growth of the tertiary industry location entropy and GDP per capita have not statistically significant long-run effect on infrastructure capital stock density.

References

Abrigo, M. R., & Love, I. (2016). Estimation of panel vector autoregression in Stata. *The Stata Journal*, *16*(3), 778-804. https://doi.org/10.1177/1536867X1601600314

Andrews, D. W., & Lu, B. (2001). Consistent model and moment selection procedures for GMM estimation with application to dynamic panel data models. *Journal of econometrics, 101*(1), 123-164. https://doi.org/10.1016/S0304-4076(00)00077-4

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of econometrics*, *68*(1), 29-51. https://doi.org/10.1016/0304-4076(94)01642-D

Aschauer, D. A. (1989). Is public expenditure productive? *Journal of monetary economics*, *23*(2), 177-200. https://doi.org/10.1016/0304-3932(89)90047-0

Barro, R. J. (1990). Government spending in a simple model of endogeneous growth. *Journal of political economy*, *98*(5, Part 2), S103-S125. https://doi.org/10.1086/261726

Canning, D. (1999). *Infrastructure's Contribution to Aggregate Output.* (World Bank Policy Research Working Paper 2246). The World Bank.

Canova, F., & Ciccarelli, M. (2013). *Panel Vector Autoregressive Models: A Survey.* Emerald Group Publishing Limited.

Calderón, C., Moral-Benito, E., & Servén, L. (2015). Is infrastructure capital productive? A dynamic heterogeneous approach. *Journal of Applied Econometrics*, *30*(2), 177-198. https://doi.org/10.1002/jae.2373

Cook, L. M., & Munnell, A. H. (1990). How does public infrastructure affect regional economic performance? *New England economic review*, (Sep), 11-33.

Holtz-Eakin, D., Newey, W., & Rosen, H. S. (1988). Estimating vector autoregressions with panel data. *Econometrica: Journal of the econometric society*, *56*(6), 1371-1395. https://doi.org/10.2307/1913103

Fan, J. L., Bai, B. L., & Pan, Q. (2004a). Progress made by the study on the contribution of infrastructure capital to economic growth–A summary of the method of production function. *Modern Economic Science*, *26*(2), 87-96.

Fan, J. L., Bai, B. L., & Pan, Q. (2004b). A Study on the Different Influence of Infrastructure on Regional Economic Growth in China. *Human Geography, 19*(2), 35-38.

Ge, J. (2012). The Estimation of China's Infrastructure Capital Stock. *Economic Research Journal*, *4*, 4-8.

Ge, J. (2016). Infrastructure and non-infrastructure capital stocks in china and their productivity: A new estimate. *Economic Research Journal*, *5*, 41-56.

Haque, M. E., & Kim, D. H. (2003). *Public investment in transportation and communication and growth: a dynamic panel approach*. University of Manchester, School of Economic Studies.

Hsiao, C. (2014). *Analysis of panel data* (No. 54). Cambridge university press.

Love, I., & Zicchino, L. (2006). Financial development and dynamic investment behavior: Evidence from panel VAR. *The Quarterly Review of Economics and Finance*, *46*(2), 190-210. https://doi.org/10.1016/j.qref.2005.11.007

McCoskey, S., & Kao, C. (1998). A residual-based test of the null of cointegration in panel data. *Econometric reviews*, *17*(1), 57-84. https://doi.org/10.1080/07474939808800403

Straub, S. (2008). *Infrastructure and economic growth in East Asia* (Vol. 4589). World Bank Publications.

World Bank. (1994). *Infrastructure for Development*. Oxford University Press.

Zhang, X. L. (2013). Has transport infrastructure promoted regional economic growth? - With an analysis of the spatial spillover effects of transport infrastructure. *Social Sciences in China*, *34*(2), 24-47. https://doi.org/10.1080/02529203.2013.787222